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GOVERNANCE OF THE SUGARCANE ETHANOL INDUSTRY: CLIMATE CHANGE AND THE WATER-ENERGY-LAND NEXUS

Lira Luz Benites Lázaro

Doctorate Thesis of the Graduate Course in Earth System Science, guided by Drs. Angélica Giarolla, and Karina Yoshie Martins Kato, approved in May 18, 2018.

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São José dos Campos, 18 de maio de 2018

En memoria a mi gran padre y maestro, profesor ***Nestor Benites Ortega.***

.

To those who use well what they are given, even more will be given, and they will have an abundance. But from those who do nothing, even what little they have will be taken away. The Parable of the Talents (Matthew 25:14-30).

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ABSTRACT

Private, business actors have taken an important role in the global governance system, not only as economic actors responsible for much of the world's goods and services production, but also as political actors in global mechanisms to govern the economic system. In this, context, the aim of this study is to elaborate an analytical framework in order to assess the specific exercise of political power of business actors at the national level with focus in the sugarcane ethanol companies in Brazil, and to examine the ways in which the political power of corporate actors influences outcomes, particularly with respect to questions of its sustainability and how its consolidation raises fundamental questions regarding the water-energy-land nexus. In the pursuit of this objective, the study explores the broad range of data obtained from Brazilian newspapers, government and business report and documents, and bulletins of non-government organizations and social movements from January 2007 to December 2017. Moreover, to construct the analytical framework of qualitative model to assess the water-energy-food nexus in the sugarcane ethanol production by considering the influence factors such as governance, innovation, labor and policies, was constructed two corpus in text format: one to train the model and another to evaluate the nexus of ethanol and validate the model. To the first corpus was used the scientific publications on sugarcane ethanol compiled from the Scopus and ScienceDirect database in the period from 1980 to March 2018, and the second corpus consists of a wide collection of literature related to the Brazilian scientific article on ethanol, and business reports and documents from the sugarcane companies. The mixed methods approaches (qualitative - quantitative) was used, with the help of software packages specialized in documentary and textual research in data mining and statistics used in applied social sciences (Machine Learning algorithms). The main contribution to knowledge of this doctoral research is through an interdisciplinary analysis of the role of the sugarcane ethanol companies in the governance and debates on its sustainability by using the structural, institutional, and discursive dimensions of business power. Furthermore, contributes in the construction of analytical framework of a qualitative model for investigating the water-energy-food nexus in the sugarcane ethanol production.

Keywords: climate change, bioenergy, corporate social responsibility, sugarcane, ethanol, governance, public policy, sustainability, topic modeling, water-energy-food nexus.

GOVERNANÇA DA INDÚSTRIA DO ETANOL: A MUDANÇA CLIMÁTICA E O NEXO ÁGUA-ENERGIA-SOLO

RESUMO

Os atores empresariais assumiram um papel importante no sistema da governança global, não apenas como atores econômicos responsáveis por grande parte da produção mundial de bens e serviços, mas também como atores políticos nos mecanismos globais para governar o sistema econômico. Nesse contexto, o objetivo deste estudo é elaborar um arcabouço analítico com o objetivo de avaliar o exercício do poder político dos atores empresariais no âmbito nacional-local com foco nas empresas produtoras de etanol de cana-de-açúcar no Brasil, e examinar as formas pelas quais o poder político destes atores empresariais influencia os resultados, particularmente no que diz respeito às questões de sua sustentabilidade e como sua consolidação levanta questões fundamentais sobre o nexo água-energia-alimentos/solo. Na busca por esse objetivo, o estudo explora uma ampla gama de dados (big date) obtidos a partir da mídia, relatórios e documentos do governo e empresas, boletins de organizações não governamentais e movimentos sociais, o período do levantamento de dados compreende os últimos 11 anos de janeiro de 2007 a dezembro de 2017. Além disso, para construir - o arcabouço analítico do modelo qualitativo para avaliar o nexo água-energia-alimento na produção de etanol de cana-de-açúcar, considerando os fatores influenciadores tais como: governança, inovação, trabalho e políticas - utilizou-se a pesquisa científica e publicações sobre etanol de cana-de-açúcar compiladas a partir do banco de dados da Scopus e ScienceDirect no período de 1980 a março de 2018. Utilizou-se a abordagem do método misto (qualitativo - quantitativo) com a ajuda de softwares especializados em pesquisa documental e textual em data mining e estatística aplicada ciências sociais (algoritmos de Machine Learning). A principal contribuição para o conhecimento desta pesquisa de doutorado é através de uma análise interdisciplinar do papel das empresas produtoras de etanol de cana na governança e debates sobre sua sustentabilidade, utilizando as dimensões estrutural, institucional e discursiva do poder. Além disso, contribui com a construção do modelo qualitativo para avaliar o nexo água-energia-alimento na produção de etanol de cana-de-açúcar.

Palavras-chave: Bioenergia, mudança climática, responsabilidade social corporativa, cana-de-açúcar, etanol, governança, políticas públicas, sustentabilidade, modelagem de temas, nexus água-energia-alimentos.

LIST OF FIGURES

Page

LIST OF TABLES

Page

CONTENTS

1. INTRODUCTION

1.1 Introduction

Businesses are recognized as a cornerstone of prosperity in society, given that companies create the resources that allow social development and welfare. Thus, understand and knowing the role that companies play within society becomes important, since they are main players in the global governance, they have potential contribution in political decision-making and on the international agenda. Furthermore, the business actors are a main contributor to greenhouse gas emissions through their economic activities, and they can contribute to the achievement of sustainable development.

Furthermore, the literature has highlighted a variety of "new" types of political activities by business, including self-regulation, codes of conduct, standards, sustainability certifications, public-private and private-private partnerships (PPPs), and the privatization of areas traditionally considered the task of public actors. In this context, scholars have drawn attention to the development of "private authority" in the international system (CLAPP; FUCHS, 2009; BULKELEY; NEWELL, 2015).

Scholars, activists and politicians claim that corporations have become extremely powerful actors and are increasingly able to shape governance at the national and supranational levels (CLAPP; FUCHS, 2009). On the one hand, the notion of corporate social and environmental responsibility is gaining ground (BENITES-LAZARO; MELLO-THÉRY, 2017). On the other hand, scandals and catastrophes caused by business actors from Seveso, Bhopal and Exxon Valdez to Mariana in Brazil, from Enron and WorldCom to Odebrecht and JSB suggest that the economic and political activities of business actors still need to be incorporated into an appropriate regulatory framework.

Nonetheless, business investments can play a key role in economic development. However, some of these activities can be more of a "burden than a blessing" due to their

impact on communities and environment, human rights, the right to health, and the land of local communities (BENITES-LAZARO; GREMAUD; BENITES, 2018).

According to Fuchs (2007, 2013), despite increasing concerns regarding the business political mobilization, however, there has been little systematic research on the political role of business in global governance. Only recently, more power-oriented and broader inquiries into the role of multinational companies in global politics have started to emerge. In this way, a comprehensive and systematic understanding of the political activities employed by businesses with respect to governance and their meaning and development in terms of business's political power is missing. This fact is also surprising, since assumptions about the power of business frequently inform arguments about the role of other actors in global governance, in particular the state, non-governmental organization and civil society (CLAPP; DAUVERGNE, 2005).

The present study responds to the need to understand the business role in the governance at the national level. In particular, the analysis is focused in the sugarcane ethanol industry. This because, in recent decades, world-view recognition of the environmental benefits of ethanol from sugarcane has grown in the context of global interest in renewable fuels to reduce dependence on fossil fuels, and reduction of greenhouse gases (GHG) emissions in the context of climate change (LA ROVERE; PEREIRA; SIMÕES, 2011; BENITES-LAZARO; MELLO-THÉRY; LAHSEN, 2017). This places Brazil as one of the important players in the development of the biofuels technology from sugarcane and as the main countries that exports ethanol.

In Brazil, the energy sector, for example, in 2016 was represented by 58.8% of non-renewable energy and 41.2% of renewable energy. According to the Brazilian Ministry of Mines and Energy report (MINISTÉRIO DE ENERGIA E MINAS, 2016), there are an increasing proportion of renewable energy in the energy grid, rising from 39.4% in 2014 to 41.2% in 2016. On the renewable side, ethanol and sugarcane bagasse had the largest share with 41.1%, followed by hydroelectric plants with 27.5%, wood and charcoal with 19.9%, and the others with 7.5% (wind, solar and biodiesel in particular) (BENITES-LAZARO; MELLO-THÉRY; LAHSEN, 2017) .

In addition, Brazil's commitment to the United Nations Framework Convention on Climate Change (UNFCCC) in the context of the Paris Agreement is mainly attributed to the reduction of CO2 emissions from the redirection of the energy grid. One of the pledged communicated through its Nationally Determined Contribution (INDC), involving the energy sector, is to achieve by 2030, 45% of the energy grid be composed of renewable sources, and increase the share of bioenergy to approximately 18% by 2030, expanding the consumption of biofuels, made possible by increased ethanol production, including the second generation biofuels (BRASIL, 2015; BENITES-LAZARO; MELLO-THÉRY; LAHSEN, 2017).

Biofuels, despite its importance as an alternative to the use of fossil fuels in a context of climate change, and its growth driven by recent energy security strategies, investment opportunities and energy policies (RULLI et al., 2016). However, their consolidation poses fundamental questions related to the water-energy-food nexus, which are confronted due to its impacts in the demand for water for its production and the guarantee of a continuous supply of food crops (GIAMPIETRO; MAYUMI, 2009; RULLI et al., 2016). As described by RULLI et al.(2016) first-generation bioethanol, mainly produced from food crops, continues to be the main contributor to the world's biofuel supply. They also point out that competition between food and biofuels will become even more intense in the near future, with the world population expected to reach 9 billion by 2050.

In Brazil, biofuels are a key component of agribusiness, and their consolidation raises fundamental questions regarding the water-energy-land (food) as well as economic and social development models. There are important economic and policy drivers behind the current trends in biofuel consumption which, in addition, to its environmental impacts, have important social implications that can best be understood by examining the water-energy-food nexus of the sugarcane ethanol production. A nexus approach can support a transition to sustainability, reducing trade-offs and generating additional benefits that outweigh transaction costs associated with greater integration across industries (HOFF, 2011; GIATTI et al., 2016; RASUL; SHARMA, 2016). These gains should attract

national interest and encourage governments, the private sector and civil society to engage in effective and integrated governance (HOFF, 2011; WEITZ et al., 2017).

Thus, the primary objective of this study is to provide an encompassing picture of the role of the sugarcane ethanol companies in the governance into this sector, and to better understand its role as a political actor in the mobilization of non-market strategies to seek good environment legislation and defend its corporate interest. Then, I examine how using these non-market strategies influences the debates on the water-energy-food issues in the production of sugarcane ethanol. By examining business political activities, including lobbying and campaign finance activities, rule-setting activities as its efforts to influence governance-relevant norms, and ideas. The analyses consider the actor-specific, business governance-led, and business's discursive power sources.

In the pursuit of this objective, the study explores the broad range of data obtained from Brazilian newspapers, government and business report and documents, and bulletins of non-government organizations and social movements from January 2007 to December 2017. Moreover, was used the scientific publications on sugarcane ethanol compiled from the Scopus and ScienceDirect database in the period from 1980 to March 2018. I used the mixed methods approaches (qualitative - quantitative) through specialized software in documentary and textual research in data mining and statistics used in applied social sciences (machine learning algorithms).

1.2. **Objectives**

Drawing on perspectives from dimensions of business power aims to study the governance and sustainability of the sugarcane ethanol industry in the context of the climate change and land-water-energy nexus.

The scope of the proposed general objective will be achieved through the following specific objectives:

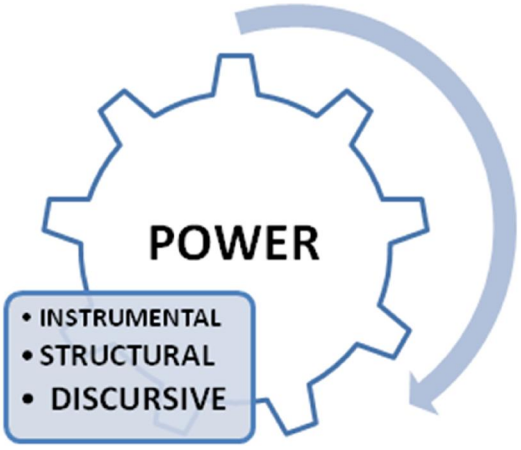
a) Construct an analytical framework for investigating changes in political debates and social discussion on climate change, ethanol production, and food security in Brazil;
b) Examine the instrumental dimension of business power in the sugarcane ethanol industry by analyzing the industry's nonmarket strategies activities to secure favorable public policy decisions and good legislative environment;
c) Study the structural dimension of business power by examining why sugarcane ethanol companies develop and use institutions to promote sustainability performance and encourage concern with best production practices;
d) Examine the discursive dimension of business power by analyzing the predominant business storytelling ploys used by Brazil's sugarcane industry association, UNICA to promote the industry as environmentally and socially responsible;
e) Examine the policy debates regarding land-water use in sugarcane ethanol production by identifying the dominant public discussions, the importance that each actor assigns to these issues, and the challenges to integrated land-water-energy policies;
f) Construct an analytical framework qualitative model for investigating the water-energy-food nexus in the sugarcane ethanol production by using Natural Language Processing algorithms.

1.3. Synthesis of theoretical framework

a) Tridimensional theory of business power

In order to identify the various mechanisms and/or strategies that companies use to influence policies, regulations and legitimize into the society Fuchs (2007, 2013) and Clapp; Fuchs (2009) have developed a systematic and comprehensive framework for analyzing business political power through a three-dimensional approach to power. Classifying them in its instrumental, structural and discursive dimensions, as it is shown in the Figure 1.1.

Figure 1.1 The three faces of business power



Source: Fuchs (2007, 2013).

The instrumental approach refers to the direct influence that business representatives can exert on government in an attempt to influence decision-making with a view to pursuing policies favorable to their group or to prevent the adoption of policies or regulations unfavorable to it. Instrumental power they attempt to wield in policy processes via corporate lobbying or political campaign financing. In Particular, scholars link this type of power to a change in the decision outcomes by one actor due to the influence exercised by another (FUCHS, 2007, 2013).

The structural power, a more dynamic type of structural power has emerged in recent years with the globalization is the increasingly put corporate actors in a position to make governance decisions themselves, either supplementing or in some cases replacing traditional actors such as states and global institutions (CLAPP; FUCHS, 2009). Some scholars have pointed to the development of private and quasi-private regimes, such as Bonsucro standards or the International Organization for Standardization's ISO 14000 standards, whereby industry players took a key role in not only setting the agenda, but also in delineating the rules companies' growing adherence to "corporate social responsibility" (CSR) and private certification standards, codes of conduct, and the growing significance they play in the regulatory structures governing the global economy.

The discursive perspectives considers attempts to socialize politicians and the public into accepting "truths" about desirable policies and political developments and pays attention to media and public relations efforts, among others (CLAPP; FUCHS, 2009). Discursive power in this sense precedes the formation and articulation of interests in the political process because of its role in constituting and framing policies, actors, and broader societal norms and ideas. Corporate actors, in other words, often play an important role in framing certain issues and problems in public discourse. This discourse in turn can have an important yet indirect influence over the ways public debates are carried out and over the choices presented to society for addressing them (FUCHS, 2007, 2013).

According to this perspective one of the business strategies is to try to convince society that the interests of the company are in reality the interests of the country or of humanitarian interest, for example, the Cargill case described in "The Invisible Giant" its strategy to influence and legitimize itself has often been clothed in terms of economic development, sometimes in humanitarian terms (KNEEN, 2002).

b) Water-energy-food nexus approach[1]

In the context of global environmental change, the water-energy-food nexus approach has been gaining significant importance in international natural resource and policy debates (CAIRNS; KRZYWOSZYNSKA, 2016; WEITZ et al., 2017). Its proponents have pointed as a conceptual tool for achieving sustainable development (HOFF, 2011; BIGGS et al., 2015), and for climate change adaptation (RASUL; SHARMA, 2016). Nexus approach promotes policy integration and coherence through identifying optimal policy mixes and governance arrangements across the nexus sectors (WEITZ et al., 2017). The nexus approach perceives integration and interdependence across the various sectors as a fundamental step for ensuring resource security in a global context of increasing and competing demands (ARTIOLI; ACUTO; MCARTHUR, 2017; WEITZ

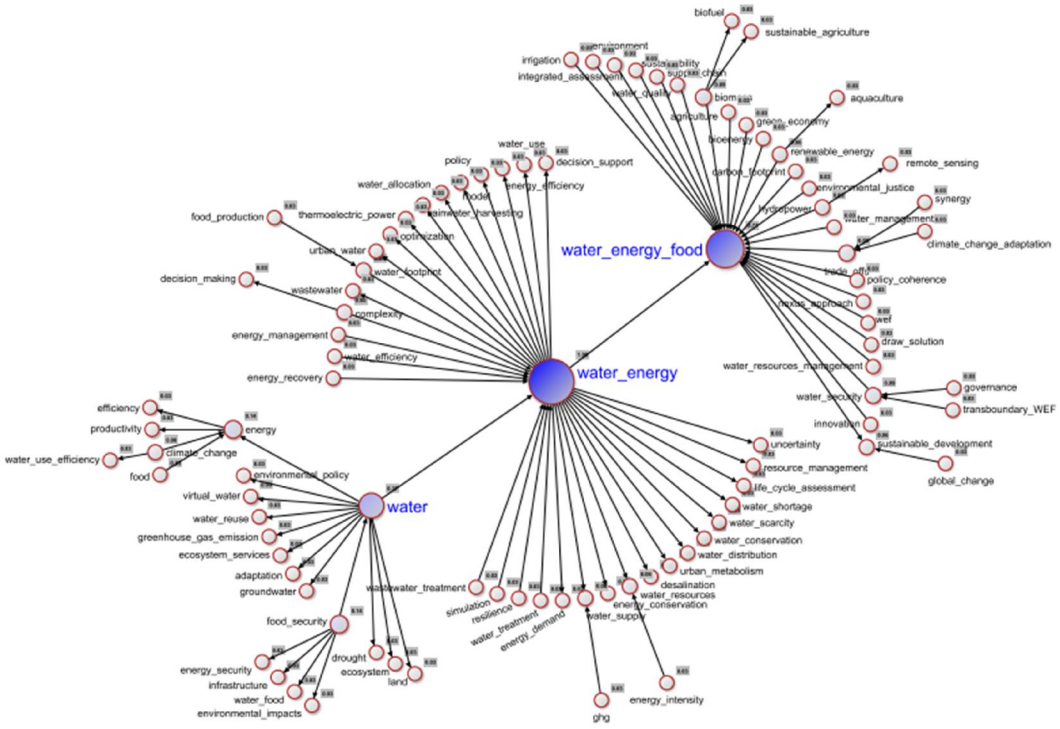
[1] This subtitle is part of the article: Benites-Lazaro, L.L. Water-energy-food nexus approach to urban governance: A network analysis.

et al., 2017). The discussion of the water-energy-food nexus in the literature seems to be calling for interdisciplinary efforts of the research with the urgent need for linking knowledge and searching cross-sector dynamics and improvements in policy coherence to tackle the imminent challenges of our times (WICHELNS, 2017).

Debates and concern about water and food crises, and the volatility of food and energy prices in the late 2000s bring the emergence of the nexus approach terminology as a way of framing cross-sector and cross-scale interactions (MIDDLETON et al., 2015). During the World Economic Forum in 2008 prominent business leaders issued a 'call to action' on the ways in which resource security across a nexus is linked to economic growth (WEF 2008). A milestone event of the Bonn 2011 Conference on the nexus for water, energy and food security highlighted the need to understand the nexus to develop policies, strategies and investments to exploit synergies and mitigate trade-offs and improve governance across the nexus sectors with active participation among government agencies, private sector, academia and civil society (HOFF, 2011). Since the Bonn conference, the nexus research agenda has drawn increasing (MIDDLETON et al., 2015), and it's being used to express an 'integrative imaginary', with a believe that integration among various sectors is possible and desirable (CAIRNS; KRZYWOSZYNSKA, 2016).

The Figure1.2 depicts the network analysis of water-energy-food nexus research. The centrality measures (Table 1.1) show that the topics related to the nexus water_energy and water_energy_food have the major importance within the network (pagerank metric) and the more treated (Degree centrality), this means that a considerable part of the abstract refer to this issue in specific. The themes of governance, water-use eficiency, remote sensing and climate change adaptation have a central position within the network (Eccentricity) means that all abstracts indirectly deal with these issues by serving as a "link" between various issues.

Figure1.2 Network analysis of water-energy-food nexus approach research



The abstract of journal articles was obtained from the Scopus and ScienceDirect database from 2007 to March 2018 about the keyword water-energy-food nexus.

Table 1.1. Network analysis keyword-abstract of Nexus

Label	Pageranks	Degree	Label	Eccentricity
water_energy	0,165	35	governance	7
water_energy_food	0,127	27	water_use_efficiency	7
water	0,062	13	aquaculture	7
food_security	0,025	5	remote_sensing	7
energy	0,025	5	transboundary_water_energy_food	7
biomass	0,015	3	sustainable_agriculture	7
trade_offs	0,015	3	global_change	7
water_security	0,015	3	synergy	7
climate_change	0,011	2	climate_change_adaptation	7
complexity	0,010	2	biofuel	7
water_footprint	0,010	2	trade_offs	6
water_supply	0,010	2	water_security	6
water_resources	0,010	2	biomass	6
renewable_energy	0,010	2	sustainable_development	6
hydropower	0,010	2	renewable_energy	6
sustainable_development	0,010	2	climate_change	6
water_use_efficiency	0,006	1	hydropower	6
global_change	0,006	1	energy_security	6
aquaculture	0,006	1	irrigation	6

The nexus debates, however, for some mask a bigger debate on resource inequality and access with a tendency towards a managerial security framing that debates the technical and hides its politics (ALLOUCHE; MIDDLETON; GYAWALI, 2015). Since that was introduced by the World Economic Forum, nexus term was appropriated into powerful managerial discourses in natural resource debates framing business imperatives and global neoliberal policy (ALLOUCHE; MIDDLETON; GYAWALI, 2015; MIDDLETON et al., 2015). The mobilization of the nexus vocabulary from a focus on business efficiency as refer by Cairns and Krzywoszynska (2016) can be positioned within both broader discursive trends one from the policy discourses of ecological modernization that proposes to solve environmental problems be in accordance with the workings of the main institutional arrangements of society, and other neoliberal environmentalism discourses that proposes a market-based solutions.

The nexus approach, despite have received criticism for emerging from a highly elitist community of the global economy and the possibility of ignoring the deep inequalities. However, their importance to provide interdependence among water, energy and food can be recognized by considering them as essential and intrinsic elements to human development and sustainability (GIATTI et al., 2016).

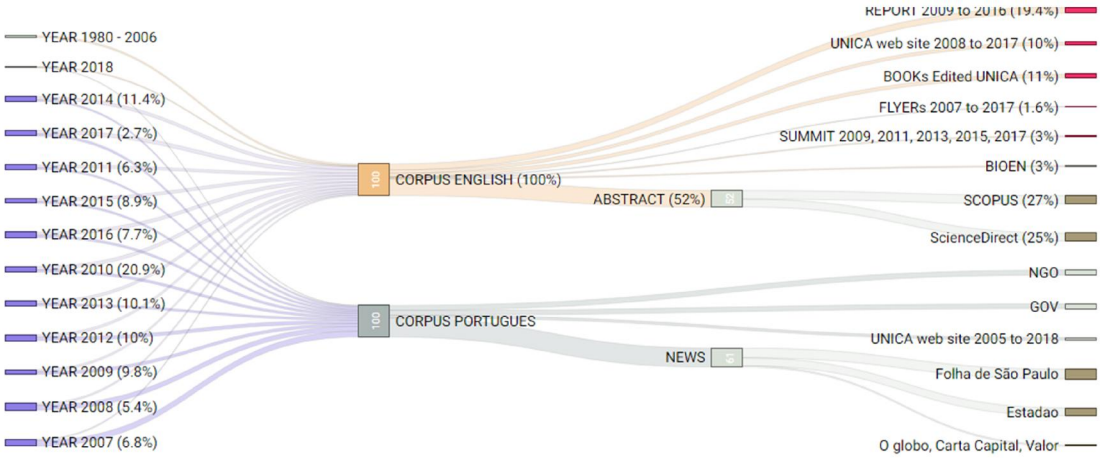
A nexus approach can support a sustainability production, reducing trade-offs and generating additional benefits that outweigh transaction costs associated with greater integration across industries (GIATTI et al., 2016; RASUL; SHARMA, 2016; SILALERTRUKSA; GHEEWALA, 2018). These gains should attract national interest and encourage governments, companies and civil society to engage in effective and integrated governance (HOFF, 2011; WEITZ et al., 2017). Despite increasing literature on water-energy-food nexus assessment, however, there are still gaps in applying nexus assessment for policy recommendations (SILALERTRUKSA; GHEEWALA, 2018).This is need due to the fact that interactions among decision makers are as important as physical interactions, and seeks to achieve common and equitable decision-making (BAZILIAN et al., 2011).

1.4 Synthesis of methodological framework

1.4.1. Material

This study as the figure 1.3 shows explores the broad range of data obtained from Brazilian newspapers, government and business report and documents, and bulletins of non-government organizations and social movements from January 2007 to December 2017. Moreover, was used the scientific publications on sugarcane ethanol compiled from the Scopus and ScienceDirect database in the period from 1980 to March 2018. I used the mixed methods approaches (qualitative - quantitative) with the help of software's specialized in documentary and textual research in data mining and statistics used in applied social sciences (Machine Learning algorithms).

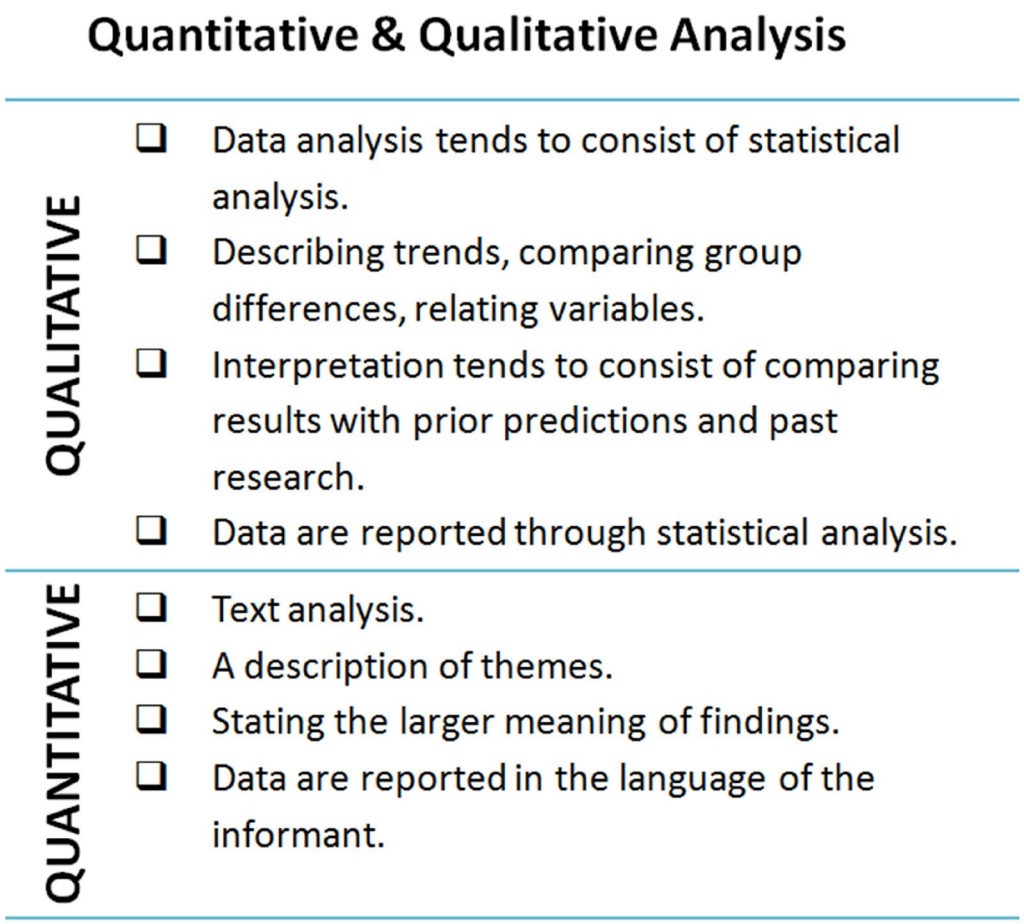
Figure 1.3 Sankey diagrams of data source for corpus construction



1.4.2 Method

When we analyze textual material (data are qualitative nature per se), we deal with words and linguistic representations and not with mere notes in a given test or questionnaire, nor with standardized answers, for example, on a Likert scale (CORTINI AND TRIA, 2014). In this case, as Table 1.2 shows, there are at least two different ways of approaching these data. On the one hand, research can focus on the way discourses were made (qualitative approach), with the implicit belief that what matters is how something is said. In other terms, what make the difference are metaphors and representations of peculiar words. On the other hand, the same material can be approached verbatim (quantitative approach), referring to the number of times certain "key" words appear in the text and their respective associations with other words, assuming that the most important is the quantity (CORTINI AND TRIA, 2014; BENITES-LAZARO; MELLO-THÉRY; LAHSEN, 2017). In other words, it is possible to decide between a qualitative and a quantitative approach, even in the case of textual material, such as transcripts of conversations or responses to questionnaires, analysis of media news, or company reports.

Table 1.2. Methodology of scientific research - quantitative and qualitative method



In this study the primary source of data were from different actors (company reports, newspaper articles, governments' reports and documents, scientific articles, etc) approximately 90% in text format, for its analysis was used a new methodological alternative, called mixed methodology (or triangulation) that consists of taking advantage of both approaches in the treatment of textual material - quantitative and qualitative. Where it is assumed that both quantitative (different forms of repetition of words) and qualitative (the peculiar way in which something was said) are very important (CORTINI AND TRIA, 2014).

In the analysis of textual material (content analysis, thematic analysis and discourse analysis) can be used a set of linguistic, statistical and graphical tools, commonly used in applied social sciences research. For this purpose, we have the assistance of

specialized software in documentary and textual research (big data), both commercial and open source, which allowed us to carry out the following analyzes:

- Explore, measure and map co-occurrence relationships between keywords;
- Classification of text and document units, using bottom-up methodology (analysis of emerging themes) and top-down methodology (predefined categories);
- Identify the lexical units (words or lemmas), context units (sentences or paragraphs) and thematic cluster of specific subsets of certain texts (discourses and categorized interviews);
- Perform different types of correspondence analysis and cluster analysis;
- Generate semantic maps that represent dynamic aspects of speech (sequential relationships between words or themes);
- Perform lexical analysis and content analysis;
- Analyze the entire corpus or only some of its subsets (groups of documents) using different lists of keywords;
- Check the contexts of occurrence (concordances) of words and slogans;
- Construct different types of contingency tables and co-occurrence matrices.

The steps for text analysis is presented in a summarized form in the Figure 1.4:

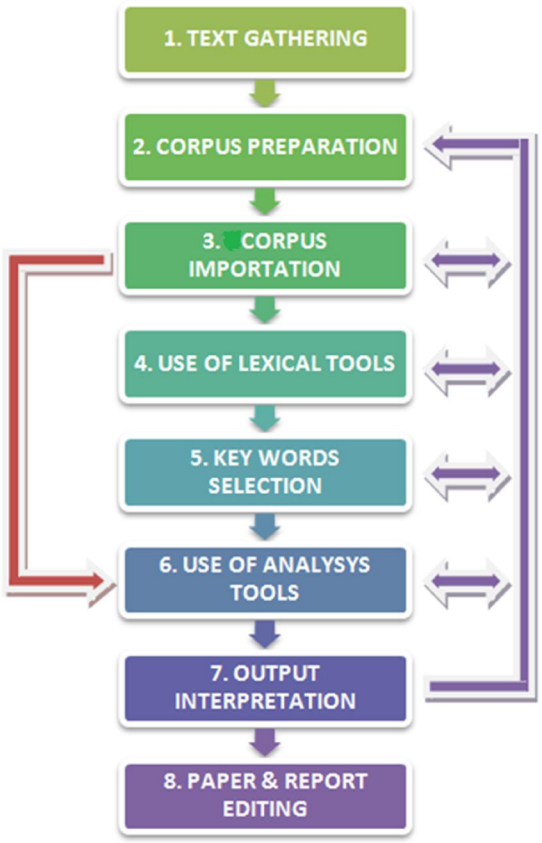
1) Text gathering - starts with the construction of the database to be analyzed, which was composed for: corporate sustainability reports, government reports and NGOs, newspaper articles, scientific article all in text format.
2) Corpus preparation - the texts to be analyzed are processed in a file (corpus) that can be handled by the software.
3) Corpus importation - consists of a series of automatic processes that transform the corpus into a set of tables integrated in a database. During this parallel process corpus is normalized, is carried out the segmentation of contexts units, automatic tagging, vocabulary building and keyword selection.
4) Lexical tools - with the help of computational algorithms, the recognition of lexical units (words or categories).

5) Keyword selection - consists in the customized of a list of lexical units (words, lemmas, or categories) to be used to create the data tables to be analyzed.

6) The use of analysis tools - allows the production of outputs (tables and graphs) that represent the significant relationships between the units of analysis and that allow us to make inferences. For our research we make use of three instruments, each of which has its own logic, uses special computational algorithms and produces specific outputs: Co-occurrence analysis allows the evaluation, measurement and mapping of different types of relations between key words, considering both pairs and groups of words that come from the corpus (word associations, analysis of sequences), Comparative analysis allows the analysis and mapping of differences and similarities between the different corpus segments, each of which is characterized by a lexical profile generated from of the key words contained in them (analysis of specificities, analysis of correspondences, cluster analysis), and thematic analysis are mainly oriented to the search of key word patterns within the context units (analysis and thematic classification, modeling of emerging themes) (LANCIA, 2017).

7) The Interpretation of outputs consists of the revision and consultation of the data obtained by the use of statistical algorithms. These data are generated in the form of tables from which we construct diagrams and graphs that aid in the process of making the inferences about their meaning, and analyze the results.

Figure 1.4 Steps for text analysis



1.5 Thesis structure

The dissertation consists of a synthesis (Chapters 1-8) of six Articles. The content of the chapters are as follows:

1. Introduction: in this chapter we offer a overview about the study, we describe the theoretical and methodological framework used in the research.

2. Topic modeling method to analyze social actor´s discourses on climate change-energy and food security nexus in Brazil. In this article by using a unsupervised probabilistic modeling—latent Dirichlet allocation (LDA)— is

examined changes in the social policy debates related to ethanol production in Brazil and its relationship with climate change and food security

3. The political dynamics of agribusiness in Brazil: Business citizenship and lobbying. In this paper, drawing on the instrumental power of business was studied the political mobilization of the sugarcane ethanol companies in Brazil, identifying the industry's nonmarket strategies activities to secure favorable public policy decisions and good legislative environment. We analyzed Brazilian policies and programs granted by the government to the sugarcane ethanol industry; the campaign finance documents. Furthermore, we analyzed large amounts of data obtained from Brazilian newspapers, government and sugarcane ethanol business documents, and bulletins of non-government organizations and social movements from January 2007 to December 2017.

4. Sustainability and governance of the sugarcane ethanol companies in Brazil: Topic modeling analysis of CSR reporting. In this paper, drawing on the structural power of business, was examined the rule-setting power in which sugarcane ethanol companies engage, and then discuss why these companies develop and use institutions to promote sustainability. We use a machine learning algorithm, latent Dirichlet allocation, to identify companies' commitment to sustainability and business-led governance by analyzing a large volume of data from public corporate documents.

5. Business storytelling about energy and climate change: The case of Brazil's ethanol industry. In this paper drawing on the discursive power of business is examined the predominant business storytelling ploys used by Brazil's sugarcane industry association, UNICA to promote the industry as environmentally and socially responsible. We used both qualitative and quantitative narrative analysis to analyze thirty-five videos and multimedia presentations produced as part of UNICA's marketing communications. Drawing on insights about tropes variously evoking hero stories, learning

stories and horror stories, we conclude that the sugarcane industry has developed hero and learning stories that portray the sugarcane industry as a sustainable business and ethanol as a 'green hero', a green, renewable energy that helps reduce greenhouses gas emissions and thus saves humanity from climate change.

6. Land-water-energy-food nexus in the production of ethanol in Brazil: Policy debates. In this article is examined the policy debates regarding land and water use in sugarcane ethanol production in Brazil by identifying the dominant public discussions, the importance that each actor assigns to these issues, and the challenges to integrated land-water-energy policies. We analyzed large amounts of data obtained from Brazilian newspapers, government and business documents, and bulletins of non-government organizations and social movements from January 2007 to December 2017, by combining an unsupervised probabilistic Latent Dirichlet Allocation (LDA) model with discourse analysis. The results showed that although the discourse has evolved over time in response to certain events, the discussions and resultant public policies do not take into account the interdependence between these sectors. For sustainable resource use, sugarcane ethanol expansion should be considered by decision-makers and companies in a wider governance structure based on nexus dynamics: trade-offs of land and water use with other sectors than bioenergy must be acknowledged.

7. A qualitative model analysis of water-energy-food nexus of the sugarcane ethanol production in Brazil. In this article is constructed an analytical framework based on a variety of empirical qualitative indicators constructed from the specialized literature on the issue. We examine the relationship between water-energy-land of the Brazilian sugarcane ethanol production in the context of climate change. Then, we identify governance gaps by addressing the problems of WEL nexus. The results show that using NLP algorithms such as LDA topic modeling it is possible to construct thematic

classification dictionaries from the existing specialized literature (scientific articles).

8. Final considerations and suggestion for futures research: in this chapter the main results found in the articles are synthesized, and proposals for future research are described.

2. TOPIC MODELING METHOD TO ANALYZE SOCIAL ACTOR´S DISCOURSES ON CLIMATE CHANGE-ENERGY AND FOOD SECURITY NEXUS IN BRAZIL[2]

2.1. Introduction

The relationship between economic growth and energy consumption (APERGIS; PAYNE, 2010; PAYNE, 2010; BELKE; DOBNIK; DREGER, 2011) forms one of the most powerful narratives linked to the rise of the Western world and its techno-economic supremacy, and has influenced energy policies even in developed and developing countries (BARCA, 2011; GOODMAN, 2016). This relationship has involved the consumption of energy extracted from fossil fuels, such that most industrial, agricultural, commercial, domestic, and consumer systems are built around a "plentiful supply of black gold" (URRY, 2010, p. 195). Nevertheless, this consumption is associated with a rise in global inequalities and the deterioration of the environment (BARCA, 2011). In particular, oil used for energy generation has been identified as the largest contributor to Greenhouse Gas (GHG) emissions that are affecting global climate in adverse ways (INTERNATIONAL ENERGY AGENCY, 2015).

According to the International Energy Agency (IEA) (IEA, 2015), GHG emissions from the energy sector represent roughly two-thirds of all anthropogenic GHG emissions, and CO2 emissions by it have risen over the past century to ever-higher levels. Thus, there is need for effective action to transform the energy sector to address the challenges of both climate change mitigation and adaptation, which in turn enhances the importance of more sustainable ways of using a variety of sustainable energy technologies (GOLDEMBERG; COELHO; GUARDABASSI, 2008; SENGERS; RAVEN; VAN VENROOIJ, 2010). In this context of worldwide interest in renewable fuels to reduce

[2] This chapter is based on the paper: Benites-Lazaro. et.al. Topic modeling method to analyze social actor´s discourses on climate change-energy and food security. Published at Energy Research & Social Science.

GHG emissions, ethanol from sugarcane was presented as clean, low-carbon energy for a positive solution to the climate crisis and fossil fuel dependence.

In Brazil, both the government and sugarcane ethanol companies have constructed national narratives about ethanol production that invoke a connection between its environmental benefits and influence on social well-being with the development of modern technologies for its production (BENITES-LAZARO; MELLO-THÉRY; LAHSEN, 2017; MALONE et al., 2017). However, this proposed agroenergy raised fundamental questions pertaining to its impact, mainly the demand for land and water needed for ethanol production and the guarantee of a continuous supply of food crops (GIAMPIETRO; MAYUMI, 2009; RATHMANN; SZKLO; SCHAEFFER, 2010; AJANOVIC, 2011; RULLI et al., 2016).

This competition between agroenergy and food has become subject to increasing controversy in terms of the claims made by those promoting their use and potential conflicts between national and global interests (GIAMPIETRO; MAYUMI, 2009). In the last few years, discourses on food security have been framed it both a national and a global problem, and have recognized it as a fundamental human right (BEE, 2014; NALLY, 2015; SONNINO, 2016). These discourses depict food security and energy security as closely related to complex environmental, social, political, and economic matters. Thus, there is need for regulatory frameworks and governance to seek interdependencies and interconnections among sectors with the active participation of government agencies, the private sector, and civil society (HOFF, 2011; LARCOM; VAN GEVELT, 2017; WEITZ et al., 2017).

The challenges of achieving integrated decision-making and coherence in policy is particularly acute, considering that sectors operate and policies are executed in areas with different institutional frameworks at different scales and through many actors (WEITZ et al., 2017). This creates the need for methods and techniques within science to study and understand the complexity of climate change, for instance, and the discussions and relationships involving agroenergy and food security. All these discussions among the actors in the period studied (10 years) were transmitted to the

public through various channels of communication that generated a large amount of textual data that would not be feasible to be treated using traditional methods, making it necessary to use new computational tools to help organize, search for, and understand these vast amounts of information (BLEI, 2012).

Therefore, the main question we raise here relates to how big data and machine learning can help explore and identify dominant public discussions, concerns and interests of the different actors, the importance that they assign to certain issues, how it has influenced political debates, what the dominant discourses, and how discussions of a certain matter have changed over the years, this from large text data aiming understand the shifts in the problem over the years to seek a solution and motivate the public to take action (HOFFMAN, 2015). This because, the major challenges for humanity of our time include climate change, water, energy and food security (HOFF, 2011), and a growing world population. It is expected that by 2050, the demand for primary energy will almost double to 80% while that for food is expected to rise by more than 50% (OECD/FAO, 2013a; IRENA, 2015). The competition between food and biofuels will become even more intense in the near future, with the global population estimated to reach nine billion by 2050 (RULLI et al., 2016).

In this study, we show the use of big data and machine learning tools to examine changes in political debates and social discussion on climate change, ethanol production, and food security in Brazil. We analyze massive amounts of data in the period 2007-2017, from Brazilians newspapers, companies and government sites, and reports and bulletins published by social movements and non-government organizations (NGOs). We combine probabilistic modeling Latent Dirichlet allocation (LDA) (BLEI; NG; JORDAN, 2003) to discover latent topics and detect novel trends, cluster analysis to identify discourses, and network analysis by codifying the different discourses in categories to enable the construction of networks of themes and concepts surrounding the topic of this study.

2.2. Background

2.2.1. Data mining and machine learning techniques

Data mining is defined as the process of exploring massive amounts of data (big data) to discover patterns, such as rules of association or temporal sequences, to detect systematic relationships between variables, subsets of data, correlations, and trends. It uses the techniques of artificial intelligence, machine learning, pattern recognition, statistical data analysis, and data visualization (HAN; KAMBER; PEI, 2012; WITTEN et al., 2017).

Data mining and machine learning have long been used in several areas ranging from financial applications, marketing, advertising, health, engineering, and video games to applications in genetics (SHAW et al., 2001; SUMATHI; SIVANANDAM, 2006; JENSEN; JENSEN; BRUNAK, 2012; ANGELI et al., 2017). In scientific research (the exact sciences and social sciences), data mining is the use of information technology to identify factors, discover information related to associations (occurrences linked to a single event), sequences (events linked over time), classification (discovering characteristics), agglomeration (detection of different clusters), prognostics, and hidden relationships in large databases (SUMATHI; SIVANANDAM, 2006; HAN; KAMBER; PEI, 2012; WITTEN et al., 2017).

Most information, approximately 80% of electronic data, is in text format (GUPTA; LEHAL, 2009). This enormous amount of data in almost every area of human endeavor is not only unclassified and unstructured (or semi-structured), but also contains usable, useless, scientific, and trade-specific data. This, has created a significant demand for new, powerful tools for turning data into useful, task-oriented knowledge (SUMATHI; SIVANANDAM, 2006). In the effort to satisfy the need to explore, organize, search for, and understand large amounts of textual information, such tools and techniques as data mining, text mining, and Natural Language Processing (NLP) have been developed, which use machine learning algorithms (SUMATHI; SIVANANDAM, 2006; GUPTA; LEHAL, 2009).

The main difference between data mining and text mining is that data are unstructured in the latter. Text mining thus involves converting unstructured text into structured data, with the addition of some derived linguistic features and the elimination of others, and its subsequent insertion into a database that can be analyzed later. NLP in turn covers a large field of applications, such as machine translation, natural language generation, sentiment analysis, topic segmentation and recognition, automatic summarization, discourse analysis, speech recognition, and text analysis with machine/deep learning (FOSTER et al., 2017; WITTEN et al., 2017).

The interdisciplinary nature of data mining research contributes significantly to its success and its extensive applications. The power of data mining can be substantially improved by integrating new methods from multiple disciplines. For example, to mine data containing natural language text, it makes sense to fuse data mining methods with methods of information retrieval and NLP (HAN; KAMBER; PEI, 2012), or data from the social media that provide an enormous amount of continuous real time data.

2.2.2. Topic modeling -LDA

Topic modeling is a collection of methods and algorithms (TÖRNBERG; TÖRNBERG, 2016) that allows to organize, understand, research, and summarize a large amount of textual information at a scale impossible by human annotation (BLEI; LAFFERTY, 2009). The relevant "algorithms are statistical methods that analyze the words of the original texts to discover the themes that run through how those themes are connected to each other, and how they change over time" (BLEI, 2011). The modeling of topics is a case study in machine learning instead of a field in itself, and is based on several fields in turn, such as Bayesian statistics, time series analysis, hierarchical models, Markov Monte Carlo chains (MCMC), non-parametric Bayesian statistics, and dispersion.

Topic modeling can be used in many kinds of data such as to find patterns in genetic data, images, and social networks (BLEI, 2012). We can approach a topic of interest - for instance, climate change to reveal various aspects of it: the interests of the different actors related to this issue, the participation of actors in climate change negotiations, the

lion's share of resource depletion, energy use, and hazardous emissions, climate change policy, the relationship in the context of politics between energy use and climate change, and efforts to limit the effects of climate change (LEVY; NEWELL, 2002; KEOHANE; VICTOR, 2011; LAZARO; GREMAUD, 2017). We can the navigate through time to uncover how discussions of these issue (climate change) have evolved over the years to explore the major cultural shifts to engender a better understanding of the problem (HOFFMAN, 2015). The thematic structure used is a new type of window through which to explore and understand this information (BLEI, 2012).

Topic modeling is based on the classical methods used in NLP, such as n-gram (DUNNING, 1994; NIGAM et al., 2000) and Latent Semantic Analysis (LSA) (DUMAIS, 2004). In n-gram model, it is assumed that documents simultaneously belong to several topics and topic distributions vary over documents. Its main advantage lies in its relative simplicity of implementation, and its scalability is achieved by increasing size of n (words). In the probabilistic model LSA (HOFMANN, 2001), it is assumed that the interdependence between words in a document can be explained by the latent issues to which the document belongs and where the matrix containing words counts per paragraph (rows represent unique words and columns represent each paragraph) are constructed using mathematical technique called Singular Value Decomposition (SVD) that reduces the number of rows while preserving the structure of similarity between columns (DUMAIS, 2004). LSA has evolved to an information retrieval technique called Latent Probabilistic Semantic Indexation (pLSI) (DEERWESTER et al., 1990)that is based on the principle that words used in the same contexts tend to have similar meanings, whose advantage lies in their ability to extract the conceptual content of a body text by establishing associations between those terms that occur in similar contexts, from the application of the method, results are obtained showing that the topics extracted from the documents are conceptually similar, even if the results do not share a specific word or words with the initially established criteria (DEERWESTER et al., 1990).

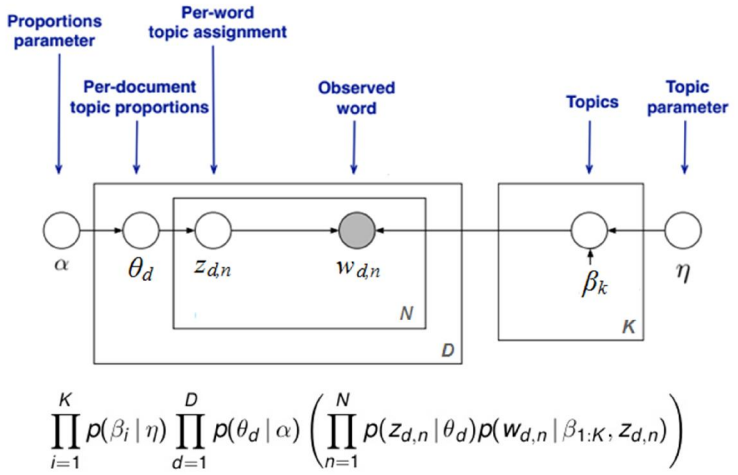
The most widely used algorithm in topic modeling is LDA (BLEI; NG; JORDAN, 2003), a Bayesian mixed model for discrete data where the elements are assumed to be

uncorrelated. This generative probabilistic model provides a powerful tool for discovering and exploring the hidden thematic structures in large datasets (BLEI, 2012). The basic idea behind LDA is that documents are represented as random mixtures of latent topics, where each topic is a probability distribution over a vocabulary (BLEI; NG; JORDAN, 2003). The algorithm can be considered to associate words with probabilities (BLEI; CARIN; DUNSON, 2010). An extension of this method is the Correlated Topic Model (CTM), where correlations among topics are allowed (BLEI; LAFFERTY, 2007).

LDA posits themes in a document collection and assumes that each document reflects a combination of topics, where a topic is a distribution over a fixed vocabulary of terms (BLEI; LAFFERTY, 2009). A topic is a list of words that occur in statistically meaningful ways (GRAHAM; WEINGART; MILLIGAN, 2012). When a document collection is analyzed under these assumptions, probabilistic inference algorithms reveal an embedded thematic structure. With this structure, LDA provides a way to quickly summarize, explore, and search massive collections of documents (BLEI; CARIN; DUNSON, 2010). In LDA, each document can be viewed as a mixture of several categories, where it is assumed that the distribution of the categories has an a priori Dirichlet distribution. The key in LDA is that any piece of text is composed by selecting words from possible baskets of words, where each basket corresponds to a topic (GRAHAM; WEINGART; MILLIGAN, 2012).

Figure *2.*1 shows a graphical model of LDA. Each node is a random variable that is labeled according to its role in the generative process. The hidden nodes—topic proportions, assignments, and topics—are unshaded. The observed nodes—the words of the documents—are shaded. The rectangles are in "plate" notation, which denotes replication. The N plate denotes the collection of words within documents and; the D plate denotes the collection of documents within the given collection (BLEI, 2012).

Figure 2.1 Latent Dirichlet Allocation model



Source: Blei et.al. (2003), and Blei (2012).

The latent parameter space therefore consists of β = {βi} (the word-by-topic distribution, an m×k left stochastic matrix), θ = {θj} (the topic-by-document distribution, a k×n left stochastic matrix), and z = {zp,j} (the topic indicators of each word in the corpus). |dj| denotes the length of document j in words, and α (resp. η) denotes the priors on the topic mixtures of the document (resp.-word-topic distributions). The inference of these parameters consists of reversing the generative process, instead of generating observed words from randomly drawn β, θ, and z. We are given the observed words, and the work involves estimating these distributions to maximize the log-likelihood of the data. This process of inference is challenging and can be solved using mean-field variational EM (ATTIAS, 2000; BLEI; NG; JORDAN, 2003), expectation propagation (MINKA; LAFFERTY, 2002), Gibbs' sampling (ROBERT; CASELLA, 2004), collapsed Gibbs' sampling (GRIFFITHS; STEYVERS, 2004), and collapsed variational inference (TEH; NEWMAN; WELLING, 2007). Each of these methods has advantages and disadvantages.

The methods based on Gibbs' sampling are Bayesian in nature, they have as disadvantage the lack of knowledge of the number of iterations necessary for our solution, that is to say, on the limit of convergence of the Markov chain. Arbitrarily, the Gibbs' sampling is allowed to run for certain, fixed number of iterations of the corpus

(typically hundreds or thousands), only then does the process of collecting the samples begins. Because the order of the columns in β is arbitrary (ratio of the samples), the obtaining of the coherent set of subjects is also random (TEH; NEWMAN; WELLING, 2007). The hyperparameters α (resp η) affect the dispersion in the theme document mixes (word-topic), higher values lead to more dispersed mixtures: fewer relevant words per subject in φ for β, or fewer relevant topics per document in θ to α (ASUNCION et al., 2009; WALLACH; MIMNO; MCCALLUM, 2009).

The LDA model is controlled by three key parameters: the number-topics (θ) and the two priors β and α. The priors control how diffused the models are, acting as additive smoothing parameters for the modeling of topics in a document and that of words in a topic. The model demonstrates that thematic analysis can be improved by a careful choice of previous hyperparameters and sampling (CARPENTER; BALDWIN, 2011).

A parameter that makes LDA useful is the value of α (resp η). Alpha (α) is a hyperparameter in the LDA model that determines the dispersion of the traces of the underlying Dirichlet distribution, influencing the dispersion in the theme document mixes (word-topic). Higher values lead to more dispersed mixtures: fewer relevant words per subject in φ for β, or fewer relevant topics per document in θ for α. Alpha is typically a small number with an a priori value of 0.01. As α increase, the distribution of subjects tends to become uniform. When α approaches zero, this indicates poor representation and means that subjects are more likely to increase in number. Setting alpha to very small value (0.001) can generate a single theme that dominates the model. The value of α can be chosen arbitrarily, or we can adjust it for our data through cross-validation or some other method (BLEI; NG; JORDAN, 2003; ŘEHŮŘEK, 2011).

In LDA, each document is modeled as a mix of topics. When the previous θ is low, the model is forced to a document using fewer topics than when the previous θ was higher, the former is added to the probability of all topics, rendering the distribution of topics more uniform (setting all issues the same probability). Similarly, topic modeling is done as a distribution over words. When the previous β (word-topic) is high, each topic is forced to balance in the assignment of probabilities of each word. Like the previous β

parameter, it moves the distribution of words in topic closer to a uniform distribution (BLEI; NG; JORDAN, 2003; WALLACH; MIMNO; MCCALLUM, 2009).

The parameter θ controls the number of topics in which the model discretizes the data. Increasing this parameter yields more refined themes. For example, if we only categorize 10 themes in a very large corpus, we cannot discover small topics. As the number of themes increases, the amount of data available to estimate each topic decreases. A large corpus allows the discretization of a large number of topics effectively. The number of topics that best serves us depends on the objectives of the research, and the size and the manner in which the textual data are presented.

As with the number of topics, experimentation allows us to find reasonable parameters for a particular problem. A starting point for both a priori parameters is the inverse number of outcomes. For example, with 50 topics, 1/50 is an initial value of document-topic prior, and with 30,000 words, 1/30,000 is a reasonable starting value for the topic-word prior. Much smaller parameter values lead to softer topic and document models, which may be more convenient for specific purposes.

2.2.3. Discourse analysis

Discourse analysis is considered by some as both a theory and a method (HAJER, 1995; JØRGENSEN; PHILLIPS, 2002; GEE, 2011). It consists of a set of techniques for structured research of texts, and involves an epistemology that explains how we obtain knowledge of the social world. A set of assumptions concerns the constructive effects of language (PHILLIPS; HARDY, 2002). Discourse analysis considers how language, both spoken and written, enacts social and cultural perspectives and identities (GEE, 2011). It is then the study of language-in-use, and is employed in a range of meanings, varying from the analysis of linguistic regularities to the normative quality of discussions (HAJER; VERSTEEG, 2005). The objects of analysis are the ways in which certain problems are represented, differences are played out, and social coalitions on specific meanings somehow emerge in the power struggles and the entire social context (HAJER, 1995).

A discourse can be better described or explained by taking into account aspects of its context. That is, contexts are generally only considered to understand or analyze discourse (VAN DIJK, 2008). "Discourse is not produced without context and cannot be understood without taking context into consideration" (FAIRCLOUGH; WODAK, 1997). Contexts or related concepts, such as “situation,” “circumstances” or “environment,” indicate that some discourse needs to be seen or studied in relationship with its environment, that is, its “surrounding” conditions and consequences (VAN DIJK, 2008). This is also true of big data, that they lose their meaning when taken out of context.

Depending on the theoretical perspective, some studies have focused on a detailed linguistic analysis of texts, rhetorical devices, constructivist studies that explore diverse ways of reality production, and critical studies that examine power relations and discursive knowledge formation (FAIRCLOUGH, 2003). From a range of perspectives, three approaches to discourse analysis were described by Jørgensen and Phillips (JØRGENSEN; PHILLIPS, 2002) by considering particularly fruitful theories and methods for research: discourse theory, critical discourse analysis, and discursive psychology. They have in common the aim of carrying out critical research, which is to investigate and analyze power relations in society and formulate normative perspectives from which a critique of such relations can be made to find possibilities of social change or action in the face of a given problem (HOFFMAN, 2015).

Despite the diversity of perspectives on discourse analysis, Heracleous (HERACLEOUS, 2006) depicts four main approaches to organizational discourse to facilitate the study of discourse analysis: interpretive, functional, critical, and structurational. The interpretive and functional approaches tend to assign greater significance to communicative action, giving primacy to human agency, the hermeneutic nature of discourse at the individual and organizational levels, and how some agents can use discourse to shape their own understanding or that of others concerning situations of interest to them. The critical approach, on contrary tends to privilege the structural level, how human agency, identity, and subjectivity are constituted, and the patterns of social domination that these structures surreptitiously

help legitimize and sustain. The structurational takes discourse as a duality of communicative actions and deep structures, interrelated through the modality of interpretive schemes.

Discourse analysis in social sciences is strongly influenced by the work of Michel Foucault (JØRGENSEN; PHILLIPS, 2002; FAIRCLOUGH, 2003; HAJER; VERSTEEG, 2005), which has played a central role in the development of discourse analysis through both theoretical and empirical research (JØRGENSEN; PHILLIPS, 2002). Foucault's work on discourses, power and knowledge follow the social constructivism premise that knowledge is not a reflection of reality, but is constructed discursively and delimited historically. Power for Foucault is described as both a productive and a constraining force closely connected to discourse, and spread across different social practices. Power in common with discourse does not belong to particular agents, such as individuals or the state, or groups with particular interests; rather, power is spread across different social practices (JØRGENSEN; PHILLIPS, 2002).

In environmental discourse analysis, Hajer (HAJER, 1995) and Dryzek (DRYZEK, 2005) have been leading researchers and their analyses have uncovered power relations within the policy arena. In a study on environmental politics, three strengths of discourse analysis were highlighted by Hajer and Versteeg (HAJER; VERSTEEG, 2005): its capacity to reveal the role of language in politics, reveal the embeddedness of language in practices, and answer how questions to illuminate mechanisms. Discourse can provide details concerning narratives, beliefs, and needs, and reveals issues addressed by the text.

In discourse analysis, there are three ways of approaching text. The traditional, qualitative one focuses on the way in which the discourse has been delivered, on the premise that the peculiar manner in which something is said matters. The second is quantitative, and makes use of statistical tests, performed by computer software. The third is a mixed method that takes advantage of both the qualitative and the quantitative techniques assuming that both the number of repetitions of words performed by software and the exploratory lexical patterns play an important role in text analysis

(BAKER et al., 2008; CORTINI; TRIA, 2014; BENITES-LAZARO; MELLO-THÉRY; LAHSEN, 2017).

2.3. Material - Corpus construction and LDA implementation

In this study, the source of data were documents in text format obtained from Brazilians newspapers (NEWS), reports from NGOs and social movements (NGO), and websites of the government (GOV) and sugarcane ethanol companies represented by the Brazilian Sugarcane Industry Association (UNICA), from January 2007 to October 2017. The documents were related to agricultural and agrarian policies, food security, climate change, and biofuels-related issues. This generated a large volume of documentary information to be analyzed, for which we made use of several procedures and tools employed in text mining and machine learning.

Corpus construction: To scrape the Web, we developed scripts using R, an open-source programming language and software environment for statistical computing and graphics using the rvest package to look for HTML code that generates a webpage, and for websites in JavaScript, we used the PhantomJS package. These packages provide an immediate and easy-to-use solution to search for content generated by webpages of free access as is the case with government, UNICA and NGOs websites. Access to newspapers that had copyrights was provided by the Observatory on Public Policies for Agriculture (OPPA) at the Rural Federal University of Rio de Janeiro (UFFRJ) (OPPA, 2017). We use the stringr package to condense the complete transcriptions (10200 news of approximately 45 MB) into a large string in UTF-8 format, classified by month from 2007 to 2017. This yielded 528 sub-corpora (12 documents per year for each of the four actors: GOV, NEWS, ONG, and UNICA)

LDA implementation: It is necessary to pre-process text documents before calculating the thematic model. First, we eliminate empty words, known as stopwords. These are common words that provide no clue about the content of the text. If these stopwords are left in the corpus when calculating the model, we obtain meaningless topics described by these empty words, owing to their high probability. Second, the derivation is often

performed using stemming algorithms for a specific language, where these algorithms tend to deform the context. It is recommended that a preliminary evaluation be conducted to determine if (stopwords) is appropriate for the desired result. Third, phrases that connote important meanings within a corpus, such as "climate change" are recoded as a single word by replacing the space between the words with an underscore, e.g., "climate_change". A practical method to identify these types of phrases in giant corpora involves the use of the n-grams method.

The implementations of LDA open-source software: include those for Topic Models (R package, variational Expectation-Maximization, and Gibbs' sampling) (GRÜN; HORNIK, 2011), LDA-C (variational EM) (BLEI; NG; JORDAN, 2003). HDPs (hierarchical Dirichlet processes) (TEH et al., 2006), LDA (R package, collapsed Gibbs), Lingpipe (Gibbs sampling) (CARPENTER; BALDWIN, 2011), MALLET (collapsed Gibbs) (MCCALLUM, 2002), Gensim (Python implementation) (CARPENTER; BALDWIN, 2011) and LDAvis (SIEVERT; SHIRLEY, 2014) - a R package tool to create an interactive Web-based visualization of LDA topic models.

To model themes, we used MALLET version 2.0.8, a Java-based package for statistical Natural Language Processing, document classification, clustering, topic modeling, information extraction, and other machine learning applications to text. MALLET uses Gibbs' sampling based implementations of LDA. We created a directory containing only text files, where each file was considered a document instance. For the purposes of this paper, the corpus was formatted as follows: newsletter was grouped monthly, one month one document, so that during the period covered (11 years), we had 132 documents for each actor, for 528 documents in the corpus. We created an output_csv directory, where Mallet saved the created files.

The thematic analysis can be improved by a careful choice of the previous hyperparameters and sampling. MALLET starts with values of hyperparameters alpha = 50/T and beta = 0.01 (WALLACH, 2001), and requires a definition of the following input parameters:

1) Elimination of empty words or stopwords: For this purpose we use a list of stopwords in Portuguese language.
2) Number of topics: As there is no rigid rule to establish the number of topics, we follow the recommended number of documents (D), Topics(T) - (D : T), (1.000: 10 - 20), (10. 000: 20 - 60), (100.000: 50 - 200) such that the format of our corpus admitted 20 themes as minimally acceptable.
3) Number of iterations: The number of iterations needed to execute the Gibbs' sample. We started with 200, the default value for the number of topics. We increased the number of iterations to allow us to improve the coherence of the topics. We found 400 as the optimal number of iterations for our application.
4) Number of thematic words printed: This is the number of words most likely to be printed for each topic following the estimation of the model. The default is to print the top-10 words.
5) Threshold ratio by topic: This parameter was used to not print topics with proportions lower than a threshold value. The default value was 5%.

Thematic analysis: We used the TLAB software for text and content-based analyses of the corpus from the thematic models obtained through LDA using Mallet. This allowed us to find the lexical units (LDA words), the themes (LDA topics) that were "typical" in subsets of the corpus (actors' discourse). It also facilitated the construction of thematic clusters (LDA topics), and a study of the relationships between themes and actors (network analysis)

The corpus was loaded using the dictionary-based classification tool of TLAB that allowed for the transformation from text into a coded corpus set of tables. Finally, this corpus is discretized by TLAB to yield more than 92,800 words, with more than 6,455,000 occurrences, with 121,000 contexts and approximately 65,000 lemmas. We then weight the elements of the matrix using Tf-Idf (terms frequency –inverse document frequency), where the weight of an element of the matrix is proportional to the number of times that the relevant term appears in each document, where rare terms are up-weighted to reflect their relative importance. We thus obtained approximately 9,800

unique words. Processing the text further reduced it to our final subset of approximately 2,800 unique words. In the last stage of preprocessing the text, TLAB created different statistical tables to be explored by the different tools of the software.

Cluster Analysis: The objective of the cluster analysis of LDA topics is to find groups of themes that present two complementary characteristics: maximum internal homogeneity and maximum heterogeneity between groups of topics. These clusters allow additional analysis of the subsets of the corpus and, with the help of statistical tools such as similarity indeces, Chi-squared test or p-Value facilitate the interpretation and inferences pertaining to the meaning of the relationships among the topics and the sub-corpus (speeches) (LANCIA, 2017).

The chi-squared test, or goodness-of-fit test, compares the occurrence of a word in a particular corpus (speech of an actor) with its occurrence in other corpora (what is said by the other actors). The similarity indices (cosine index) are used to analyze the co-occurrence of lexical units (LDA words) in the interior of the elementary contexts (sub-corpus), were "1" means that two vectors (words with the same similarity) are equal (parallel or complete superposition), and "0" means that they are perpendicular unrelation to each other. The p-value expresses statistical significance ($p = 0.05$).

Some reasons for why we use cluster analysis to explore the results of LDA modeling are: The grouping of words and topics adds simplicity and clarity. The most representative themes and words are better highlighted in a 2D map. These graphical representations are visually attractive and the data in the tables are a powerful communication tool.

For the cluster construction of the LDA topics, we made use of the bisecting k-means algorithm (BKM) (JUDD, 1985; STEINBACH; KARYPIS; KUMAR, 2000), which is a grouping technique for the type partition that uses the minimum squares sum criteria. It is a partitional, hierarchical version of the k-means algorithm. The BKM algorithm allows us to clusterize our corpus using such LDA as initial condition. This is equivalent to carrying out a supervised clustering process, which involves the

construction of a contingency table of LDA words multiplied by LDA topics, followed by chi-squared test applied to all combinations of LDA words and topics. Finally, a correspondence analysis of the resulting contingency table conducted.

2.4. Results and discussion

Figure 2.2 shows the 20 main themes with their respective keywords obtained using LDA. These themes are: financial crisis, water crisis, food security, biofuels, GMO-pesticides, ethanol, climate change, international market for ethanol, national market for ethanol, UNICA, research, market access, struggle, agricultural policy, trade, development, agribusiness, food prices, energy policy, and investments. Larger balls indicate themes with more frequent occurrences in the corpus, like trade, national market, and food security.

Figure 2.2 Themes and ten first keywords from the application of LDA

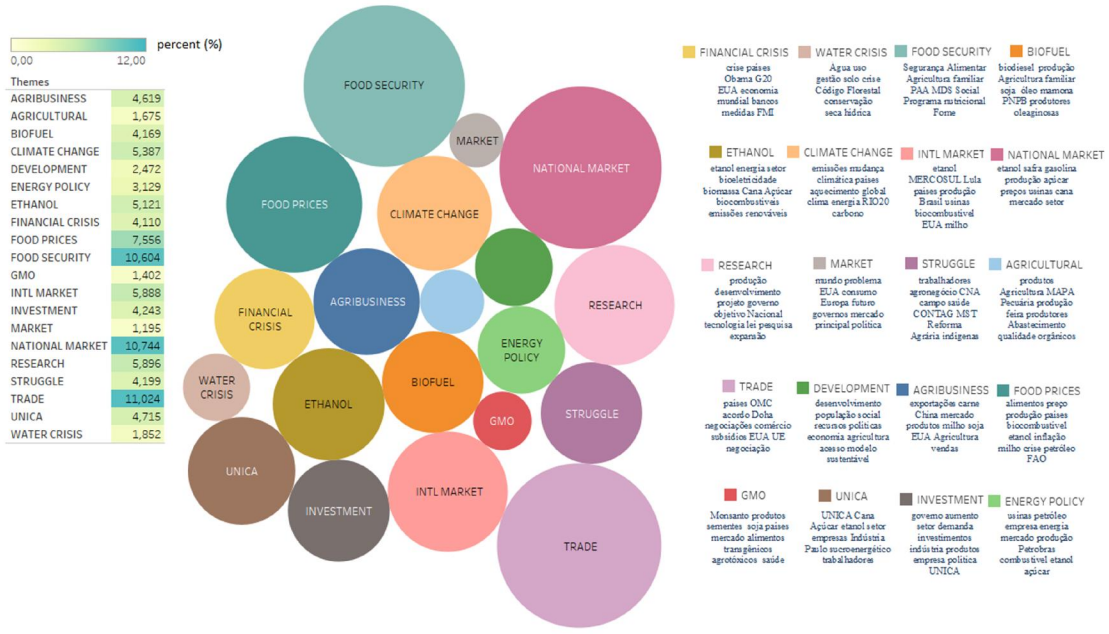


Figure 2.3 and Table 2.1 show the highest-ranked issues for each actor addressed over time. The actor UNICA, highlights “ethanol,” and “Unica”, this last is a theme related to several activities that this institution carried out as an association to promote a positive image of sugarcane companies. The actor GOV, emphasizes policies and

programs related to food security during all period analyzed. The media (actors NEWS) and NGO tended to emphasize various themes. For instance, in the period 2013-2016, the actors "News" emphasized theme “national market” related to debates concerning the internal fuel market, when the government intervenes in the energy market (oil price) to curb inflation. The NGOs assigned importance to almost all themes, focusing on some in certain periods, for example, themes related to debates on struggles in rural areas, slavery, and the health of peasants.

Table 2.1. Heatmap of LDA themes (actors and years distributed).

Themes	GOV	MOV	NEWS	UNICA
AGRIBUSINESS	13,74	10,38	75,72	0,16
AGRICULTURAL	47,58	24,67	26,43	1,32
BIOFUEL	34,87	29,38	34,69	1,06
CLIMATE CHANGE	6,85	8,49	82,33	2,33
DEVELOPMENT	16,12	32,84	48,96	2,09
ENERGY POLICY	1,18	11,79	83,96	3,07
ETHANOL	3,31	5,48	46,25	44,96
FINANCIAL CRISIS	0,36	9,16	89,95	0,54
FOOD PRICES	3,61	14,75	80,27	1,37
FOOD SECURITY	77,80	13,57	8,56	0,07
GMO PESTICIDES	1,05	36,32	62,11	0,53
INTL MARKET	1,13	6,02	91,85	1,00
INVESTMENT	3,48	14,78	80,00	1,74
MARKET ACCESS	1,23	18,52	79,63	0,62
NATIONAL MARKET	2,68	5,91	84,27	7,14
RESEARCH	14,02	23,28	52,69	10,01
STRUGGLE	12,48	70,47	16,34	0,70
TRADE	0,54	3,01	95,92	0,54
UNICA	3,76	12,52	36,78	46,95
WATER CRISIS	16,33	32,67	45,82	5,18

percentage (%) 0,0 100,0

Themes	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
AGRIBUSINESS	7,35	9,90	5,11	3,04	1,28	8,47	7,19	3,99	15,65	32,91	5,11
AGRICULTURAL	1,76	6,17	4,41	2,64	3,08	10,57	8,81	5,29	5,73	29,52	22,03
BIOFUEL	21,59	17,52	10,09	21,06	4,78	9,38	3,89	3,89	3,01	1,24	3,54
CLIMATE CHANGE	36,30	2,19	3,70	2,88	15,21	33,56	0,41	0,55	2,33	1,23	1,64
DEVELOPMENT	13,73	7,76	5,07	6,27	15,22	22,99	6,87	5,07	3,88	5,07	8,06
ENERGY POLICY	21,23	14,86	16,51	13,92	13,92	4,48	4,01	3,07	3,30	1,89	2,83
ETHANOL	13,26	9,94	9,94	13,54	10,23	9,22	4,61	5,76	4,76	10,66	8,07
FINANCIAL CRISIS	8,80	15,80	39,68	10,05	4,13	14,36	2,87	2,15	1,26	0,54	0,36
FOOD PRICES	14,26	45,80	5,47	6,45	4,49	7,03	5,27	3,61	3,81	3,52	0,29
FOOD SECURITY	10,51	9,67	4,52	6,26	2,99	10,58	9,88	12,11	14,06	13,92	5,50
GMO PESTICIDES	1,05	1,58	2,63	0,53	1,58	25,79	24,74	11,58	4,74	23,16	2,63
INTL MARKET	47,87	12,53	8,15	4,76	1,63	12,78	5,51	1,75	1,63	2,88	0,50
INVESTMENT	17,74	13,74	5,57	7,30	8,52	14,43	8,87	4,70	7,48	6,61	5,04
MARKET ACCESS	17,28	9,88	6,79	8,02	17,90	16,67	8,02	0,00	6,17	6,17	3,09
NATIONAL MARKET	12,77	9,13	11,33	13,19	3,57	7,62	10,44	11,95	11,40	4,81	3,78
RESEARCH	18,40	9,51	7,63	7,26	7,13	12,14	8,51	4,38	7,88	9,14	8,01
STRUGGLE	10,54	9,31	5,80	3,16	4,92	7,56	7,21	4,39	3,34	14,59	29,17
TRADE	42,44	36,81	7,63	3,48	0,20	3,28	2,95	0,54	0,80	1,14	0,74
UNICA	14,24	12,05	20,81	17,21	4,54	9,23	6,57	5,32	2,97	2,82	4,23
WATER CRISIS	15,14	2,79	0,80	5,58	12,35	12,75	2,79	7,17	29,88	1,99	8,76

percentage (%) 0,00 50,00

Figure 2.3 Time line top of LDA themes by actor in 2007-2017.

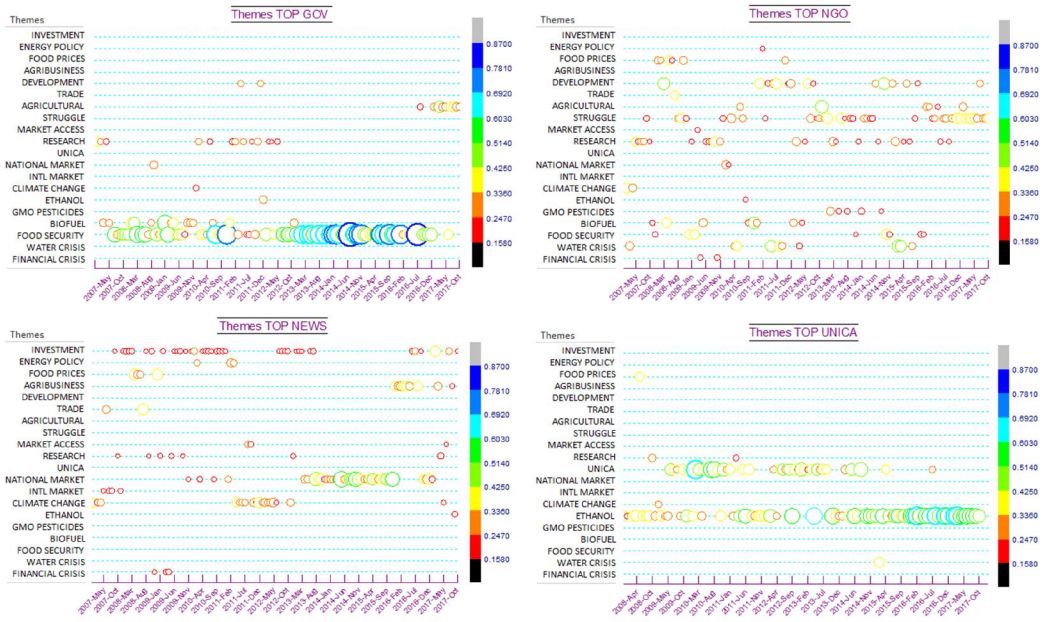


Figure 2.4 depicts the timeline in four themes: climate change, food prices, food security and ethanol. For example, under the topic of climate change, the actor NEWS emphasized in 2007 the release by the Intergovernmental Panel on Climate Change (IPCC) of its Fourth Assessment Report, and when the Kyoto Protocol came into effect. The enforcement of the Kyoto Protocol, the subsequent opening of the carbon market for business, and discussions surrounding the first period of the Protocol (LAZARO; GREMAUD, 2017). The sugarcane sector played an important part in the Kyoto Protocol's clean development mechanism for the generation of bioenergy projects from sugarcane bagasse. These activities were related to their corporate social responsibility activities (BENITES-LAZARO; MELLO-THÉRY, 2017). The peak in 2011-2012 reflected the United Nations Conference on Sustainable Development (Rio+20), held in Rio de Janeiro, Brazil on 20-22 June 2012, and the discussions at the end of the first period of the Kyoto Protocol.

The theme food prices, was one of the topics where the four actors participated in discussions, and was focused on the period 2007-2009. Under the theme of food security, the actor GOV exhibited importance during the entire period analyzed, followed by the NGOs, whereas ethanol was a theme emphasized by UNICA throughout the period of analysis.

Figure 2.4 Linear trends of LDA themes: climate change, food security, and ethanol

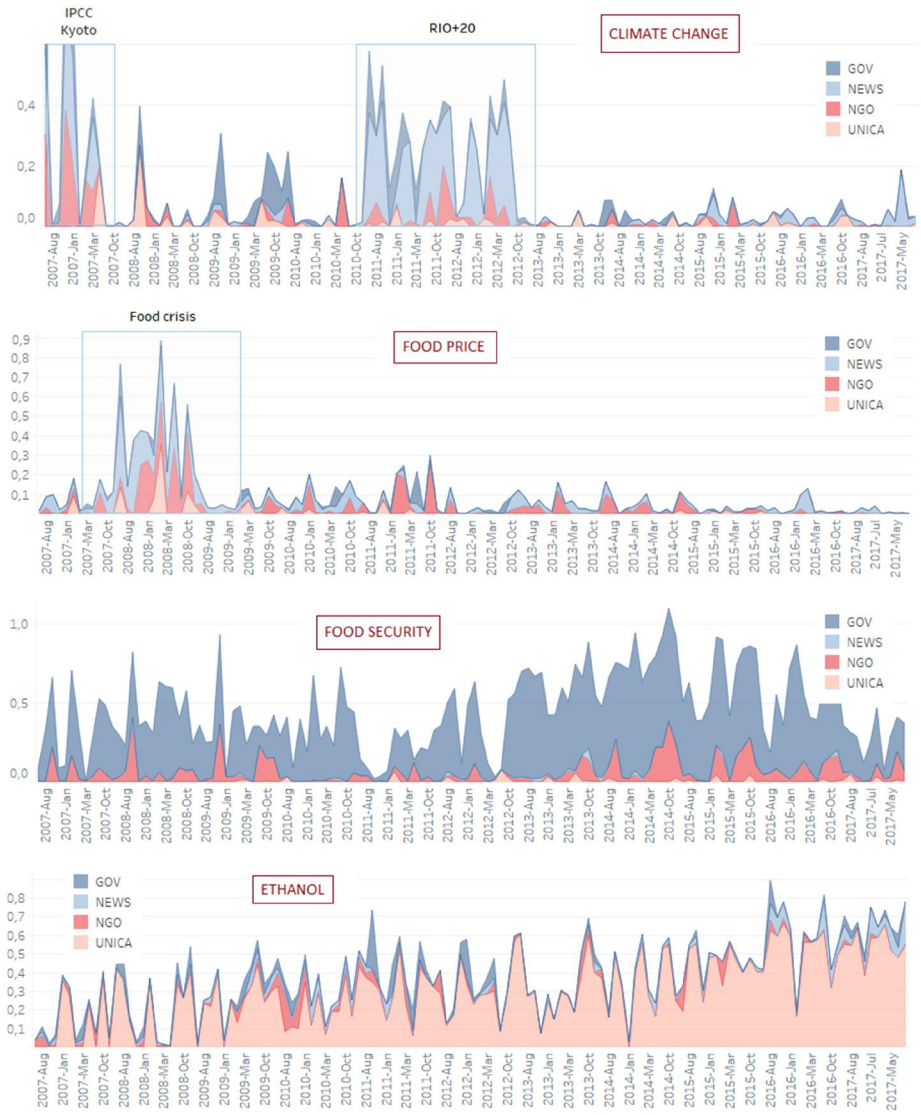


Figure 2.5 depicts multidimensional scaling (MDS) maps obtained using the indexes of similarity (cosine index).These MDS maps allow us to interpret the relationships that exist among LDA topics (years and actors) and the dimensions that organize the space in which they are represented. The quality of the adjustment is given by the value of the *stress* function (<0.10 greater is the quality of the obtained adjustment), of 0.034 for the themes, 0.037 for years, and 0.0109 for actors. In Figure 2.5 is show the majority of them are in the quadrant of the left side, in orange. These themes were addressed mainly by GOV, UNICA, and ONG, with the peak of the discussion occurring in 2007. This

does not mean that the actor News did not address these issues, Table 2.1 shows that in the period analyzed those issues were also addressed by "News". But primarily this actor emphasized the theme "trade", where the percentage was high with 95.92% of the occurrences.

The themes represented by the blue balls are climate change, food security, and biofuels, which indicates that these issues were similar by various facts being one of them because they had been addressed in 2008, when it arose the debates on the controversy of the biofuels and food security (NOGUEIRA; CAPAZ, 2013), and on the other hand, proponents of renewable energy that highlight the contribution of biofuels to reducing dependency on fossil fuels, and hence to mitigate climate change (SOUZA et al., 2017).

Figure 2.5 Multidimensional scaling (MDS) map

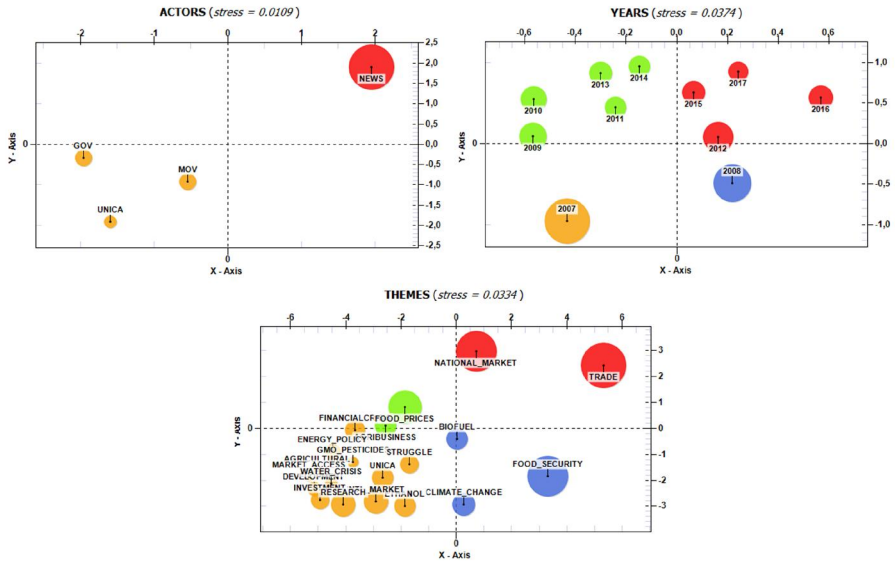


Figure 2.6 depicts a correspondence analysis of the themes, which allow for the evaluation of the proximity/distance or similarity/dissimilarity between themes and enables us to analyze and identify the dominant discourses of the actors. For instance, the results for food security highlight several government policies and programs, and display the dominant discourse whereby food security is a priority of the Brazilian government, for instance, the "zero hunger program", a political strategy based on a set

of other programs, such as the federal public food acquisition program (PAA), the school feeding program (PNAE). The program aimed to support family-owned farms based on access to credit and insurance (the PRONAF). On the theme ethanol, the main discourse highlighted was about the positive contribution of ethanol to the environment and development, and discourses mainly from the government and companies claiming that ethanol does not compete with the provision of food (RATHMANN; SZKLO; SCHAEFFER, 2010; NOGUEIRA; CAPAZ, 2013). This has been highlighted in several studies by Brazilian research centers (LEHTONEN, 2014).

Figure 2.6 Correspondence analysis of themes.

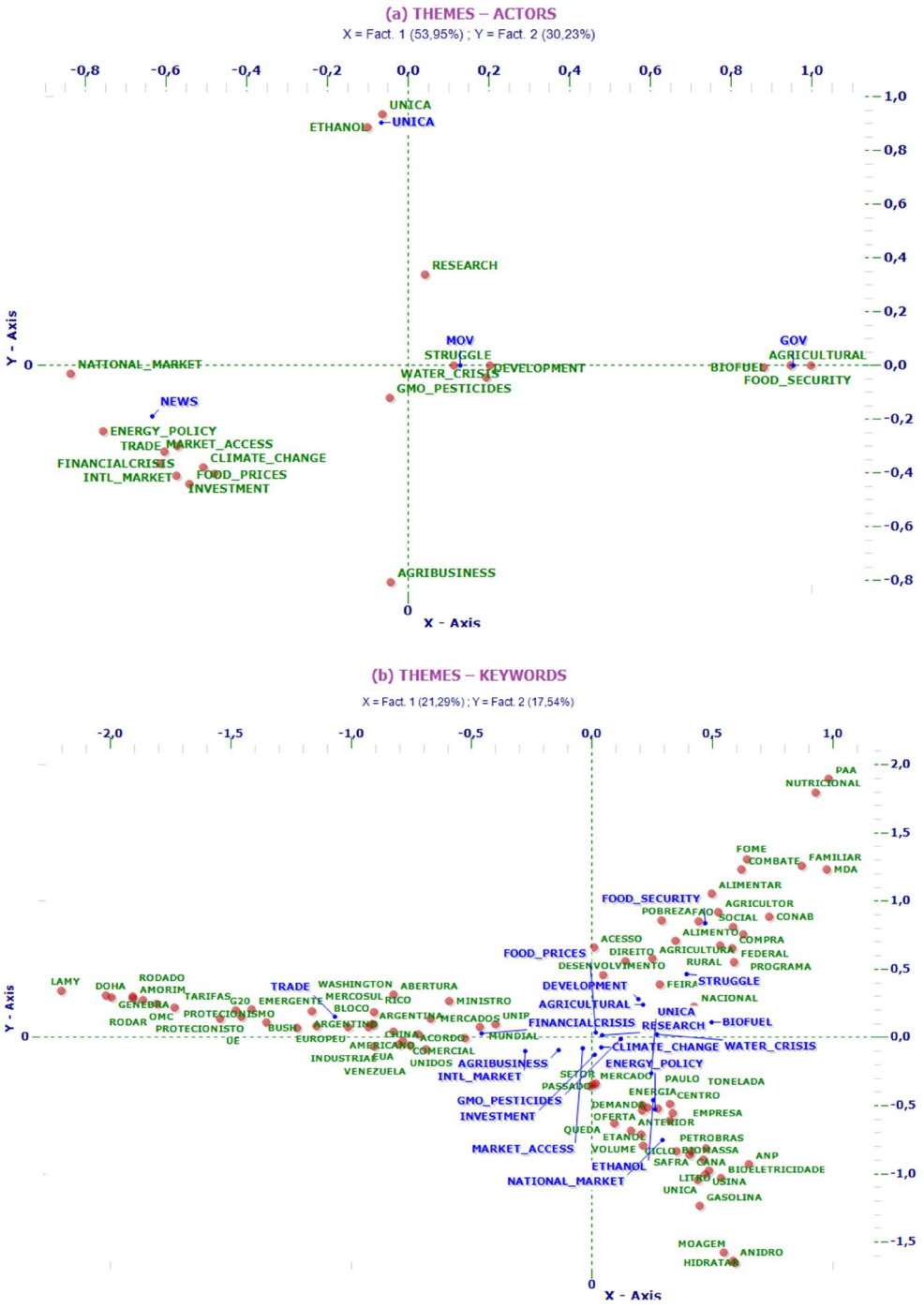
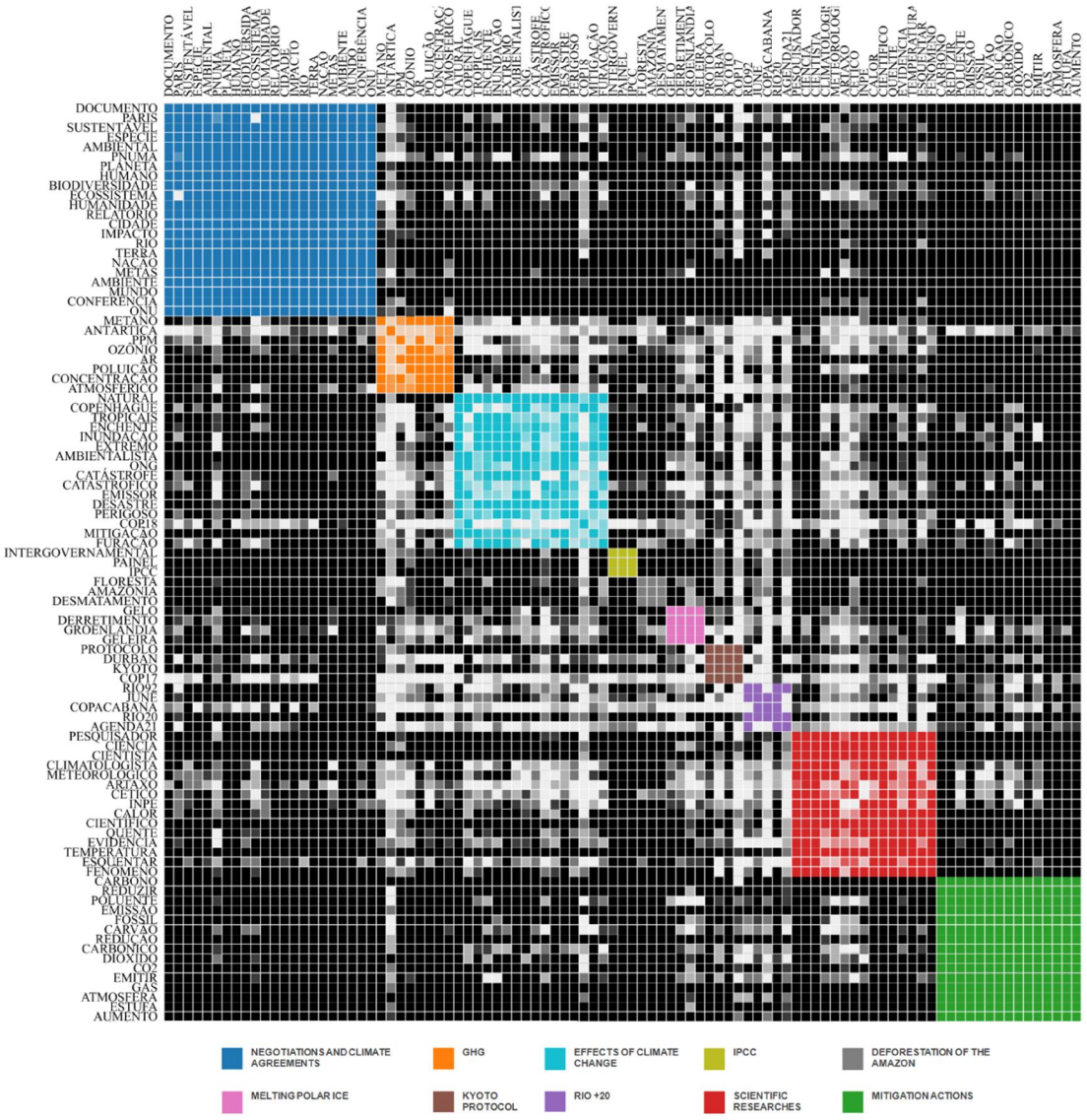


Figure 2.7 shows the results of similarity of words classified by LDA on the theme "climate change"." It should be noted that these similarities were translated into semantic relationships. Each pixel represents the similarities of a pair of words, and

words with the same similarity were grouped into clusters (sub-groups) differentiated by colors. The color of a grouping shows the similarity for that group of words. In Figure 2.7 the major cluster is grouped in red, and is related to activities for the sustainability of sugarcane companies. In Figure 2.7 are four "major" clusters group of words that had significant similarity among themselves and similarity with other words outside the cluster: the highlights in blue, light blue, red and green, and its respective sub-groups. Although these visual results cannot substitute a complete analytical evaluation, this is an encouraging result, as it shows that the LDA correctly identified the limits of each subgroup as if it had been discriminated by human reviewers, in spite of the fact that the algorithm had no knowledge related to the theme.

Figure 2.7 Thematic cluster to the theme climate change



These figures indicate that the results of the unsupervised analysis (similarity exploration) show that the themes reconstructed by LDA are easily interpretable and coherent, making the automatic learning approach viable in classifying documents for discourse analysis.

This result (Figure 2.7) indicates that not all issues had the same importance for all actors, and that certain themes were not of significant interest all the time. Given this, can we conclude that the data matrix is incomplete, given the number of issues? The

answer is not necessarily: we expect to find themes according to actor with higher densities. Such "agglomeration" occurs in spaces of high dimensionality when the issues are heterogeneous for different actors with different desires and needs. These actors look for blocks of topics that serve their purposes, creating varied thematic and discursive sets.

The results of this study demonstrated that LDA allows us to explore data, identify themes (Figure 2.2), detect events through time, modeling the evolution of topics over time, where each actor has participated in the debates, and offering opinions and news related to the themes (Figure 2.3). LDA permitted to capture the discursive landscape of the four actors, and identify the interests in certain themes, for example, climate change and food prices (Figure 2.4) the four actors participated in the discussions, as they shared motivations or purposes represented by the latent variables. A major benefit of LDA along with the segment boundaries is that it outputs the topic distribution associated with each segment (Figure 2.5). This information is potentially useful in segment retrieval applications and discourse analysis (MISRA et al., 2009), as shown in Figure 2.6. LDA also can be used to model connections between topics, and compute links between objects in a cluster thematic (Figure 2.7).

Although, these techniques are a useful tools of inquiry, and provide “quantitative relations and hence can be measured, interpretation is fundamentally a qualitative enterprise, involving interpretation, expert knowledge of the specific text material, and calibration of the tool to produce coherent and interpretable topics” (TÖRNBERG; TÖRNBERG, 2016). Topic modeling programs like LDA do not know anything about the meaning of the words in a text. The researchers are the arbiters of the meanings of results based on their knowledge of the issues in question (KETCHEN; SHOOK, 1996; BENITES-LAZARO; MELLO-THÉRY; LAHSEN, 2017) by taking into account social, political, historical, and intertextual contexts (BAKER et al., 2008). In this study, we use LDA to generate the themes and then qualitatively analyze both their constituent words and the documents relating to these themes through “elemental context” tool (LANCIA, 2017) that allows insight into how “text and talk” are adapted to their social environment which facilitates this qualitative analysis (BENITES-LAZARO; MELLO-

THÉRY; LAHSEN, 2017). "This means that the qualitative and quantitative aspects of the analysis cannot be neatly separated, but are rather integrated as two sides of the same coin" (TÖRNBERG; TÖRNBERG, 2016).

Some problems of method observed in this study are as follows: 1) Modeling themes were not reproducible because the LDA algorithm is probabilistic. In our experiment, making 20 attempts, we found approximately 10% of the subjects were different. In this case, we chose the ones that were more “stable,” that is, the model that presented small statistical fluctuations with respect to the others, and ones that allowed for the easiest interpretation of the objectives of our research. 2) Another important point is that before running the LDA model, it is necessary to do a stopwords cleanup of the corpus, which can be challenging, but clarifies the generation of the topics. 3) Regarding the words in the themes, when a theme is general (few topics), the fact that two words appear as part of a topic does not mean that they appear in the same document. However, as the number of subjects in modeling increases, these words tend to separate to form specific themes. This is shown in the general theme on climate change and UNICA (Figure 2.7) where the BKM clustering algorithm gets to describes them using "minor" topics.

The traditional approach to discourse analysis is mainly based on qualitative ethnographic studies, but an alternative involves NLP methods and machine learning techniques, such as topic modeling. For this purpose, the discursive rhetoric of the different actors was transcribed and converted into textual documents (corpus) that reflected their desires and needs. In a first approximation, the frequency of occurrence in the use of certain words was equivalent to their interest in a specific topic. The themes were the latent variables that generated the patterns of co-occurrences of opinions (for example, interests, needs, or associative networks).

Despite, discussions on the qualitative and quantitative dichotomy, in recent years, a different and concrete approach is gaining ground within science that is aligned with interdisciplinary appeals, which can link knowledge and expertise to development of cross-sector dynamics that seek deep interdependencies among sectors (JACOBI; GIATTI, 2017). This faces immense challenges, which are exacerbated by climate

change. A key example is the water-energy-food nexus (HOFF, 2011) that deals with the contingency and interdependence among these sectors. Therefore, the need for thinking about such a nexus arises, which can break the barriers of sectoral efficiency (JACOBI; GIATTI, 2017). That is, providing clean energy like through ethanol can contribute to sustainable development, but ensuring that its production has the best possible effects in the other sectors is vital.

This study has implications for water-energy-food nexus, which is a recent framework to consider interdependencies in a world of deep scarcities. Traditionally, water, energy and food concerns have been dealt with separately while neglecting their substantive consequences in terms of trade-offs, such as the amount of water needed in all stages of sugar cane and biofuel production (HOFF, 2011). Furthermore, this analysis showed that the question of managing sectors such as the biofuel/energy, and food can not only focus in companies or government, social actors are also relevant to the interactive relationship with society, such as the media and NGOs. Such thinking must be considered in terms of a social science endeavor beyond simply a technical issue (CAIRNS; KRZYWOSZYNSKA, 2016).

2.5. Conclusions

Big data taken out of context loses its meaning. Thus, when using both LDA and text analysis, the context is fundamental to understanding and explaining events and discourses, as are concerns of actors on a certain issue, and in a given period of time. The researcher is in charge of understanding the problem and inferring what is happening. Despite theoretical advances and complex mathematical methods in data mining and machine learning, expert knowledge to interpret the discourses remains invaluable.

Topic modeling can be a very powerful tool to provide a different approach for the social sciences in dealing with complex issues such as the nexus between energy and food in the context of climate change—deep interdependencies, serious scarcities, and

possible antagonistic positioning in light of discourses of different social actors in a complex arrangement, where governance is needed

Using LDA in isolation may have yielded difficulties in understanding the meaning and context of the issue studied. Thus, in this study, we combined LDA with discourse analysis, which allowed us to answer the following main questions: What is the discourse of the various actors on climate change, ethanol, and food security issues? What are the topics that have been most addressed, or the themes to which most importance has been assigned? Do the actors say the same things all the time? It covered diverse themes, and interest in them often changed over time. This combination provided a more complete context and different types of information to identify the social context of the connections among data, and allows us to understand the issue at hand.

The combination of the above two techniques has allowed us to understand that the speech and interests of actors on a specific issue were not constant over the years. For example, Figure 2.3 shows the topics emphasized by the four actors, and the periods in which they were stressed. It is also possible to detect the topics and the periods for which the actors' attention coincided. Figure 2.4 shows the interest in the theme "food price" when all actors assigned same importance to it in the same period, 2007–2009. The interest in a specific issue not was the same if actors needed to compete (Figure 2.6). Many discourses also achieved the same goal, so that several discourses were "charged" in the same latent variable. Some issues had the same importance in the discourse of different actors, and therefore were said to "belong" to several actors, with each theme defined by a different latent variable.

The context of this study reinforces the need for a search for integrative governance structures, as there is a clear dichotomy between synergy and conflict in trade-offs in the nexus. Societal integration in this sense must involve identifying barriers to policy coherence to combine the conventional technical–administrative and sectoral views, making it possible to establish shared criteria to guide negotiation by balancing the interests of a variety of social actors.

Future research on LDA topics can be directed to build categorized dictionaries (assign varied weights to topics) as if they were indicators of construction. This dictionary can then be applied to other corpora through supervised and fuzzy clustering. Our own future work based on the results of this study will focus on analyzing the climate–water–energy and food nexus.

3. THE POLITICAL DYNAMICS OF AGRIBUSINESS IN BRAZIL: BUSINESS CITIZENSHIP AND LOBBYING[3]

3.1 Introduction

Concern about the impact generated by economic interests on the human lives and environment are not at all recent. Many other issues moreover with social and ethical implications have emerged into the business responsibility such as abuses of corporate power, insider information, and issues of use of political action to influence outcome of legislation (BONARDI; KEIM, 2005; MATTEN; CRANE, 2005; CARROLL; BUCHHOLTZ, 2012). In particular, the influence of business on politics though a variety of means to anticipate and influence government decisions to promote helpful legislation or defeat harmful legislation has been at the core of several debates and researched in some disciplines. It even brought the need to move the broader question of the implications of business's influence on politics for democracy, sustainability, and the environment (CLAPP; FUCHS, 2009; SCHERER; PALAZZO, 2011; SUPRAN; ORESKES, 2017).

Several authors has been studied how companies use several mechanism to spread doubt against climate science that, for example, emission of carbon dioxide is a major cause of global warming, and spend significant resources on lobbying against measures to protect the environment (HILLMAN; HITT, 1999; ORESKES; CONWAY, 2010; DELMAS; LIM; NAIRN-BIRCH, 2015). Such research is consistent with the general perception that wrong incentives are driving privileges that deny rights of others and encouraging policy decisions at the expense of the public interest (OECD, 2014; OXFAM, 2015). In addition, highlights the environmental fragility, when confronted or when appears to be conflict between economy issues and the environment, the environment tends to lose (GREY, 2018).

[3] This chapter is based in the article: Benites-Lazaro, L.L. et. al. The Political Dynamics of Agribusiness in Brazil: Business Citizenship and Lobbying. Submitted at Business Research Journal.

In the last decade, in Brazil, a special moment is witnessed, marked by the desirable ethical transformation in corporate culture for fight against systemic corruption (CARSON; PRADO, 2016; CASTRO; ANSARI, 2017). At the same time has been noticed the biggest scandals involving the largest Brazilian companies, for example, Odebrecht and JBS involved in corruption scandals by their relationship with politicians and government representatives. As well as, several scandals that involves mostly the agribusiness with employed people working in slave-like conditions, and debates on environmental and human health risk by agricultural land use changes for the increasing use of agrochemicals. These are just some examples that bring the need to study the responsibility of business in the society, the political connections with government and its nonmarket strategies such as lobbying activities to secure favorable public policy decisions and good legislative environment, and how this political strategies can help to offer business a broader competitive advantage and assist in the creation of value (OLIVER; HOLZINGER, 2008; WALKER, 2012).

Despite, business has attracted criticism for their relationship with politicians and by its lobbying actions, which is considered by several as detrimental to socially responsible behavior (HILLMAN; HITT, 1999; GAO, 2008; LOCK; SEELE, 2016). Many studies show that political connections enjoy greater benefits to business. These benefits include access to funding, lower taxes and fees, and power over market regulation (FISMAN, 2001; CLAESSENS; FEIJEN; LAEVEN, 2008; CHOI; JIA; LU, 2014). It has been pointed out also, the potential of lobbying as a democratic instrument of representation of interests at the same time it points out problems that lobbying activities can cause imbalance that may result in the unjustifiable advancement of special interests (MANCUSO; GOZETTO, 2011).

3.2 Background

3.2.1.Business political mobilization

Instrumentalist approach of business power, according to Fuchs (2007) is first and foremost associated with direct influence of business interests in politicians and

bureaucrats seeking formal political decision-makers. This business political activity its related to lobbying combined with the provision of financial support for election campaigns and party finance (FUCHS, 2007; BRIFFAULT, 2008; NAOI; KRAUSS, 2009). By definition, lobbying does not have to involve any transfer of money, and in many countries the direct attempts to exchange money for political favors would be illegal (FUCHS, 2007). Thus, lobby is characterized as neutral word, since the its definition does not establish a priori that the defense of interests is done in a licit or illicit manner (MANCUSO; GOZETTO, 2011).

However, lobbying and campaign finance raise common concerns about unequal wealth and improper influence or corruption and often is associated with the illicit defense of private interests rather than the public interest, because government officials will make decisions based on their own private benefit to aid their reelection efforts or to add to their personal wealth (BRIFFAULT, 2008). Overall, lobbying is defined as "a firm-level strategic action aimed at changing policy proposals to benefit firms and/or industries and increase their value in the long run" (UNSAL; KABIR HASSAN; ZIREK, 2017, p. 411). In the same way Hillman and Hitt (1999 p. 834) refer to lobbying as part of a company's strategy, which aims "to affect public policy by providing policy makers specific information about preferences for policy or policy positions and may involve providing information on the costs and benefits of different issue outcomes."

Questions of the political influence of business via lobbing and via campaign and party finance activities is a large extent the result of two specific developments, according to Fuchs (2013, 2007), the political mobilizations of business, and the increasing willingness of policymakers to listen to business. The former development indicates a deliberate response by business actors to the arrival of broad social and environmental regulations on the political agendas and business's learning of the value of being involved in the policy process. The second development results from policymakers' need for technical and economic information and expertise as well as contributions, which has fostered and expansion in the access granted to business actors in the policy process.

The dynamics political mobilization, in terms of the combination of business interest in political activity and the dependence of policy-makers and bureaucrats on technical information has received criticism by development of "clientilist relationships" between the two groups there (FUCHS, 2013). However, business lobbies also have pursued profitable public private partnerships at the United Nations (NEWELL; PATERSON, 1998) as well as effectively prevented regulation. Moreover, business interests benefit from the fact that decision-making processes at global institutions tend to be more removed from public view, too, as well as from a lack of institutionalized processes of participation, which could define procedures for the creation of a level playing field (FUCHS, 2013).

Debates about the implications of corporate power by its political mobilizations mechanism for democracy, human rights, sustainability and climate change-issues arise concerns about a potentially disproportionate influence of some interests. For instance, the study of Clapp and Fuchs (2009) showed how corporations have come to play a key role in the setting of the rules and regulations that govern the global agrifood system. They establish private standards, participate in public-private partnerships, lobby national governments as well as multilateral institutions, and shape discourse on norms relating to issues such as health, sustainability, and risk.

In this study conducted by TOURANGEAU (2017) lobbyists and government support represent significant relations of power in the development of Bill C-18 on Canada's Agricultural Growth Act, which amended several pieces of agricultural legislation. Interactions between the actors and organizations in these debates were preceded by instrumental advantages that supported the passing of the Bill, such as corporate lobbying and a Conservative majority government. The instrumental power held by the Conservative Party of Canada and supporters of Bill C-18, according to author explain why the New Democratic Party of Canada's consistent failure to make amendments to the Bill in hopes of a 'balanced' legislation.

In particular, institutional power explains the corporation mobilizations to develop or influence public policies in partnership with government bodies or will it seek to dictate policies by more confrontational tactics such as assertive lobbying, oppositional coalitions, threats, or even bribery (FUCHS, 2013).

3.2.2 Sugarcane industry history of relationship with State in Brazil

The Brazilian State relationship with the sugarcane industry is directly linked the whole of its production activity history, from its technical transformations to the search for new markets, from production financing, research to the current captive market guarantee, with the addition of obligate anhydrous ethanol in gasoline. This relationship and the intervention of the State in the industry is modified according to the difficulties and the different moments through which this sector passes (DE MORAES; ZILBERMAN, 2014; RAMOS, 2016).

In the 1970s, the successful inclusion of ethanol in the Brazilian fuel structure with the creation in 1975 of the Brazilian National Alcohol Program - colloquially so-called as *Proálcool*, would have been as a result of industry political mobilization. As it described by de Moraes and Zilberman (2014) lobbyists for the sugar producers in the state of São Paulo were quite active and visible in the 1970s. For instance, at the time, the Cooperative of Sugar and Ethanol Producers of São Paulo (Copersucar) beyond using their access to decision-making circles, it made a great institutional channel of communication to disseminated diverse technical studies to defend their positions, and pressing for their preferences to be defined as the common interest, mainly regarding the proportion of anhydrous ethanol to be blended into the fuel mixture.

In the period that lasted *Proálcol* (1975-1989) were granted government budget allocations and was instituted subsidized interest financing policies that were granted to sugarcane producers mainly to mills with extremely beneficial financing conditions, whose main component was negative interest. The two oil price shocks (1973 and 1979) further justified state support for a new expansion cycle for the production of ethanol (DE MORAES; ZILBERMAN, 2014; RAMOS, 2016). According to Ramos (2016)

until the end of the 1980s, state participation was concerned with sector intervention and not just regulation. During 1990-2002, the sector goes through a period of finalization of state intervention for liberalization, and then the regulation emerges until the present. The regulation maintained the obligatory mixing of anhydrous ethanol with gasoline, as well as established support for ethanol storage, subsidized low-interest financing, support for research and investments for production, sugarcane improvement, acquisition of machinery and farm equipments (DOS SANTOS et al., 2016). One of the government mechanisms to contribute the production increase of the sector has been by using decrees that stipulate the percentage of this biofuel (anhydrous) in gasoline. From the time of Proálcool program to the present, the percentage of anhydrous ethanol mixed with gasoline has increased from 5 to 27%, this pass by several oscillations in the percentage of anhydrous ethanol in gasoline, for instance in 2000 was 20%, in 2007 reach 25% and 27% in 2015 (MAPA, 2015).

In the period 1996-2002, due to the stability of the oil price, the end of government subsidies and the internal problems with the supply of ethanol, this market was stagnant. In 2003, the second impulse to ethanol began, and this period was called "flex-revolution" (2003-2008), with the launch of flex-fuel cars. This new phase resulted in an increase in the production of sugarcane and, consequently, in the importance of the sugarcane-energy sector in the national economy, and the Central-West region became the center of the new expansion of sugarcane activity (MORAES; BACCHI, 2015). Furthermore, the scenario of optimism with sugarcane ethanol sector is verified with the establishment by policy instruments and energy planning actions such as the National Agroenergy Plan, the National Energy Plan 2030, and the 10-year Energy Expansion Plan, the prospect of ethanol becoming a commodity, and the economic feasibility of bioelectricity from the burning of bagasse and sugarcane straw. At the same time, according to dos Santos et al. (2016) the federal government extended subsidized credit to impulse the activity in this sector. The financing covers all the productive stages and relations and the most diverse purposes. The peak of disbursement occurs in 2010, when it reaches R$ 8.28 billion, falls in the crisis to R$ 3.87 billion in 2012, and returns to R$ 6 billion in 2013 and 2014 (SANTOS et al., 2016).

In 2013 the Brazilian Chamber of Deputies launched the parliamentary front for the valorization of the sugarcane-energy sector aiming to defend the main demands of this sector into the country's political debate and adding efforts to propose public policies that will guarantee the resumption of growth of the sector. As a result, it achieved in the Legislative Branch: the increase of the blend of anhydrous ethanol in gasoline; incentives for the improvement of flex-fuel engines under the Inovar-Auto Program, which will be replaced by the new policy for the automotive industry, Rota 2030, whose rules are still under discussion; the inclusion of ethanol and sugar in the Special Tax Reintegration Regime for the Export Companies (REINTEGRA) and the extension of the lines of financing for construction of warehouses, under diferenciate conditions to the sugarcane industry (CÂMARA DOS DEPUTADOS, 2015; UNICA, 2018).

Finally, on December 27, 2017, after intense mobilization of the sugarcane ethanol industry, the Brazilian government launched the National Biofuels Policy (RenovaBio) to stimulate the expansion of the production of bioenergy. Its objectives are to draw up a joint strategy to recognize the strategic role of biofuels in the Brazilian energy matrix, both for energy security and for mitigation of reduction of greenhouse gas emissions. Provide an important contribution to the Brazil's Nationally Determined Commitments under the Paris Agreement, and ensure predictability for the fuel market by inducing gains in energy efficiency and reduction of greenhouse gas emissions in the production, marketing and use of biofuels (BRASIL, 2017).

3.2.3. Key players in the Brazilian sugarcane sector

The institutional environment of the sugarcane ethanol industry in the beginning of the decade of 1990 resulted in profound changes in the relationships among the players, which was necessary to substitute government intervention for market liberalization, given the mutually dependent relationship between the parties (DE MORAES; ZILBERMAN, 2014). The sugarcane industry has a structured, though heterogeneous, private organization with varying degrees of organization in the agriculture and industry relations. The industry lead the interlocution with the government and the relationship

with suppliers of sugarcane, but little influence the dynamics of distribution and resale (SANTOS et al., 2016).

As show the Table 3.1, in the public sphere the sector is of interests of various important government institutions such as the Ministry of Mines and Energy (MME), Ministry of Development, Industry and Foreign Trade (MDIC), National Council of Energy Policy (CNPE), National Agency of Petroleum, Biofuels and Gas Natural (ANP), Interministerial Council of Sugar and Alcohol (CIMA), the Sugar and Alcohol Sectorial Chamber (CSAA), which depict different levels of representative organization and spaces for negotiation and policy demands with the executive branch and the National Congress, etc. In the corporate sphere is highlighted the important role of the Brazilian Sugarcane Industry Association (UNICA), which is currently the principal associative entity in the Brazilian sugarcane industry. Its member companies account for more than 60% of the sugarcane produced in the country. The UNICA has headquarters and offices in the cities of São Paulo and Ribeirão Preto, as well as in Washington and Brussels, proactively defending the interests of the sector, promoting the development of new markets and consolidating the position of ethanol as a global commodity (DE MORAES; ZILBERMAN, 2014; UNICA, 2017a). The participation of the Council of Producers of Sugarcane, Sugar and Alcohol (CONSECANA) is also emphasizes in the negotiation of interests and technical standards of production, land renting rules, and sugarcane price.

Table 3.1. Key players in the sugarcane ethanol since 1990

Public actors	**Private actors**
Ministry of Mines and Energy (MME)	UNICA -Brazilian Sugarcane Industry Association
National Council for Energy Policy (CNPE	CONSECANA
Interministerial Sugar and Alcohol Council (CIMA)	Council of Sugarcane, Sugar, and Ethanol Producers
Agency National Petroleum, Natural Gas and Biofuels (ANP)	ORPLANA - Organization of Cane Planters in the Center-South Region of Brazil
Ministry of Agriculture, Livestock and Supply (MAPA)	ANFAVEA -National Association of Manufacturers of Automotive Vehicles
Sectorial Chamber of Sugar and Alcohol (CSAA)	Sugarcane Technology Center (CTC)
Ministry of Foreign Affairs (MRE)	
Ministry of Finance (MF)	
Brazilian Cooperation Agency (ABC)	
Ministry of Development, Industry and Foreign Trade (MDIC)	
Brazilian Agency for the Promotion of Exports and Investments (APEX)	
National Bank for Economic and Social Development (BNDES)	
EMBRAPA Agroenergy.	

There are studies of Cerdas (2015) and Consentino (2011) that show the mobilization of the sugarcane ethanol industry in the international arena through the crucial role of UNICA. This institution has developed, in recent years an active role of representation outside Brazil, with special attention being paid to the “lobby” in the United States and Europe, where corporate influence in politics receives legal sanction and is considered part of the political system (GALAN, 2012). This influence is different in the Brazilian political system such is refer Cerdas (2015) where the formulation and implementation of public policies is centered on state agencies and is founded by ever-changing patterns of personal relationships, which makes the boundaries between public agencies and private interests less structured.

The outcomes of the UNICA's mobilization in the defense of the interests of the sector has been the recognition, for instance, by the United States Environmental Protection Agency (EPA) that Brazilian sugarcane ethanol is an "Advanced biofuel"; the review by the Government of the State of California of the carbon intensity of renewable fuels: the Low Carbon Fuel Standard (LCFS) as well as the overthrow of tariffs on the importation of Brazilian ethanol in the United State (CONSENTINO, 2011; CERDAS, 2015). The UNICA's lobbying activities outside Brazil illustrates one of the most significant organizational changes in the representation of the sugar industry and implies developing expertise in complex institutional settings, with political, financial, commercial and even cultural regimes different from what exists in Brazil. This fact, gives evidence of its expertise in the political mobilization to defend corporate interests, and that these same strategies may be used at a local level within Brazil.

3.3 Material and Method

The source of data in this study were documents in text format obtained from Brazilians newspapers (MEDIA), reports from Non-governmental organizations and social movements (NGO), news and documents from websites of the government (GOV) and sugarcane ethanol companies represented by the Brazilian Sugarcane Industry Association (UNICA). The documents was collected for the period January 2007 to December 2017, and are related to agricultural and agrarian, food security, climate change, water security and biofuels-related issues. This generated a large volume of documentary information to be analyzed, for which we made use of several procedures and tools employed in text mining and machine learning.

Our purpose in this article is to identify and discover micro-themes related to lobbing activities and identify the discourses of the actors. With this aims we use topic modeling algorithms latent Dirichlet allocation (LDA), a powerful tool that extracts topics/themes and micro themes from document collections. LDA is described with the following notation:

p\(\beta _{1:K},\theta _{1:D},z_{1:D},w_{1:D})=\prod_{i=1}^{K}p(\beta _{i})\prod_{d=1}^{D}p(\theta_{d})(\prod_{n=1}^{N}p(z_{d,n}|\theta_{d})p(w_{d,n}|\beta _{1:K},z_{d,n}))

Here $\beta_{1:K}$, represents the topics, where each $\beta_K$is a distribution over the vocabulary. The topic proportions for the *d*th document are θ_d, where $\theta_{d,K}$ is the topic proportion for topic k in document *d*. The topic assignments for the *d*th document are Z_d, where $Z_{d,n}$ is the topic assignment for the *n*th word in document *d*. Finally, the observed words for document *d* are w_d, *w*here $w_{d,n}$ is the *n*th word in document *d*, which is an element from the fixed vocabulary (BLEI, 2012).

First, to discover micro-themes, we used MALLET version 2.0.8, a Java-based package for statistical natural language processing. Second, with the outcome of the MALLET, we performed the contextual analysis of the themes by using T-Lab software. T-Lab is software that uses a set of statistical, linguistic and graphical tools to analyze texts material. One of the advantages of the T-Lab is that it allows a quantitative treatment of textual data, and a qualitative analysis of the results in order to "make sense" in the discourse context (BENITES-LAZARO et al., 2018).

Furthermore, to identify the electoral campaign finance by sugarcane companies, we have extracted data from the Brazilian Superior Electoral Court related to campaign financing of the 2010 election. For this analysis we only consider the companies associated with UNICA. To identify the policies outcomes, we extracted the data from the publicly available HTML documents on the Brazilian National Congress.

3.4 Results and discussions

Figure 3.1 shows the percentage of contexts related to the word lobby that appears in the micro themes obtained from LDA. For instance, in the theme Forest Code, lobby appears with the highest percentage of 42.35%. This refers to the diverse and controversial debates among the actors about the entry into force of the Brazilian Forest Code in 2012. Claims from the NGO actors that the agribusiness lobbying to seek and

preserve its benefits through the representation of the so-called ruralist bloc in the Brazilian Congress. Some of the discourses from the NGO actors were that the ruralist party represented a “lobby of the lag” looking for their own benefit at any cost. The “powerful ruralist lobby” continues to accumulate victories such as the enactment of the Forest Code that will allow more deforestation and the expansion of agribusiness was one of the claims of the ONG actors.

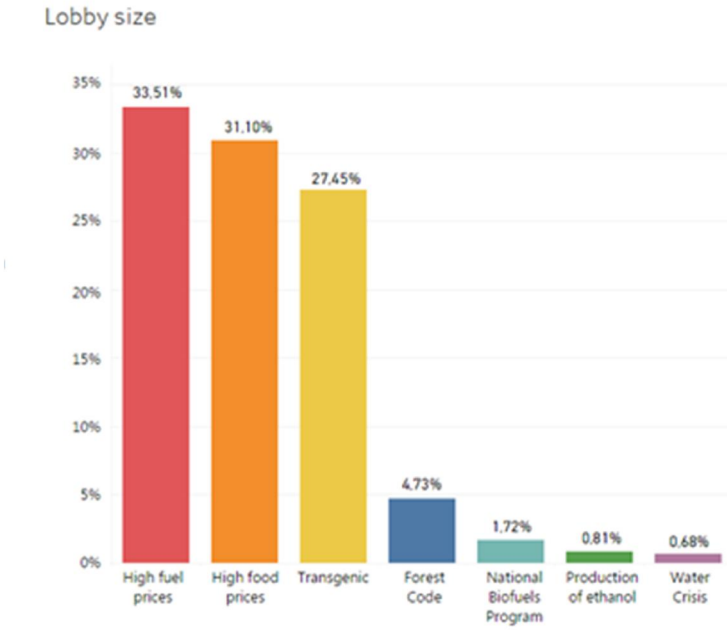
The political mobilization of the agribusiness illustrates how this sector has become the key forest policy definer in Brazil. Such as an early study of SOARES-FILHO et al. (2014) shown that agribusiness lobby took advantage of a favorable political moment, related to a substantial drop in deforestation rates in the Brazilian Amazon achieved in 2010, to propose the creation of a new Forest Code. The most important changes in this law that benefit to agribusiness were that: Illegal land occupations and forest felling before 2008 were subject to an amnesty, and given the title of consolidated rural area. Over 90% of Brazilian rural properties qualify for amnesty for their environmental debts that would have required them to restore forests. Areas of Permanent Protection (APPs), such as forest areas acting as buffers between rivers and plantations or pastures (Riparian Preservation Areas), were reduced by 80%, from 30–500 m to 5–100 m (see SOARES-FILHO et al., 2014; KRÖGER, 2017).

The sugarcane industry also was criticized by NGO actors for its mobilization in favor of the promulgation of the Forest Code. As they refer how UNICA spend millions of dollars to promote ethanol worldwide, spreading it as a clean and sustainable energy solution. But the most powerful sugarcane millers association called on President Lula to support the new Forest Code bill, which ends the protection of Brazilian forests, as it will allow an increase in deforestation.

A large gain for the sugarcane sector appointed by the MIDIA actor is that since the New Code exempts the recomposition, compensation or regeneration of the new parameters established, in cases in which the suppression of the native vegetation was carried out respecting the percentages by the legislation of the time, the so-called consolidated rural areas. Another benefit with the promulgation of the Forest Code for

sugarcane producers, is in cases of injure caused by a fire, the imposition of the fine will depend on the competent authority demonstrate the nexus causal relationship between the action of the owner or its agent and the actual damage that had hitherto been assumed, given that the precautionary principle was applied in the previous legislation.

Figure 3.1. Lobby-word in the micro-themes from Latent Dirichlet Allocation analysis of text documents published 2007–2017 about sugarcane ethanol production in Brazil.



Regarding the lobby on the theme related to food and fuel price, was mainly about the crisis period of 2008, and show how the rise of the prices in this two essential elements to satisfy basic human needs provoked huge debates about the relevance of investments in biofuels. The most vigorous defense of sugarcane ethanol came from Brazilian government, the MEDIA and some ONGs. President Luiz Inacio Lula da Silva at that time qualified as a smoke screen launched by powerful lobbies that attribute sugarcane ethanol production to increases price inflation. He pointed out that food price inflation results from high oil prices, which affect fertilizer and freight costs; exchange rate changes and speculation in financial markets; of falls in world stocks; of increased food consumption in developing countries such as China, India and Brazil; and above all the maintenance of absurd protectionist policies in the agriculture of rich countries such as

the corn ethanol lobby that tries to include a new extension to subsidies. Furthermore, the study of BENITES-LAZARO et.al. (2017) showed that international NGOs such as Greenpeace and Oxfam recognized the virtues of Brazilian ethanol. For instance, Oxfam position was that Brazilian sugarcane ethanol represented a "special case" among the otherwise harmful ethanol fuels by its contribution in greenhouse emission reduction. WWF has actively engaged with the industry using roundtable processes to promote sustainable resource use such as Bonsucro certification.

The results in this theme of lobby in food and fuel price demonstrate that the main discourses of the actors was about the foreign lobby, for example, the domestic market controls, subsidies and tariffs that U.S. policy imposes on Brazilian ethanol as a result of the lobbing demand in this country.

The lobby in the theme agrochemicals is mainly addressed by ONG actors, which claims on the changes in the law on pesticides and their repercussions on health and environment. Because, the agronomic recipe does not work and there are very few laboratories in the country that are capable of analyzing water and human contamination by pesticides. The main criticism of NGO actors is that agribusiness and its strong lobbying in the entire structure of the Federal Government is facing the probability of worsening the scenario with the changes of laws lighter and less effective. They claim that there are deputies who lobby the agrochemicals and are in favor of genetically modified organisms. There are several studies such as CLAPP (2008); CLAPP; FUCHS, 2009; STEPHAN (2012) that depicted the agrochemical companies' strategy to interfere in the regulatory process, lobbying with the training of public workers and law enforcement officials dealing with this area.

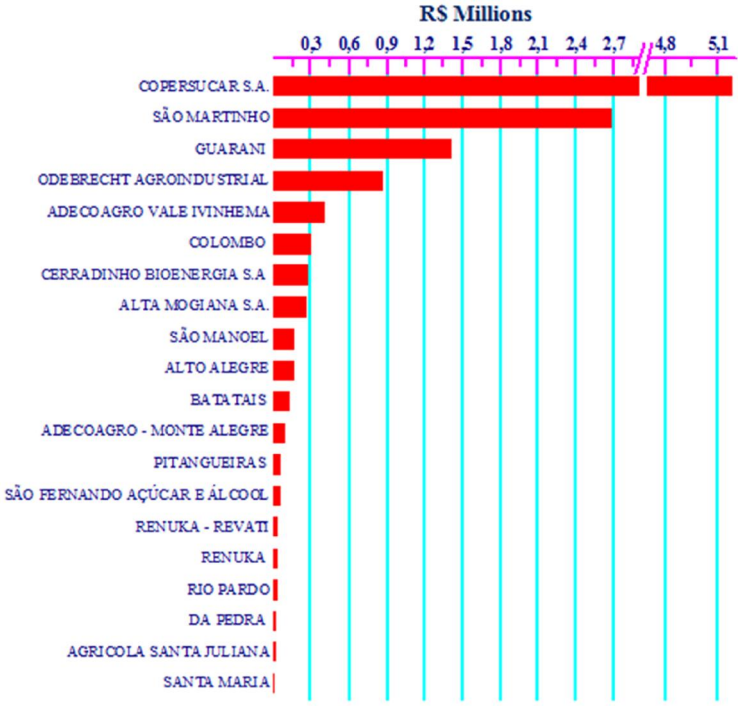
Regarding the lobby in the theme biofuels policy, in this study we focused in the RenovaBio law, which by some actors ONG and MEDIA was the result of an intense lobby from the sugarcane ethanol industry. UNICA beyond using their access to decision-making circles, it made a great institutional channel of communication to disseminated about the importance of RenovaBio as an essential initiative for the implementation of the Paris Agreement. One of the main discourses were that the

proximity of United Nations COP 23 in 2017 lends urgency to the RenovaBio proposal, in order to ensure that the Brazilian Delegation to that Conference has something concrete to present.*" RenovaBio is a unique opportunity for Brazil to reaffirm its global leadership in the production and use of renewable energy"*. "*The implementation of RenovaBio is essential to enable the necessary investments in the biodiesel and ethanol sectors, so that they can adequately meet the Brazilian commitment to increase the presence of biofuels in the national energy matrix"*, were some discourses of the UNICA.

Regarding water management policies, the industrial sector mobilization and active participation was crucial in the discussions of Law 9.433 of 1997, which created the National Water Resources Policy and instituted the National Water Resources Management System, followed the drafting of Law 9,994, of 2000, which created the National Water Agency, and was one of the main interlocutors of the drafting of Law 10.881, of 2004, which defined the figure of the delegate entities. The business sector was present in the debates of the National Council of Water Resources, which regulated all the instruments of the National Water Resources Policy. In the quotidian of the National Water Resources Council and its technical chambers, industry representatives participate in all debates and stand out by engaging and presenting proposals. The presence of the sugarcane industry representatives in the state councils of Water Resources maintains the same commitment of participation and involvement. The creation of the National Water Agency boosted water management in the country by its technical staff. It promoted progress in the granting of authorizations for the use of water resources, in the preparation of studies for the planning of water resources, and consolidated institutional management structures, notably the Watershed Committees. However, the fragility of the National Water Resources Council and the state Water Resources Councils indicates that the agenda is far from the center of government strategic decisions. The main criticism is that the management of water have a technocratic tendency dominated by a socio-economic elite with technical training (SOUSA JR; FIDELMAN, 2009).

Figure 3.2 shows the campaign finance by sugarcane companies related to the election of 2010. Corpersucar S.A,one of the world's largest exporters of sugar and ethanol financed with over R$ 5 million followed by San Martinho, Guarini, and Odebrecht Agroindustrial. In accordance with the legislation of the Superior Electoral Court Art.81§ 1º The donations and contributions from legal entities to electoral campaigns at the time are limited to two per cent of gross revenues in the year prior to the election. The scandals related to corruption and the electoral campaigns financing of the recent years made this law revoked. For the elections after 2014 the campaigns finance for legal persons was prohibited.

Figure 3.2. Election Campaign Donations by sugarcane ethanol companies in 2010



Source: Tribunal Superior Eleitoral (2017).

Regarding to the electoral campaigns financings carried out by the companies of the sugarcane ethanol is illustrative the plea bargain of the CEO of the business group Odebrecht, Marcelo Odebrecht, which revealed the high influence of private sector agents in the federal government. Odebrecht explains its influence with former Finance Minister Guido Mantega, which generated benefits to the ethanol industry. According to

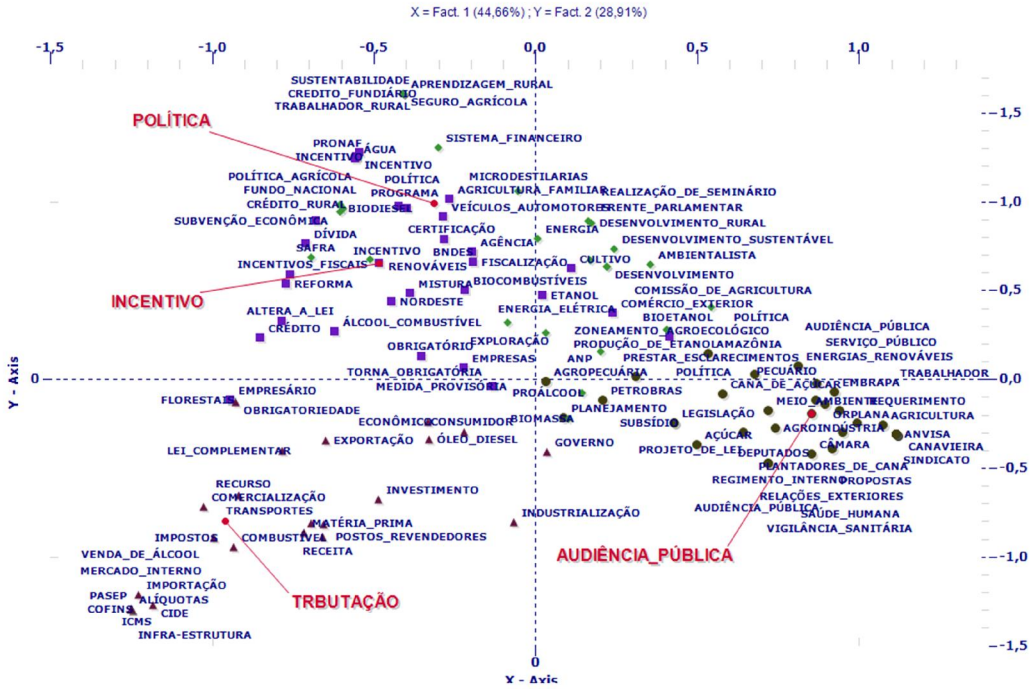
Odebrecht seeing the measures that the government intended to announce, asked the minister to postpone the measure and listen to representatives of the businessmen, UNICA's technicians and their staff to solve this and come up with a reasonable package. The result was the exemption on ethanol from the collection of federal taxes Social Integration Program (PIS) and the Contribution to the Financing of Social Security (Cofins) until 2016. On August 2013, the President of Brazil through the Provisional Measure nº 613 (medida provisória[4]) granted tax incentives to sugarcane producers and the chemical industry through presumed reduction of PIS and Cofins. Marcelo Odebrecht said that the aid to the sector would be rewarded with campaign donation by its position of great electoral donor (NOVACANA, 2017).

The Figure 3.3 show the results of the survey from the website of the Brazilian national congress (1951-2017) related to the policies to the sugarcane sector. We applied cluster analysis, a set of statistical techniques that aims to detect groups of objects. In this case are present four clusters: "public audience" aimed at giving arguments to the law projects to promote debates about their importance of its approbation. "Incentive" such as the increase of the blend of anhydrous ethanol in gasoline, incentives for the improvement of flex-fuel engines, the inclusion of ethanol and sugar in the Special Regime for the Reintegration of Taxes for Exporting Companies - REINTEGRA, and the extension of the financing lines for the construction of warehouses, under differentiate conditions. By Reintegra program exporters of ethanol and sugar received the returns taxes paid on export up to the limit of 3% of business revenue. This incentive represents a renunciation of R$ 3 billion for the public coffers (O GLOBO, 2014). The theme "tribute" is related to taxes such as CIDE, PIS and COFINS that benefit the sugarcane ethanol industry. For instance, in 2017 government reduced the taxation of the PIS and COFINS on ethanol; this change was forecast that will cause the government to lose R$ 501.7 million in expectation of collection for government coffers (AGENCIABRASIL, 2017).

[4] Provisional Measure is a legal act in Brazil through which the president of the republic can enact laws without approval by the National Congress.

However, for the UNICA these measures, while important for the sector, are insufficient. The main demand of the sector was the long-term vision, especially with regard to ethanol and biomass, with clear, stable and consistent public policies that allow the recovery of the sector's competitiveness and investments. For this demand mobilized the RenovaBio be enacted. The ethanol sector, the most benefited by RenovaBio, considers the program as the only one capable of bringing new investments. For others RenovaBio is a perfect replacement of the Contribution of Intervention of the Economic Domain (Cide), because have two important advantages. The first is that with the RenovaBio program, the ethanol sector wins twice, with the income from the bonds and with the rise in the price of ethanol. Cide is a tax charged on fossil fuels to encourage ethanol; the revenue gain goes to the public sector, contributing to the fiscal adjustment. The gain of the ethanol producing sector is indirect, due to the increase in price.

Figure 3.3 Policy outcomes that benefit the sugarcane ethanol sector.



The data are from the publicly available HTML documents on the Brazilian National Congress with the keyword sugarcane and ethanol in the period 1951-2017.

The study of the concession of incentives and tax benefits can be analyzed from the Lowi's typology of public policies composed of three categories: distributive, regulatory and redistributive policies (LOWI, 1964). Distributive policies are highly individualized decisions its benefits focus on easily identifiable winners, while its costs are pulverized among various losers-that is, all those who ultimately will finance the distribution of private and clientelist favors (SEFTON, 2008; MANCUSO; MOREIRA, 2013). In regulatory policies the laws are stated in general term the costs and benefits can be spread evenly. In redistributive policies the categories of impact are much broader, approaching social classes. Redistributive policies clearly place in welfare state programs, which are redistributive only for those who entered retirement or unemployment rolls without having contributed at all (LOWI, 1964).

The granting of tax benefits to sugarcane companies can be characterized as a distributive policy. In fact, laws that grant tax advantages to specific business segments deliver unique benefits to their recipients. Such laws also disperse the costs of tax privileges among outsiders, that is, the rest of society, whose tax burden may be high to compensate for lost revenue, or may fail to receive public services that would be financed by revenue of the social contributions waived (MANCUSO; MOREIRA, 2013).

Distributive policies such as the granting of tax benefits tend to be preceded by intense mobilization of the beneficiaries, who make a strong one-off lobby for the approval of the desired measures, and tend to cause much less mobilization (if any) of the rest of society in the opposite direction, in difficult to mobilize large and dispersed groups. This biased game in favor of special interests may lead to a result contrary to the public interest (FUCHS; LEDERER, 2007; MANCUSO; MOREIRA, 2013).

3.5 Conclusions

The results show that the sugarcane ethanol industry were supported by the government in several interventions, received heavy subsidies, regulations and constant incentives. These policy-influencing mechanisms were preceded for intense political mobilization

for the approval of the desired measures for the sector. Furthermore, the results showed the business and politician's relationship through party finance. Thus, the instrumentalist power of business was addressed by this industry.

This study indicates that main policies related to sugarcane ethanol was resulted from an intense political mobilization, for instance at the time of Proálcool program, the main association of sugarcane producers, Copersucar used its influence with the decision-makers to defend its position and its invocation in favor of economic profitability by introducing ethanol into the energy matrix. Today, the main organization that represent sugarcane ethanol companies, UNICA beyond using their access to decision-making circles, it made a great institutional channel of communication to disseminated about the importance of RenovaBio as an essential initiative for the implementation of the Paris Agreement, and the reduction of greenhouses gas emissions.

However, the main concern is the possibility that the benefits addressed to the sugarcane industry will put in detriment to government support for other sectors, for instance, the recent discussion on the concession of reduction taxes on industrialized products for electric cars, and the strong opposition of the UNICA for consider a contradiction between ethanol and electricity in the national strategy of renewable mobility. Despite, the specialized scientific literature has emphasized the bioenergy contribution in the reduction of greenhouse gas emissions, particularly vehicle emissions. The discussion on the production of biofuels is centered on arguments that encompass social inclusion, food security, water security, national and international sectorial corporatist expressions of interests and its political mobilization, as well as environmental issues.

Therefore, it is worth asking if the entire cost of supporting the production of ethanol is justified by its possible benefits for the environment. Future research based on the results of this study should focus on analyzing the discursive power of companies to identify how companies have an important role in the formulation of certain issues and problems in policy debates as well as its strategies to influence and convince society

that the interests of the company are in reality the interests of the country or of humanitarian interest.

4. SUSTAINABILITY AND GOVERNANCE OF SUGARCANE ETHANOL COMPANIES IN BRAZIL: TOPIC MODELING ANALYSIS OF CSR REPORTING[5]

4.1 Introduction

The discussion on the role of business in society has a long and wide-ranging history (CARROLL; BUCHHOLTZ, 2012). Over the past two decades, this debate has been motivated by a growing awareness of several social problems, ranging from climate change to poverty reduction and unsustainable production systems in the industrial sector that contributed significantly to the pollution and exploitation of the environment (TSENG et al., 2013; BENITES-LAZARO; MELLO-THÉRY, 2017). Consequently, there has been an unprecedented number of pleas for corporate social responsibility (CSR) with the prospect of businesses becoming socially responsible and good corporate citizens (MATTEN; CRANE, 2005; CARROLL; BUCHHOLTZ, 2012).

Business response to this growing concern involves engaging in activities that were once the sole responsibility of the state, such as education, public health, social security, malnutrition, homelessness, illiteracy, as well as adopting voluntary CSR standards and defining ethical codes (CRAGG, 2005; MATTEN; CRANE, 2005; SCHERER; PALAZZO, 2011). In particular, the Earth Summit of 1992 reinforced the institutionalization of socio-environmental issues, leading to the establishment of voluntary certifications, eco-labeling, sustainability indicators, product life-cycle analysis, and best production practices by corporations as a means to incorporate sustainability (KNIGHT; JENKINS, 2009; LOZANO, 2012; LÁZARO; GREMAUD, 2016).

Self-regulation to promote CSR with codes of conduct as the most common means continues to be the subject of widespread interest to companies (KOLK; VAN

[5] This chapter is based on the paper: Benites-Lazaro, L.L., Giatti, L., Giarolla, A. Sustainability and governance of sugarcane ethanol companies in Brazil: Topic modeling analysis of CSR reporting. Published at Journal of Cleaner Production, Volume 197, Part 1, 1 October 2018, Pages 583-591, doi.org/10.1016/j.jclepro.2018.06.212
https://www.sciencedirect.com/science/article/pii/S0959652618318626

TULDER, 2002). There are several private voluntary arrangements governing most major global economic sectors including financial system, chemicals, energy, minerals and mining, forestry, biofuels, and sensitive agricultural commodities such as coffee, cocoa, and soy. Such arrangements extend across a wide range of policy arenas in human rights issues, labor conditions, health and safety norms, quality management procedures, and the environmental impact of production (VOGEL, 2008; PONTE, 2014; SCHUSTER; MAERTENS, 2016).

However, these private standards based on voluntary codes of conduct are highly controversial and have received several criticisms. The vast majority of voluntary standards have been adopted unilaterally by trade associations or individual firms without the conventional input or control of the state or public actors (VOGEL, 2008; HART, 2010). With private control, motivations and principles can be governed by private financial interest (CRAGG, 2005; HART, 2010). The main criticism is that business actors use these codes primarily as marketing ploys and superficial window-dressing measures to secure and increase profits and avoid public regulation (HAUFLER, 2001; GRAHAM; WOODS, 2006; FUCHS, 2013), which has served even as a legitimizing tool to seek social acceptance of industry and their products (SUCHMAN, 1995; CLAPP; FUCHS, 2009).

In this study, we explore Brazilian sugarcane ethanol companies' commitment to sustainability and business-led governance measures. Drawing on the structural power of business (FUCHS, 2007, 2013; CLAPP; FUCHS, 2009), we discuss why these companies implement and use institutions to promote sustainability performance, and whether this institutions encourage concern with the best production practices. With this analysis, we aim to contribute to the theoretical and empirical debates around private governance, private regulation, and the challenges for sustainability. By examining the rule-setting power in which business engage through voluntary standards or codes of conduct, we can achieve a better understanding of how standards govern interactions in local contexts and how it can facilitate its business for commitment to sustainability. The companies' growing adherence to private certification standards, CSR practices, and the increasing significance they play in the regulatory structures governing the

global economy indicate the importance of understanding this aspect of corporate power (CLAPP; FUCHS, 2009).

Brazilian sugarcane ethanol, in particular, has been widely regarded as the world's most successful and largest biofuel program. It has been considered as a renewable source of energy and as a form of "advanced biofuel" (SOUZA et al., 2017) because it provide local environmental and social benefits, and contributes at global level to reduce pollution and climate-altering greenhouse gas (GHG) emissions by replacing fossil fuels as alternative energy source (GOLDEMBERG, 2007; LA ROVERE; PEREIRA; SIMÕES, 2011; BENITES-LAZARO; MELLO-THÉRY; LAHSEN, 2017). The sugarcane ethanol plays an important role in the achievement of Brazil's pledge to reduce GHG under the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement (BENITES-LAZARO; MELLO-THÉRY; LAHSEN, 2017). In order to achieve this pledge, the Brazilian government launched the National Biofuels Policy (RenovaBio) on December 27, 2017 to encourage the production of ethanol and biofuels. Furthermore, sugarcane is one of the main sources of agricultural wealth in the country and, therefore, plays an important role in the national economy with positive impacts on economic development and improvement of the balance of payments (NEVES et al., 2011). Other social benefits include job creation and enabling access to the labor market by people with little or no education (MORAES; OLIVEIRA; DIAZ-CHAVEZ, 2015).

However, criticisms of unsustainable production practices can alter the scenery and stress socio-environmental relationships in multiple ways (SOLOMON; BAILIS, 2014). For example, poor labor conditions and life situations have risks to the workers' health mainly associated with manual cane harvesting (ROCHA; MARZIALE; HONG, 2010; MCGRATH, 2013), unemployed due to the mechanization of farming methods (ROSENDO; DE MATOS, 2017), changes in land-use and indirect deforestation (LAPOLA et al., 2010), depletion of water resources (SCARPARE et al., 2016a), air pollution emissions due to its production expansion (TSAO et al., 2011), and debates on food security (NOGUEIRA; CAPAZ, 2013). Therefore, these critical issues related to unsustainable production practices need to be addressed by sugarcane ethanol

companies to portray the sugarcane industry as a sustainable business and ethanol as a "green hero," a clean and renewable energy that helps mitigate global climate change (BENITES-LAZARO; MELLO-THÉRY; LAHSEN, 2017).

4.2 Structural power of businesses

The structural power of businesses that has emerged with globalization in recent years marks the expansion of a more passive agenda-setting power to encompass an active rule-setting power. Thus, business actors are increasingly in a position to make governance decisions, either by complementing or replacing traditional actors such as states and international governmental organizations in some cases (FUCHS, 2007, 2013). According to Fuchs (2007) business actors exert their structural power through self-regulation arrangements and public-private or private-private partnerships (PPPs) such as the International Organization for Standardization's ISO 14000 standards, Global Compact, Forest Stewardship Council (FSC), several certifications, and code of conduct and standards.

In the last two decades, many companies have developed their own codes outlining the humanitarian and environmental standards of their business practices, and/or subscribe to one or more industry or cross-industry codes, certification schemes, and voluntary sustainability standards (SCHERER; PALAZZO; BAUMANN, 2006; VOGEL, 2010). This form of governance arrangement allows businesses to exercise an active rule-setting power by influencing the adoption, implementation, enforcement of these rules, and then assuming an obligatory quality that has distributional consequences for others within its supply chain or sector (Fuchs and Lederer, 2007). They delineate roles and responsibilities of management and accounting systems and regulate the provision of resources for the implementation, monitoring, auditing, certification, and labeling processes by demonstrating the performance of the industry or company to the outside world (FUCHS, 2007).

Numerous studies indicate both the benefits and the costs of private regulatory standards. While some claim that business are economic and not normative agents, they

will only undertake actions that promote their self-interest (O'rourke, 2006). They signify an attempt to greenwash or whitewash themselves with voluntary environmental or social codes (DAHL, 2010; MAHONEY et al., 2013), which legitimize the businesses. Here, legitimacy refers to "a generalized perception or assumption that the actions of an entity are desirable, proper, or appropriate within some socially constructed systems of norms, values, beliefs, and definitions" (Suchman, 1995 p. 574). For instance, Cho and Patten's (2007) study show that companies use environmental disclosure seeking legitimacy, and Benites-Lazaro and Mello-Théry (2017) in their study on CSR in Latin America display how CSR emerges as one of the ways through which companies can attain legitimacy or social acceptance within their respective societal contexts.

In contrast, others perceive these standards as a sincere effort by companies, sectors, and business actors to monitor and improve their management practices, and social and environmental performance (SCHUSTER; MAERTENS, 2016; GOEDHUYS; MOHNEN, 2017). These voluntary standards are considered to fill the regulatory vacuum that has emerged as a result of globalization, and make potential contribution of business organization, technical, and financial resources toward governance (Fuchs, 2007). Moreover, business codes of conduct, certifications, and sustainability standards may help businesses in internalizing ethical behavior and raising productivity levels through a process of continuous improvement (SCHUSTER; MAERTENS, 2016; GOEDHUYS; MOHNEN, 2017).

For example, many studies have indicated the benefits that businesses can achieve by adopting ISO 14001 to improve their environmental management systems, reputation, relationship with stakeholders, and financial performance (POTOSKI; PRAKASH, 2005; GAVRONSKI; FERRER; PAIVA, 2008; RUSSO, 2009). However, critics have questioned the manner in which some firms adopt these standards and their effectiveness in improving the environment management practices (Boiral, 2007; Yin and Schmeidler, 2009) seeking legitimacy of its environmental performance, but without necessarily implying a substantive environmental commitment (ARAVIND; CHRISTMANN, 2011; VÍLCHEZ, 2017). Some also believe that these standards have

limited objectives, barely rooted in pragmatism, and strategic engagement focusing only on technical or legal issues leading to "depoliticization" and marginalization of concerns regarding inclusion, justice and equity (CHEYNS, 2011; SELFA; BAIN; MORENO, 2014; DE MAN; GERMAN, 2017).

Despite the business rule-setting activities gaining several criticisms and being fervently disapproved by scholars and practitioners, the fundamental questions pointed out by Fuchs (2007) are what the implications of such codes of conduct or standards for problem-solving are, and what the benefits to the society and environment are, if businesses adopt them. There is a significant difference in the means of regulation of irresponsibility companies with the use of regulation to attract and promote sustainable forms of production to prevent companies from being irresponsible (NEWELL, 2008).

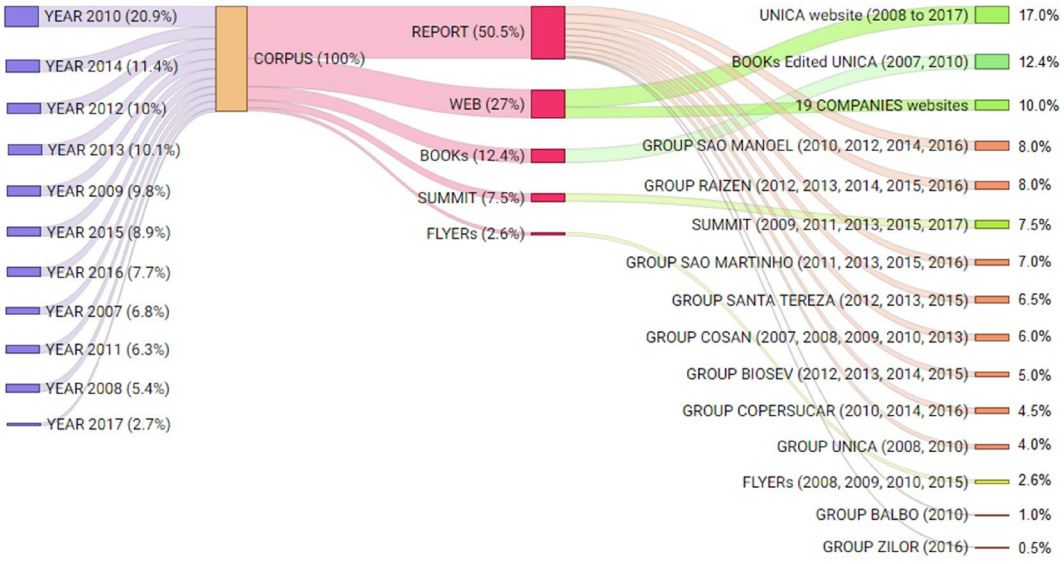
4.3 Materials and Methods

We first identify the sugarcane and ethanol companies from the ranking list of one thousand biggest companies in Brazil published by the economy and business newspaper Valor Econômico in 2016. This list presents 29 largest companies in the sugarcane and ethanol industry (VALOR ECONÔMICO, 2017). In addition, we identify the member companies of the Brazilian Sugarcane Industry Association (UNICA), which are responsible for more than 50 percent of all ethanol produced in Brazil and 60 percent of overall sugar production. UNICA is the largest organization in Brazil representing sugar, ethanol, and bioelectricity producers, with 41 business groups and some individual companies associated (UNICA, 2017b). After identifying the companies in this sector, we searched CSR and sustainability reports on the websites of the respective companies. If a company did not have a sustainability report, we searched the websites by CSR communications; we only considered the reports and documents in English version. Not all companies have their report and website in English.

The data for analysis and corpus construction were documents from 2007 to 2017, which we categorized into five sets as shown in Figure 4.1: (1) reports including 32 sustainability reports related to nine companies and UNICA's reports; (2) websites

including CSR communications from 19 companies and UNICA's website; (3) flyers related to several activities and projects; (4) Ethanol Summit reports; and (5) books edited by UNICA. We extracted the data from the publicly available HTML documents on the UNICA website by web scraping using the rvest package in R (rvest is a package that makes it easy to scrape or harvest data from html web pages). Documents in pdf format such as flyers, books, and sustainability reports were converted to txt format using the tm package in R (tm is a text mining package to corpus handling preprocessing). All data sets were structured, cleaned, and reshaped using the OpenRefine software. We finally obtained the corpus as a CSV file of approximately 4,300 rows (each row representing newsletters webpage, chapter of book, reports and documents) and 7MB to be read and treated by the T-Lab software.

Figure 4.1 Sankey diagrams of data source for corpus construction.



Note: We have not considered the Bunge sustainability reports because their report is about their main activity (i.e. agrifood)

To identify or discover the main themes/topics of sugarcane companies' commitment to sustainability, we use topic modeling algorithms in text mining, a powerful tool that extracts "topics" from document collections. One of the most widely used algorithm is the latent Dirichlet allocation (LDA), a generative probabilistic model of a corpus (Blei et al., 2003), which "provides a powerful tool for discovering and exploiting the hidden thematic structure in large archives of texts" (BLEI, 2012, p. 82). It allows us to

organize, understand, research, and summarize a large amount of textual information (BLEI; LAFFERTY, 2009). The basic idea behind this mathematical method is that documents are represented as random mixtures of latent topics, where each topic is characterized by a probability distribution of words over a vocabulary (Blei et al., 2003).

LDA is described more formally with the following notation:
p\(\beta _{1:K},\theta _{1:D},z_{1:D},w_{1:D})=\prod_{i=1}^{K}p(\beta _{i})\prod_{d=1}^{D}p(\theta_{d})(\prod_{n=1}^{N}p(z_{d,n}|\theta_{d})p(w_{d,n}|\beta _{1:K},z_{d,n}))
Here $\beta_{1:K}$, represents the topics, where each $\beta_K$is a distribution over the vocabulary . The topic proportions for the *d*th document are θ_d, where $\theta_{d,K}$ is the topic proportion for topic k in document *d*. The topic assignments for the *d*th document are Z_d, where $Z_{d,n}$ is the topic assignment for the *n*th word in document *d*. Finally, the observed words for document *d* are w_d, *w*here $w_{d,n}$ is the *n*th word in document *d*, which is an element from the fixed vocabulary (BLEI, 2012).

In this study, we use T-Lab's modeling tool of emerging themes, a very sophisticated algorithm combination of LDA (BLEI; NG; JORDAN, 2003) and Gibbs sampling (GEMAN; GEMAN, 1984), which provides a simple way of identifying, examining, and modeling the main topics from the texts (LANCIA, 2017). We use T-Lab's bottom-up approach, which analyzes word co-occurrences through probabilistic modeling.

The modeling of the emerging themes tool allows us to decide both the number of themes/topics and the words that characterize each of them. After testing, any constructed model can be further analyzed (LANCIA, 2012). For the analysis, we carry out the following processes: First, we compute the co-occurrences of key-words by probabilistic modeling with 50 themes. Second, we explore specific themes. The outcomes of this step indicates a typical word on a value table where TYPE = specific when the word belongs to the selected theme colored only in blue, and shared otherwise, (p) = probability value of each word for themes, in which "high probability" indicates a probability ≥0.75; (LANCIA, 2017). Third, we assess the semantic

coherence of each theme and after testing, we apply the model. Finally, we obtained 36 themes. The analyses were performed by others T-Lab tools such as correspondence analysis and key contexts of thematic words to extract the elementary context, which allow us to deepen the thematic value of specific keywords for qualitative analysis.

Furthermore, we performed a semantic network map by using the sequence of themes tool. To compute centrality measures, we later analyzed the semantic network among the themes using the open source software Gephi for visual exploration of networks. This, network analytic tool is used to represent the nodes (themes) and edges (relationships) in a network and analyze the network data (WASSERMAN; FAUST, 1994).

4.4. Results

Figure 4.2 presents the 36 main themes that Brazilian sugarcane and ethanol companies communicate with regard to sustainability commitments and business-led governance measures. These themes include: agro-**e**nvironmental, bioelectricity, biofuels, certification, climate, code, committee, consumption, education, emission, financial, flex-fuel, health, industry, job, labor, land, life, local, logistic, model, position, preservation, production, program, report, riparian, standard, supplier, sustainable, tariff, technology, trade, UNICA, voluntary, and water.

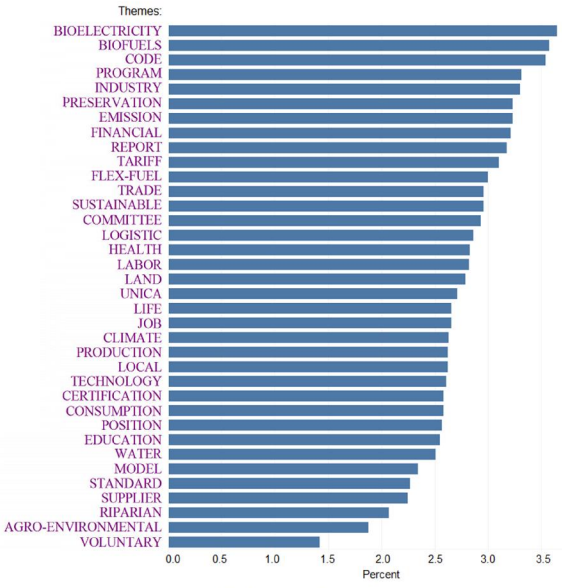
Figure 4.2 Keywords sorted by weighted descending order.

Note: Blue colored are specific of one theme only, black colored are shared by more themes.

Figure 4.3(a) depicts "bioelectricity" as the theme with the highest percentage followed by "biofuel," "code," and "program," which indicate that these themes have most occurrences in the total corpus. When this is presented as normalized value of document classification as shown in Figure 4.3(b), it shows themes such as "environment" followed by "sustainable" and "certification" with high percentage of participation in the five categories (i.e., websites, sustainability reports, summit reports, flyers, and books). This indicates that companies are mainly concerned in showcasing their

environmentalism, together with the effort to communicate on environmental initiatives and sustainability standards.

Figure 4.3 Participation and classification of themes.



a) Participation of Themes

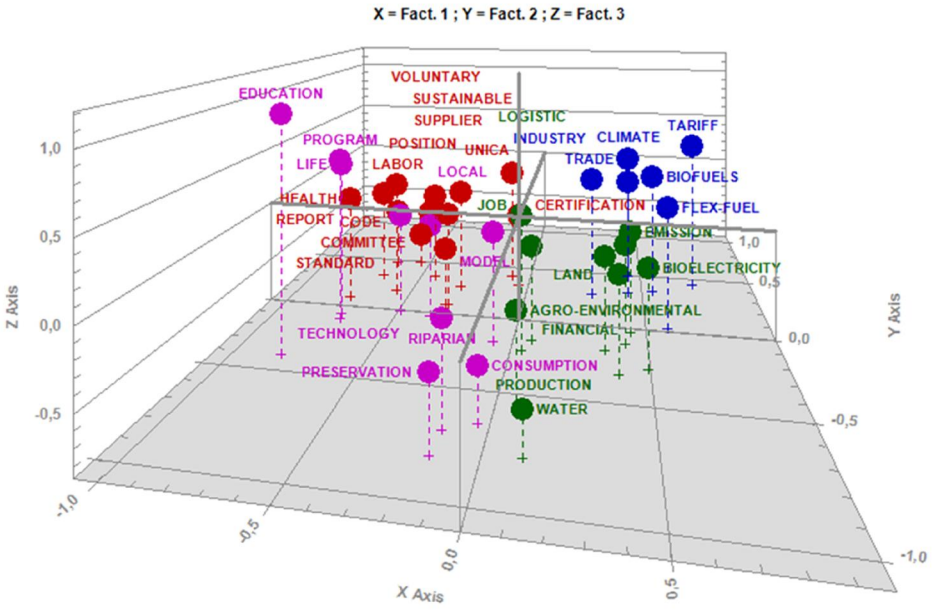
Themes	WEB	REPORT	SUMMIT	FLYER	BOOKs
AGRO-ENVIRONMENTAL	5,420	6,853	4,48	8,33	5,750
BIOELECTRICITY	0,520	1,381	0,92	1,28	0,350
BIOFUELS	2,240	0,891	1,60	1,85	1,000
CERTIFICATION	7,010	5,719	10,54	6,16	6,750
CLIMATE	1,210	1,425	0,80	0,28	1,350
CODE	4,030	2,084	3,48	3,09	3,200
COMMITTEE	1,140	2,344	1,00	0,73	1,450
CONSUMPTION	2,870	2,316	1,84	1,55	2,100
EDUCATION	3,920	4,744	1,64	5,98	4,150
EMISSION	1,760	1,956	1,40	1,79	1,600
FINANCIAL	2,330	2,066	0,74	0,31	1,650
FLEX-FUEL	3,600	2,103	1,36	0,96	2,150
HEALTH	1,980	1,944	1,88	2,18	1,000
INDUSTRY	0,700	1,381	1,98	2,59	0,600
JOB	0,540	1,063	0,42	0,51	0,200
LABOR	3,160	4,297	6,44	5,75	3,700
LAND	0,160	0,644	0,14	1,93	0,150
LIFE	0,980	1,794	0,74	0,73	1,150
LOCAL	0,610	0,969	0,24	0,04	0,800
LOGISTIC	1,400	1,431	1,16	0,36	0,750
MODEL	4,370	4,813	4,74	6,34	6,100
POSITION	2,110	2,131	2,66	3,79	3,300
PRESERVATION	3,100	1,309	1,04	0,59	1,100
PRODUCTION	3,400	6,013	7,94	11,16	3,950
PROGRAM	4,510	4,809	3,46	2,23	4,200
REPORT	4,210	2,606	4,28	4,00	2,150
RIPARIAN	9,130	6,753	9,14	4,56	10,000
STANDARD	1,380	2,191	4,72	1,51	3,250
SUPPLIER	5,010	5,066	2,58	1,00	5,450
SUSTAINABLE	7,060	3,638	6,40	6,15	8,400
TARIFF	0,410	0,697	0,60	2,86	1,100
TECHNOLOGY	3,860	2,900	2,20	3,54	4,150
TRADE	0,180	0,500	0,38	0,04	0,450
UNICA	1,870	1,013	0,36	0,38	0,850
VOLUNTARY	2,700	3,403	4,22	2,65	2,100
WATER	1,120	4,791	2,52	2,85	3,600

Percent
0,00
12,00

b) Classification of Themes

Figure 4.4 illustrates the three dimensional correspondence analysis of the themes. In accordance with Fuchs this themes are “certification,” “standard,” “sustainable” of the quadrant 2 related to several sustainable certifications. Themes as “tariff” in opposition of “preservation” indicating that they are distant topics, while “tariff” theme deal with issues such as tax, importation rates, North American subsidies and protectionism; “preservation” theme in contrast focused on issues of biodiversity conservation at local context.

Figure 4.4 Three-dimensional display of thematic correspondence analysis.



	Themes	X	Y	Z
I	INDUSTRY	0.2844	0.2802	0.1711
	CLIMATE	0.4396	0.3164	0.1396
	TRADE	0.4452	0.4949	0.2603
	BIOFUELS	0.5443	0.3431	0.1821
	FLEX-FUEL	0.5853	0.0278	0.1153
	TARIFF	0.728	0.4484	0.4348

	Themes	X	Y	Z
II	CERTIFICATION	-0.0384	0.3076	-0.2138
	UNICA	-0.0827	0.4009	0.1367
	SUSTAINABLE	-0.2942	0.2527	0.0146
	SUPPLIER	-0.3085	0.0765	-0.0734
	STANDARD	-0.3176	0.0777	-0.3836
	VOLUNTARY	-0.4328	0.349	-0.099
	REPORT	-0.5459	0.4911	-0.5937
	LABOR	-0.566	0.1718	0.1119
	COMMITTEE	-0.5968	0.8435	-0.6182
	CODE	-0.6554	0.4793	-0.3582
	POSITION	-0.6763	0.3186	-0.0753
	HEALTH	-0.7454	0.0851	0.0133

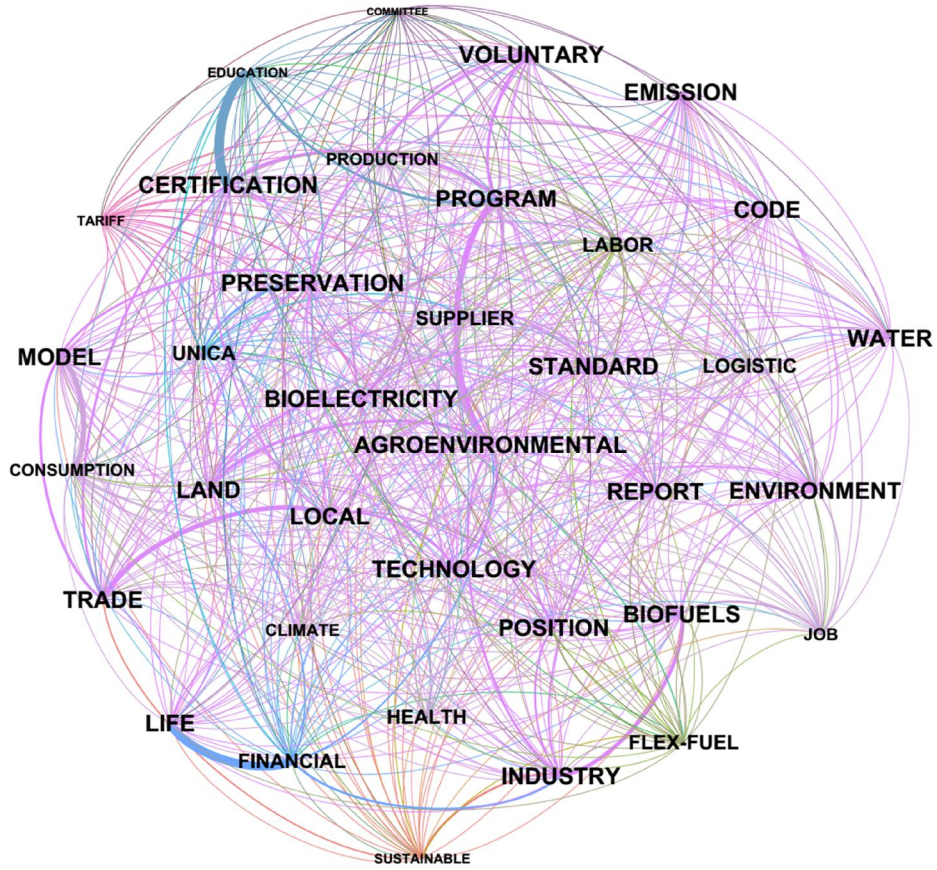
	Themes	X	Y	Z
III	CONSUMPTION	-0.0371	-0.6644	-0.4974
	TECHNOLOGY	-0.0713	-0.1865	-0.0087
	RIPARIAN	-0.1382	-0.7112	-0.1659
	PRESERVATION	-0.145	-0.8263	-0.3743
	MODEL	-0.3565	-0.029	-0.1031
	LOCAL	-0.4872	-0.0088	-0.0473
	PROGRAM	-0.7102	-0.1127	0.4699
	LIFE	-0.7226	-0.0685	0.4155
	EDUCATION	-0.8171	-0.3975	0.9621

	Themes	X	Y	Z
IV	JOB	0.0427	-0.2344	0.1705
	LOGISTIC	0.0728	-0.1558	-0.1179
	AGRO-ENVIRONMENTAL	0.0709	-0.5936	-0.2016
	WATER	0.1172	-0.7957	-0.5786
	PRODUCTION	0.3438	-0.1768	-0.1462
	LAND	0.3904	-0.3314	-0.1489
	FINANCIAL	0.4198	-0.1176	-0.0927
	EMISSION	0.4393	-0.0299	-0.0582
	BIOELECTRICITY	0.4918	-0.2823	-0.1262

Figure 4.5 depicts the network semantic by means of the centrality and the connections between the themes. The weighted degree indicates that the salient topics expressed by the themes “agro-environmental” followed by “certificate” and “program.” Weighted degree assign an importance score based on the number of links held by each node. In this case, the “agro-environmental,” theme with high weight degree value in the network. This can be explained by the fact that the certificate consolidates the best

sustainability practices in the sugarcane production and its requirements range from the elimination of sugarcane burning, soil and water conservation, protection and restoration of riparian areas, and wildlife protection measures. This is also because most of the companies are reporting that they obtained their green ethanol certificate as a result of the implementation of the Agro-environmental Protocol. Related to betweenness centrality and authority measure, almost all themes have values nearby by betweenness measures and authority, which indicate the importance of its influence on the flow of information between other themes in the network, and its importance for company to address as concern in its communications.

Figure 4.5 Network semantic of the themes.



THEME	WEIGHTED DEGREE	AUTHORITY	BETWEENESS ENTRALITY
EMISSION	0.608	0.170106	0.44796
BIOFUELS	1.484	0.170106	0.44796
TARIFF	0.706	0.156268	0.287611
SUSTAINABLE	0.524	0.156527	0.223027
TRADE	1.216	0.170106	0.44796
INDUSTRY	1.438	0.170106	0.44796
ÚNICA	1.078	0.165414	0.418548
LAND	1.36	0.170106	0.44796
LOCAL	1.758	0.170106	0.44796
AGRO-ENVIRONMENTAL	2.004	0.170106	0.44796
FINANCIAL	1.466	0.165414	0.418548
PRODUCTION	1.236	0.161368	0.218928
CLIMATE	0.874	0.161375	0.221011
CERTIFICATION	1.958	0.170106	0.44796
FLEX-FUEL	0.906	0.165674	0.352127
COMMITTEE	0.366	0.151546	0.252261
POSITION	1.116	0.170106	0.44796
PROGRAM	1.896	0.170106	0.44796

THEME	WEIGHTED DEGREE	AUTHORITY	BETWEENESS CENTRALITY
BIOELECTRICITY	1.38	0.170106	0.44796
EDUCATION	1.242	0.15626	0.287611
CODE	0.862	0.170106	0.44796
HEALTH	0.838	0.165808	0.316777
LOGISTIC	0.908	0.165674	0.352194
SUPPLIER	1.352	0.165808	0.316777
MODEL	1.396	0.170106	0.44796
LIFE	1.388	0.170106	0.44796
LABOR	0.986	0.165674	0.352127
REPORT	1.062	0.170106	0.44796
WATER	0.526	0.170106	0.44796
TECHNOLOGY	1.196	0.170106	0.44796
ENVIRONMENT	1.024	0.170106	0.44796
CONSUMPTION	1.056	0.161097	0.286603
STANDARD	1.266	0.170106	0.44796
PRESERVATION	1.652	0.170106	0.44796
JOB	0.764	0.161104	0.288686
VOLUNTARY	1.004	0.170106	0.44796

4.5. Discussion

The results (Figure4.1-Figure 4.5) indicate several CSR and governance-led activities implemented by sugarcane companies as an ongoing process of improvement of socio-environmental conditions and the best production practices. They are as follows:

Agro-environmental Protocol – It refers to a voluntary agreement signed between the representatives of UNICA, the Organization of Cane Planters in the central-south region of Brazil, and the government of the state of São Paulo in 2007 (UNICA, 2017b). The protocol establishes a number of commitments and technical policies, such as early phase-out of sugarcane pre-harvest field burning, establishment of mechanization practices, and protection of riparian forest areas from sugarcane properties. It also proposes and implements the technical plan for the conservation of water resources and reduction of water consumption, and the waste management plan that generated in the agro-industrial process (SMA, 2018).

Upon formalizing this agreement, companies receive the Green Ethanol Certificate or "Green Protocol." This protocol is an important achievement in the industry's environmental agenda emphasizing the positive environmental aspects of mechanization practices by forcing the reduction of GHG emissions and promoting the incorporation of sustainable practices (BENITES-LAZARO; MELLO-THÉRY; LAHSEN, 2017).

Bioelectricity, biofuel, production, and technology – These four themes connect the products and production system of the sugarcane industry and technology, which has been the target of heavy investments in research and technology by both the public and private sectors. Today, sugarcane is the basic feedstock not only for sugar, but also for an impressive and growing variety of value-added products such as bioelectricity and second-generation biofuel from waste and residues such as bagasse and straw. In particular, with an increasing percentage of flex-fuel cars in Brazil, ethanol helps reduce the dominant position held by fossil fuels and contributes toward the reduction of GHG emissions. Hence, it is considered as a technology of national pride (MALONE et al., 2017). These four themes are related to the "**emission," "flex-fuel," and "climate"** themes, which mainly highlight the effectiveness of biofuel in the struggle against climate change. The discourse on sugarcane expansion has been concealed by climate change mitigation, energy security, support from farmers and national development (BENITES-LAZARO; MELLO-THÉRY; LAHSEN, 2017; MALONE et al., 2017).

Certification – Bonsucro or the Better Sugarcane Initiative, which is a multi-stakeholder initiative that develop a global certification scheme to verify and guarantee compliance with sustainability criteria of sugarcane and ethanol production (SELFA; BAIN; MORENO, 2014; UNICA, 2017b). In Brazil, sugarcane producers, faced with a probable dissemination of certifications with rival schemes concentrated efforts to find a more comprehensive alternative and with greater international prestige, are gradually becoming associated with Bonsucro (CONSENTINO, 2017). Members of Bonsucro include representatives from non-government organizations, such as WWF, Ethical Sugar and Solidaridad, and companies and institutions, including Cargill, British Sugar, Bacardi, Cadbury Schweppes, Shell, British Petroleum, Coca-Cola, Cosan and UNICA (UNICA, 2017b).

Bonsucro certification was recognized by the European Union (EU) in July 2011 as a means to meet the sustainability criteria established by the EU Renewable Energy Directive (RED). The EU Bonsucro standard has an additional section of criteria to be met by producers and transformers wishing to sell ethanol in the European market (Moura and Chaddad, 2012). The five main criteria are: (1) complying with applicable laws; (2) respecting human rights and labor standards: complying with ILO labor conventions governing child labor, forced labor, discrimination, freedom of association and collective bargaining, and providing employees with at least the national minimum wage; (3) managing efficiency to enhance sustainability; (4) assessing the impacts of sugar cane companies on biodiversity and the ecosystem; and (5) improving key areas of the business (BONSUCRO, 2017a).

Code, standard, and voluntary - These themes are related to the many codes of conduct and standards adopted by the industry, for example, ISO 9000 and ISO 14000 standards, OHSAS 18001, and sustainability "roundtables" such as Roundtable on Sustainable Biomaterials (RSB, formerly Roundtable on Sustainable Biofuels). Standards are the major mode of governance for biofuels, and voluntary certification. Further, codes of conduct were adopted to safeguard the sustainability of sugarcane production and preserve mandated biofuel demand (MOSER; HILDEBRANDT; BAILIS, 2014).

Education, health, job, and life - These are related to CSR activities. Almost all companies claim to have a vision focused on the development of the region where it owns its units and invests in projects to ensure sustainability in production and guarantee responsible relations, with an aim to improve the quality of life of its employees and their families and community. CSR practices are mainly, concentrated in the areas of education, health, and environment. Education initiatives aim to improve the obstacles of social exclusion, low qualification, and illiteracy through projects that promote the development of the community in which the company operates by investing in the well-being of its employees and their dependents.

Labor and program – These themes are related to the "National Commitment" and "Renovação" program to improve labor conditions and the quality of life of workers in the sugarcane industry, while offering training programs for those willing to shift to other activities due to the mechanization process.

The "National Commitment for the Improvement of Labor Conditions in Sugarcane Production" launched in 2009, is a trilateral agreement between the government, private sector, and labor unions to prioritize the adoption of better labor practices in the sugar-energy industry. Companies that make a voluntary commitment receive a "social certificate." This, voluntary certification program aims to encourage sugarcane producers to implement best labor practices and provide acknowledgment for participating businesses. The certificate was abandoned in 2013 after reports revealing serious violations of labor practices in companies that had gained their social seal of conformity (LABRUTO, 2014).

The "Renovação" is a program for training and retraining sugarcane cutters who are unemployed as a result of the mechanization of sugarcane harvesting. This program was implemented by UNICA, and its members have joined with the Federation of Rural Wage Earners in the State of São Paulo (FERAESP).

Land, preservation, and riparian - These themes are related to the Sugarcane Agroecological Zoning program (ZAE Cana), which was launched in 2009 with an aim

to guide the sustainable expansion of sugarcane production and eliminate any possibility of expansion that might lead to deforestation. Further, it ensures that no sugarcane is planted in the country's most sensitive biomass: the Amazon, the Pantanal, and the Upper Paraguayan Basin. This zoning program comprises information on soil and potential climate, surface water availability, underground water vulnerability, restrictions on mechanized harvesting, and the protection of biodiversity and conservation units (COELHO; GUARDABASSI, 2014).

Financial, trade, industry, logistic, model, and position – The sugarcane industry in Brazil is considered as a driver of development with an extensive social development and a base of economic support in the country (GOLDEMBERG; COELHO; GUARDABASSI, 2008). However, the economic performance of ethanol production is affected by external, economic, social, political, and climatic factors such as the fluctuation of energy market, extreme weather that disturbs logistic and agricultural operations, as well as variations in subsidy policy. For example, RenovaBio, a new biofuel policy that encourages the production of ethanol, both for energy security and the reduction of GHG emissions, but which places challenges and concerns about the socio-environmental impacts of the expansion of sugarcane.

Water and consumption - Sugarcane is the most irrigated crop in the country covering around 30% of the total land under cultivation. Although sugarcane is a crop with good resistance to water stress, to derive benefits in terms of productivity, longevity, and quality, its growth and development is largely dependent on favorable water conditions (AGÊNCIA NACIONAL DE ÁGUAS, 2017). In watersheds with less water availability, sugarcane production can be a significant competitor for water resources. These impacts, which can deteriorate water resources through intensive use, can be mitigated by the management of water resources through the efficient reuse of abstracted water. According to its analyzed communications, companies are seeking to reduce its water consumption through new water reusing technologies, better control of volumes of recycled water, and effectively monitored cooling towers . Furthermore, it highlights the importance of the participation of UNICA as the titular and substitute member of the State Water Council and the river basin committees in São Paulo. The

body of Council is responsible for discussing and approving the State Policy on Water Resources in the State of São Paulo (UNICA, 2017b) .

These themes (Figure 4.1) reveal the sugarcane industry's efforts in defining sustainable practices, for instance, the use of water and land, and their CSR practices, mainly the social initiatives for the community and employees such as focus on health and education programs, initiatives aimed at the preservation of the environment related to conservation, densification, and tree planting. It also reveals the active participation, especially through UNICA, in implementing the rule-setting agenda for the sector, establishing codes of conduct through initiatives and certifications that support the sustainability of biofuel production.

One channel by which UNICA and the sugarcane companies exercise their structural power (Fuchs, 2007) is through the cooperation and participatory governance in the form of PPPs, for example, the establishment of the Agro-environmental Protocol, the participation in the committee of Bonsucro in Brazil, the National Commitment, the Renovação program, and the UNICA participation in the State Water Council and the river basin committees in São Paulo state. This mode of ethanol governance has established its legitimacy through the participation of multi-stakeholders agents. Particularly with regard to the standards and certification schemes such as RSB and Bonsucro, which provide sustainability compliance of sugarcane and ethanol production (BONSUCRO, 2017a; RSB, 2017), its governance is based on cooperation between companies and non-government organizations, with public institutions playing only a minor role (SELFA; BAIN; MORENO, 2014; DE MAN; GERMAN, 2017).

However, some studies indicate deficiencies of this type of multi-stakeholder standards and certification system regulations. An analysis of Bonsucro and RSB found severe constraints on their ability to discipline the companies upon which they are financially dependent, and on their standards (FORTIN; RICHARDSON, 2013). The threat of certificate withdrawal for participating firms is often softened in practice by the option to withdraw, thereby allowing companies to "save face" by withdrawing rather than being sanctioned (SELFA; BAIN; MORENO, 2014). In their study, Selfa et al. (2014)

demonstrate how Bonsucro certification legitimizes the expansion of biofuel production in Colombia and the expansion of legal water grabs. Despite the private governance attempts to achieve legitimacy through stakeholder representativeness and trustworthiness, these standards often reflect the unequal balance of power, privilege of powerful actors, and conventional production systems (ELGERT, 2012; SELFA; BAIN; MORENO, 2014).

On the other hand, CSR practices has its importance in the factor fortification of the socially responsible image with direct, and indirect beneficiaries, financing companies, community, clients, government, and the press. Sugarcane production has been viewed as an extremely degraded agricultural system, and has been associated with unsustainable practices as described in the introduction section, which has led to great social and environmental impact. Thus, efforts have been made to improve the image of this environmentally degrading sector to gradually change by adopting more sustainable, and new technologies with a concern for meeting public policies and incorporating environmental awareness.

This study reveals that companies have adopted various CSR activities as a response to criticisms. For instance, the National Commitment was established in response to the criticism of poor labor conditions. The Agro-environmental Protocol as a response to the criticism on air pollution by sugarcane pre-harvest field burning, and the problems in the respiratory health of the population. The agro-ecological zoning as a response to the criticism on the expansion of sugarcane production and deforestation. The Renovação program was adopted as a response to the criticism on unemployment of sugarcane cutters; the companies began to voluntarily implement several initiatives aimed at the requalification of these workers seeking new work opportunities within their own mills or in other segments of the economy. This results are consistent with previous studies that indicate that companies adopt CSR activities as a response to criticisms and demands from stakeholders seeking social acceptance and legitimacy (BENITES-LAZARO; MELLO-THÉRY, 2017).

Furthermore, this study reveals that motivation of sugarcane ethanol companies for carrying out activities that indicate their concern with sustainability and establishing codes and global standards such as Bonsucro and RSB has been by the interest in entering the foreign market. The introduction of sustainability regulations as a de-facto precondition for market access has brought new costs to the biofuel industry, making sustainability certification a tool for opening doors to new markets (PACINI et al., 2013; MOSER; HILDEBRANDT; BAILIS, 2014).

The sugarcane sector, despite the criticisms, is recognized as a sustainable industry for its products such as ethanol, bioelectricity, bioplastic, and the second-generation biofuel. The sector has displayed advances and transformation in the production system, making significant contributions in defining sustainable practices. Nevertheless, there are still critical issues, such as the management of the use of water, energy, and their potential conflicts with food production and indirect land-use changes that the companies are not communicating with detailed actions, but only as mere compliance actions. Further, there is no integrative management considering synergies and tradeoffs between different sectors and actors, especially for the development of the water-energy-food nexus in the context of climate change (HOFF, 2011; GIATTI et al., 2016). Another relevant issue is the labor conditions of workers, mainly because there is still a good percentage of manual cane cutting that has been associated with very severe risks to workers' health due to exposure to heatstroke and extremely intense work rhythms involving repetitive movements and perilous postural (VILELA et al., 2015; ROSCANI et al., 2017).

It is worth stressing that a greater part of the sugarcane production lands are exposed to water-scarce territory of São Paulo's macrometropolis (GIATTI et al., 2016). Hence, more interconnected initiatives are necessary to deal with the sustainability of sugarcane ethanol production chain (e.g., the issue of resilience related to sustainability). In this sense, once there is a clear concern connecting climate, reduction of GHG emissions, and biofuel, there should be another viewpoint considering the vulnerability of the sector to droughts that can become more severe and frequent due to climate change. For instance, in the interconnected territory with the overlapping and interdependent

scarcities of water, energy, and food, the constraints and risks for sugarcane production must be a very relevant aspect for sustainability.

4.6. Conclusions

In this study, we examined the structural power of business in the Brazilian sugarcane ethanol companies by identifying the rule-setting power in which they engage, how they can facilitate their business for commitment to sustainability, and why they developed and use institutions to promote sustainability performance and encourage concern with the best production practices. The results show that the sugarcane industry conducted numerous practices for sustainability and has established standards, and codes of conduct. Particularly through an alliance between UNICA and the Brazilian government, it has advanced in the area of sustainability by creating policies, actions, and programs to establish voluntary best practices in companies. These arrangements such as green ethanol certificate as a result of the implementation of the Agro-environmental Protocol; and the ethanol social certificate that government created to guarantee for social sustainability internationally resultant of the National Commitment program, have helped minimize criticism on its unsustainable socio-environmental practices.

The results reveal that in the context of the sugarcane ethanol industry, the structural power of business is exercised as a problem-solving tool to reinforce social and environmental improvement and economic fairness in the production system. The business response to the society in the face of complex environmental and social issues (e.g., climate change, water and energy insecurity) are increasingly required for companies to engage in institutional entrepreneurship. By applying codes of conduct and sustainability certifications contribute to new governance arrangements, and responding to criticisms.

The results also suggest that the industry's production system is not yet managed properly. The decision taken in this sector may have consequences in other sectors, if it does not consider the interconnections and interdependencies with other sectors, such as

the nexus of climate, energy, and water, as well as the threatening climate change. As the economic performance of the industry is affected by social, political, and climatic factors, careful planning and decision-making are necessary across multiple government sectors and agencies to formulate strategies that recognize deep interdependencies between sectors to ensure sustainable expansion of sugarcane production. Thus, future research should focus on analyzing the relationship between actors in different sectors and, in particular, water-energy-food nexus in the production of ethanol and their management challenges. In addition, the results of this study could be used to conduct more in-depth analysis on each of the themes.

5. BUSINESS STORYTELLING ABOUT ENERGY AND CLIMATE CHANGE: THE CASE OF BRAZIL'S ETHANOL INDUSTRY[6]

5.1 Introduction

Brazil's program to produce ethanol from sugarcane has gone through various phases during its more than forty-year existence. Nowadays, its environmental benefits are widely touted among its advocates (LEHTONEN, 2014), but the country's military regime initially launched the National Alcohol Program (colloquially referred to as Proálcool), from which it arose in 1975 to meet geopolitical and energy security objectives. Ethanol production from sugarcane was spurred by a need to enhance the trade balance and national energy self-sufficiency in the context of an economically deleterious trade deficit provoked by dependence on foreign oil and the 1973 international oil crisis (GOLDEMBERG; COELHO; GUARDABASSI, 2008). Proálcool became an important pillar of the military dictatorship's great ambitions to transform Brazil into a superpower (LANNERSTEDT, 2013). The change in the energy supply matrix assumed the ability to produce food and energy simultaneously, in the process helping tropical Brazil to achieve its geopolitical ambitions (VIDAL, 2005; CARVALHO-NETTO et al., 2014).

Proálcool contributed to the successful development of the sugar-ethanol industry. During the first ten years of the program alone (1975-1985), the territory dedicated to ethanol production doubled and production almost tripled, reflecting significant increases in yields. The expansion of sugarcane has been constant since 1975 although production was slower between 1985 and 2000 (SILVEIRA; JOHNSON, 2016). In 2003, the introduction of flex-fuel automobiles resulted in significant increases in ethanol production investments, further consolidating the industry and leading to the formation of large companies (DE MORAES; ZILBERMAN, 2014).

[6] This chapter is based in the paper: Benites-Lazaro, L.L., de Mello-Théry, N.A., Lahsen, M. Business storytelling about energy and climate change: The case of Brazil's ethanol industry. Published at the Energy Research & Social Science, Volume 31, September 2017, Pages 77-85. doi.org/10.1016/j.erss.2017.06.008.
https://www.sciencedirect.com/science/article/pii/S2214629617301834

In recent decades, recognition of the environmental benefits from sugarcane ethanol has grown in the context of worldwide interest in renewable fuels to reduce pollution and climate-altering greenhouse gas (GHG) emissions (DE MORAES; ZILBERMAN, 2014). Today, Brazil is the country where renewable energy contributes the largest part of the total national energy matrix, representing 42% of all renewable energy (MINISTÉRIO DE ENERGIA E MINAS, 2016), and bioenergy of sugarcane alone accounts for 18% of all energy sources (CORTEZ, 2016). The government forecasts that 45% of its energy will come from renewable sources in 2024 (PORTAL BRASIL, 2015), and it presents biofuels as a necessary component of this transformation. The sugarcane ethanol is presented as a "Brazilian solution" to the problems of fossil fuel dependence and climate change (BNDE; CGEE, 2008).

As expressed in the Intended Nationally Determined Contribution (INDC) communication under the United Nations Framework Convention on Climate Change (UNFCCC), Brazil has one of the largest and most successful biofuel programs to date, including cogeneration of electricity using biomass. In its INDC communication presented in the context of the Paris Agreement, the country made two main pledges involving the energy sector: (1) achieve 45% of renewable in the energy mix by 2030, something it in large part would achieve by expanding the demand for renewable energy sources; (2) increase the share of sustainable biofuel in the Brazilian energy mix to approximately 18% by 2030 by expanding biofuel consumption, enabled by an increase in ethanol production, in part, from second generation biofuels, and increasing the share of biodiesel in the diesel mix (UNFCCC, 2015).

Brazil's ambitious pledge under the UNFCCC, and the recognition of the strategic importance of sugarcane ethanol to achieve these commitments are celebrated by the sugarcane industry (KUTAS, 2015). However, in addition to the poor labor conditions offered by the industry, the economic and environmental virtues of ethanol have become contested, including its alleged potential for GHG emissions reductions (SENGERS; RAVEN; VAN VENROOIJ, 2010; GASPARATOS; STROMBERG, 2012). Important critics tie it to harmful land use change and deforestation, hunger in developing countries, food and water insecurity and biodiversity losses (NAYLOR et

al., 2007; GERBENS-LEENES; HOEKSTRA; VAN DER MEER, 2009; LAPOLA et al., 2010; FRANCO et al., 2016). As these criticisms run counter to the three pillars of sustainability, the problems they point to would need to be addressed by the sugarcane sector to legitimize its claims that ethanol production indeed is sustainable.

To achieve this end, companies often employ storytelling as a strategic resource (BOJE, 1995, 2008; MARZEC, 2007) to improve perceptions of their legitimacy in different contexts among both internal and external constituents (HARDY; LAWRENCE; PHILLIPS, 1998; BOWMAN et al., 2013). Their storytelling adds to the strength of conventional corporate communications by delivering a powerful engagement message to influence their stakeholders (MARZEC, 2007).

This paper examines the predominant business storytelling ploys used by the Brazilian Sugarcane Industry Association (UNICA) to promote positive images of the sugarcane companies as an environmentally and socially responsible industry. We analyzed thirty-five videos and multimedia presentations of UNICA's marketing communications. This was carried out by means of qualitative and quantitative narrative analysis (FRANZOSI, 2010; COMPAGNO, 2014) using the software packages T-Lab (LANCIA, 2017) and Iramuteq (IRAMUTEQ, 2017), and drawing on Janda and Topouzi's story typology of hero, learning and horror stories (JANDA; TOPOUZI, 2015).

5.2 Literature Review

5.2.1. Climate Change, Energy and associated Storytelling

The contemporary quest for a transition to a low carbon economy to reduce greenhouse gas emissions to levels that minimize deleterious interference in the natural climate system centers on moving away from fossil fuel dependence (BAO; MIAO; CHEN, 2008; URRY, 2010). Fossil fuel combustion for energy generation was pointed out as the largest contributor to climate change, accounting for 68% of the world's total emissions (INTERNATIONAL ENERGY AGENCY, 2015).

Scientists stress that the negative impacts from fossil fuel use and the threat of climate change at the local, regional and global levels need to be countered by a transition to renewable energy sources, meeting rising energy needs with a variety of more sustainable energy technologies (GOLDEMBERG; COELHO; GUARDABASSI, 2008; SENGERS; RAVEN; VAN VENROOIJ, 2010)

The unprecedented increase in energy consumption and the energy policies that promote it represent the energy as fundamental for development (PAYNE, 2010; BARCA, 2011) and were portrayed with narratives of economic growth and the industrial revolution (BARCA, 2011). As Benites and Gremaud (BENITES; GREMAUD, 2017) show in a study of the Kyoto Protocol's Clean Development Mechanism (CDM) projects in Latin America and its contribution to sustainable development, the energy generation CDM projects predominate in the region. The energy sector is seen as strategic to maintain the economic development. Due to, this strategic importance the energy projects receive political-institutional incentives for their implementation. In the Brazilian sugarcane case, for instance, the initial motivation to execute CDM projects was by political-economic incentives, mainly related to the Program of Incentives for Alternative Electricity Sources (PROINFA), which promotes to increase the share of electricity produced from wind, biomass and small hydro sources to the national interconnected electrical system. In addition to incentives and subsidies of PROINFA, the government provided the guarantee that all this generated energy would be purchased by Eletrobrás –the Brazilian electric utilities company. Thus, the sugarcane industry would have the opportunity to intensify its business through the sale of energy generated from the sugarcane bagasse and the sale of Certified Emission Reductions (CERs) generated by CDM.

In recent decades, the threat of human-induced climate change assessed by the International Panel on Climate Change (IPCC) (INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC), 2013) has led government actors, companies, organizations and community movements to press for climate policies on the authority of the science (WHITMARSH, 2011; ARNOLD, 2015). Narratives deployed by these groups often reflect apocalyptic visions (SWYNGEDOUW, 2010) and adopt messages

of urgent, moral imperatives for a world-wide rise in cultural awareness among the political elites and wider public for the need for a new understanding and acceptance of human responsibility (DANIELS; ENDFIELD, 2009; HAMBLYN, 2009; BROWN et al., 2011).

In their analysis of the climate change discourse in the UK, Ereaut and Segnit characterize climate change narratives as integrating a lexicon calling for urgent action, a lexicon which deploys two dominant repertoires that, respectively, are alarmist and optimistic (EREAUT; SEGNIT, 2006). Transmitting narratives and images like polar bears stranded on bits of ice sheets which have become iconic of climate change, or it depicting human struggles with famine, droughts, floods and water shortages (NEILL; NICHOLSON-COLE, 2009). The alarmist repertoire is fundamentally pessimistic, with narratives of doom, death, judgment, heaven and hell (EREAUT; SEGNIT, 2006).

The optimistic repertoire comes in two versions: personal and corporate. The personal form of this repertoire is about small changes among a large number of people to counter climate change, constructed as motivated by ethics and/or self-interest (EREAUT; SEGNIT, 2006). The corporate model argues that tackling climate change can be handled by businesses and will result in economic benefits which are outweighing the costs. This repertoire is also one of the three key strands that Diana Liverman (LIVERMAN, 2009) identifies among international climate policy narratives, distinguished for its framing of the market as a source of solutions, mainly in the form of carbon trading to mitigate climate change. This repertoire is related to the emergence of a corporate social responsibility discourse (CSR) (EREAUT; SEGNIT, 2006; ALLEN; CRAIG, 2016).

In business discourses, climate change emerges as a “new narrative” of opportunity (LIVERMAN, 2009) rather than a threat (BULKELEY; NEWELL, 2015) positioning the companies at the forefront of the climate solutions (HAWKEN; LOVINS; LOVINS, 2010). The opportunity consists in benefits to be derived from emissions trading, and from investments in clean technology (BULKELEY; NEWELL, 2015). The opportunity to profit from taking action on climate change (BULKELEY; NEWELL, 2015) emerged

in the Kyoto Protocol's flexible mechanisms. An example of this, the CDM became a focus of business environmentalism (LIVERMAN, 2009), portrayed as a means of achieving sustainable development, economic savings for companies through economic efficiency, and as offering new business opportunities for development of projects and tradable credits for GHG reductions (BUMPUS; LIVERMAN, 2008). The CDM has also been used to showcase the CSR initiatives that benefit local communities (BENITES-LAZARO; MELLO-THÉRY, 2017).

Storytelling can be important in the "framing, explanation, motivation, and understanding of policies and strategies" such as is described by Janda and Topouzi (JANDA; TOPOUZI, 2015). These authors use three kinds of stories: hero stories, learning stories and horror stories to examine the UK government's energy policy for buildings. The authors describe an energy hero story as being about seeing technology as "a silver bullet (one technology) or silver buckshot (combination of things)" frequently promised to be the "magic elixir" that will save society from climate change. In a learning story, according to the authors "there are no heroes and no villains", the protagonists are common people who need to respond to a challenge and they must rely on their own actions. This story "can be difficult and contentious" and "asks for participation, reflection and does not provide a single truth". The story occurs in all the detailed richness and peculiar elements of the real world.

Horror stories are different from hero and learning story types that are inspiring and educational (JANDA; TOPOUZI, 2015). They are scary stories about the construction of evil and its relationship with the real world. This include polarization between the hero and the villain (ARNOLD, 2015). "Horror is more than just fear. Horror, unlike fear, seems to have existential significance embedded within it" (ASMA, 2014). According to Janda and Topouzi, one main characteristic of the horror story is the incredulity of people who are close to the evil threat surrounding them all, as also portrayed in the climate change focused film "The Day After Tomorrow". Climate change appears as horror like, "it is invisible to the naked eye; it reveals itself over time; it is supra-natural if not super-natural; and there are many disbelievers" (JANDA; TOPOUZI, 2015).

5.2.2 Storytelling in the business practices

Storytelling is a central part of individual lives, but common storylines also structure how corporations convey their strategies and actions (MARZEC, 2007). In storytelling, there are implicit rules for who can tell stories, to whom, and where, and for how stories can be told and experiences framed (BOJE, 2008). Similarly, dominant tropes guide how people make sense of corporate events or how they fail to do so (BOJE, 2001; GABRIEL, 2004). A shared storyline "evokes a common vision of the future, sketches the journey to achieve that vision, [and] identifies critical milestones along the way"(MARZEC, 2007).

In modern business practice, storytelling is also a tool by which to facilitate knowledge sharing (JAMES; MINNIS, 2004) and to build trust, transfer tacit knowledge, develop norms, facilitate un/learning, and generate emotional connections (SOLE; WILSON, 2004). Business campaigns are commonly designed to get stakeholders to share the company's spirit and goals in ways that engage, "build community interaction and elicit emotional responses" (HOWARD, 2016). Thus, "the nature of stories that are designed to share or convey knowledge" is the ultimate purpose "to promote and disseminate 'effective action', either in the performance of specific tasks or in general behavior" (SOLE; WILSON, 2004).

The symbols and meanings generated by storytelling are generally – consciously or unconsciously used to achieve certain goals (BOWMAN et al., 2013). The storytelling of a variety of industries are viewed as strategies (BOJE, 1995, 2008; MARZEC, 2007) that integrate "an array of tools, each suitable to a different business purpose" (DENNING, 2006) and which are purposefully used to manage and convey meaning (VAARA; TIENARI, 2011). Often, such discourses disclose less of what happened and more of something equally important: what people believe or want to believe has happened or ought to happen (GABRIEL, 2004), and it is possible to elaborate and enrich them, infusing them with new meaning (BOWMAN et al., 2013).

The storytelling approaches are useful resources for companies in the context of growing public concern for the environment, serving to advance a new ideology about CSR by shaping public understanding of the nature of the environmental challenges and eliciting practices and responses to threats such as climate change. For instance, businesses may try to sell their products with claims about their eco-friendliness, urging citizens to help the environment by using them (ENGARDIO et al., 2007; CHEN, 2016). In recent decades, images of the natural environment have become a persistent part of rhetorical strategies evident in companies' advertising, strategies which rework prominent images, messages, dreams and desires (GUNSTER, 2007; CHEN, 2016).

Some studies focused on visual narratives of companies' advertisements discuss how the invocation of natural themes reinforces the escapism promoted by their products while obfuscating the devastating environmental impacts of these products (CHEN, 2016). As showed in the study of North American automobile advertising conducted by Gunster (GUNSTER, 2007), the car's mobility is reconfigured as opening passageways into epic landscapes. Reverent images of nature used in the advertising materials are presented as a "seductive antidote" to the endlessly-mediated quality of the virtues of auto-mobility. "The industrial power of the car combines with the raw physicality of nature to offer us a momentary transcendence of the gap that otherwise separates us from the real" (GUNSTER, 2007).

Similarly, in a survey of 24 advertisements produced by four top-selling automobile brands in China, Chen (CHEN, 2016) notes that nature is constantly framed in the advertisements "as either a valuable commodity for human consumption or an added value for high-end car models that in fact have low energy efficiency". Implicitly, as the author shows, the car's advertisements in China appropriate the growing public concern about the deterioration of the environment to create the illusion that the car can be reconciled with green consumerism.

Another study of Budinsky and Bryant (BUDINSKY; BRYANT, 2013) shows how green advertisements in Canada of Clorox Green Works cleaning products, the Ford Escape Hybrid, and Toyota Prius motor vehicles are re-contextualized "the ways in

which environmental messages and ideas are appropriate and used to obfuscate" important issues such as climate change or sustainability. For instance, according to authors, the Clorox brand is founded upon caustic chemical cleaners that use ingredients that are damaging to the human health, the environment or both. However, the company presents their products as "all-natural" and "therefore clean and safe". Furthermore, for authors, the cars' advertisement demonstrates the contradictions that exist in the visual imagery representation of the car in connection of humans to nature, versus the impact of these vehicles on our planet and the contribution to the world's carbon footprint.

In her study of business power in global governance, Doris Fuchs (FUCHS, 2007) shows how companies strategically shape norms and ideas through the use of selected story-lines and symbols. Through the power of discourse, they associate the role of accepted "truths" about desirable policies with their own corporate goals, and generally seek to control and influence the public perception of their business activities. This discursive power is also exercised via sponsoring and advertisement activities as well as so-called "reports" or multimedia presentations. Values, lifestyles, and identities communicated through these channels shape politics and society, for instance, currently fostering individualistic and materialistic values and depoliticized lifestyles.

A study by Fuchs with Jennifer Clapp (CLAPP; FUCHS, 2009) analyzed agri-food corporations' discursive practices, showing that grain industries through persistent public statements promoted arguments in favor of the approach to US food aid policy that benefited them, thus influencing the public debate on the topic and winning Congressional support. The most prominent industry argument in favor of in-kind food aid portrayed it as a source of pride for Americans, while also invoking a series of arguments about the importance of developing future markets, protecting national security and fighting both corruption and AIDS in the developing world. In this manner, they framed the debate over food aid such that their favored approach came to be seen as the right and moral approach to food aid.

5.3 Material and Methods

In this study we used of both qualitative and quantitative narrative analysis that makes use of statistical tools and qualitative interpretation to explore connections between words and numbers and between properties of specific narratives and specific types of statistical analyses (FRANZOSI, 2010; COMPAGNO, 2014).

Narrative analysis provides insights into how phenomena such as company and management practices are discursively constructed and transformed, and how linguistic processes of storytelling are at the core of organizational and managerial activity (VAARA, 2010). Identified narratives or stories can be subjected to either qualitative or quantitative analysis (FRANZOSI, 2010). Whereas qualitative analysis of storytelling or narratives is nearly as old as the history of humanity (RIESSMAN, 2008; FRANZOSI, 2010), "quantitative analysis of narratives is a much more recent scientific endeavor" that is usually carried out with the help of computer software that will allow us to store or retrieve the information of a narrative text into the categories of a story (FRANZOSI, 2010).

For Cortini and Tria (CORTINI; TRIA, 2014) there are three ways of approaching textual material: 1) A researcher can focus on the way in which discourses have been told, on the premise that what does matter is the how something is said – for instance, certain metaphors and peculiar word choices; 2) The same textual material can be analyzed for references made – e.g. the number of repetitions of singular words and of word associations, assuming that what counts is quantity; Or 3) A mixed-method taking advantage of both the qualitative, anchored to narrative analysis, and also quantitative perspectives in texts, assuming that both the number of repetitions and the peculiar way by which something has been said may play an important role in the text analysis.

In this paper, we adopt the third approach and we use software package Iramuteq (IRAMUTEQ, 2017) and T-Lab (LANCIA, 2017), an all-in-one set of statistical, linguistic, and graphical tools for text analysis, which allow a mix of qualitative and quantitative analysis. We use the multidimensional scaling (MDS) T-Lab tool. One of

the techniques that T-Lab uses is MDS Sammon method, a set of data analysis techniques that allow analysis of similarity matrices by visually representing the relationships among the data within a space of reduced dimensions, in this case to represent relationships among the lexical units (words) (VELTRI; ATANASOVA, 2015; LANCIA, 2017).

We also used several tools offered by the IRaMuTeQ software such as:

1) The classification method of Descending Hierarchical Classification (DHC), which consists in calculating the frequency of a word occurring in the text linking the number of occurrences of each word and their positions of the larger text. From this calculation, IRaMuTeQ software determines a statistical frequency indicator known as chi-square ($\chi 2$). It obtains clusters of text segments that present similar vocabulary. From these matrix analyses IRaMuTeQ organizes the data into a DHC dendogram which illustrates relationships between the clusters. The software performs calculations and provides results that allow a description of each of the clusters in terms of their characteristic vocabulary (lexicon) and their variables (asterisks).
2) It provides textual context or "elemental context" (in T-Lab terms) of the text that allow insight into how "text and talk" are adapted to their social environment (VAN DIJK, 2009), which facilitates the qualitative analysis.
3) The software also provides another way of graphing representation of the results on bi-dimensional spaces constructed along explanatory factors, through a factorial correspondence analysis made from DHC. Based on the selected clusters, the program calculates and provides the most characteristic text segments of each cluster (corpus in color), allowing the contextualization of the vocabulary typical of each cluster (CAMARGO; JUSTO, 2013).

The corpus (data) for this study consists in transcripts from thirty-five videos and multimedia presentations of marketing communications sponsored by UNICA between the years 2007 and 2016, productions we extracted from UNICA's web site. UNICA's public communication includes opinions, sustainability reports, press releases and

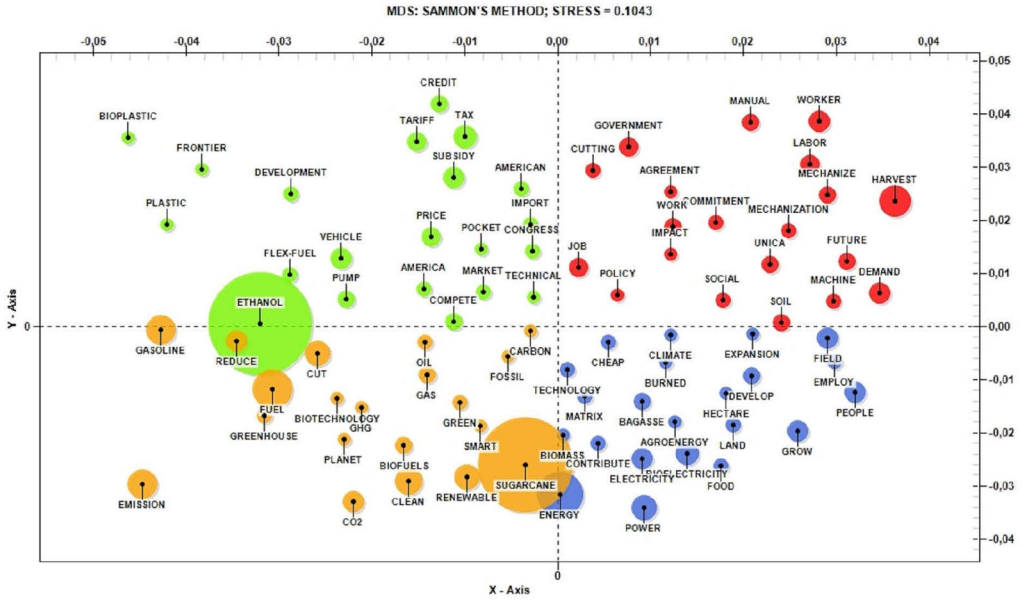
statements, publications and documents, videos and multimedia presentations of the marketing communication including advertising campaigns, jingles, spots and information campaigns. The largest organization in Brazil representing sugar, ethanol, and bioelectricity producers, UNICA's official mission is to play a leading role in the consolidation of the Brazilian sugarcane industry as a modern agribusiness complex equipped to compete sustainably. UNICA members are responsible for more than 50 percent of all ethanol produced in Brazil and 60 percent of overall sugar production (UNICA, 2017b).

5.4 Results and discussion

Figure 5.1 shows the MDS map obtained using T-Lab to analyze the discourses of the thirty-five transcribed marketing communications in the form of videos. The degree of correspondence between the distances among the points is measured by a *Stress function* – the lower the stress value (e.g. < 0.10), the greater the goodness of the obtained adjustment (LANCIA, 2017). As shown in Figure5.1, the stress value is 0.10, so that is a good statistical representation of our analysis.

The MDS of Figure 5.1 divided the data into four thematic areas and their *stress* value. The top side of the green color centers on two main topics: (1) U.S. ethanol policy in the form of subsidies, tariffs and taxes applied to Brazilian sugarcane ethanol, and 2) shows "ethanol" as dominant topic in discussions about green and renewable products from the industry, such as bioelectricity, bioplastic, or flex-fuel vehicles. The red color is about the São Paulo state law Agro-Environmental Protocol, the so-called "green protocol or green ethanol", which establishes mechanization practices and the elimination of sugarcane straw burning, and is dominated by the words "mechanization," "harvest," "machine", "worker". The orange words encompass "sugarcane", "renewables", "energy", "emission", "cut" and "CO2", "green" and "smart" are about strategies for reducing emissions of GHG from sugarcane ethanol contribution. The blue side presented topics as "technology", "matrix", "land", "expansion" and "food".

Figure5.1 MDS map of sugarcane marketing communications



word	X-axis	Y-axis	OCC
ETHANOL	-0.0319	6.332E-4	142
SUGARCANE	-0.0034	-0.0259	130
ENERGY	2.441E-4	-0.0315	54
FUEL	-0.0307	-0.0117	44
HARVEST	0.0362	0.0237	31
EMISSION	-0.0446	-0.0297	28
GASOLINE	-0.0426	-5.836E-4	27
CLEAN	-0.0160	-0.0290	24
POWER	0.0093	-0.0340	23
CUT	-0.0258	-0.0050	22
RENEWABLE	-0.0098	-0.0283	21
BIOELECTRICITY	0.0139	-0.0238	20
TAX	-0.0099	0.0359	18
REDUCE	-0.0345	-0.0027	17
WORKER	0.0281	0.0386	17
CO2	-0.0220	-0.0328	17
FIELD	0.0289	-0.0020	17
PEOPLE	0.0320	-0.0123	16

word	X-axis	Y-axis	OCC
GROW	0.0258	-0.0195	15
VEHICLE	-0.0232	0.0129	15
SUBSIDY	-0.0112	0.0280	15
DEMAND	0.0346	0.0064	14
ELECTRICITY	0.0090	-0.0248	14
TARIFF	-0.0151	0.0347	12
JOB	0.0022	0.0110	11
LABOR	0.0271	0.0305	11
GOVERNMENT	0.0076	0.0338	11
PRICE	-0.0136	0.0170	11
FUTURE	0.0311	0.0122	10
GAS	-0.0140	-0.0090	10
DEVELOP	0.0208	-0.0092	10
BAGASSE	0.0091	-0.0140	10
BIOFUELS	-0.0165	-0.0224	10
WORK	0.0124	0.0188	10
SOIL	0.0240	7.629E-4	10
UNICA	0.0228	0.0117	9

Figure 5.2 shows the factorial analysis of correspondence, which was applied to the text data using the IRaMuTeQ software. Analysis of correspondence makes it possible to synthesize the information and thus facilitate its interpretation by means of graphs in which the relationships between both the corpus and the lexical units (words) that make them up are represented. The software algorithm was able to determine 3 clusters and 100 percent of the sum between the factors of the axis “x” and axis “y”, which is considered a good quality analysis (IRAMUTEQ, 2017). The factorial analysis is interpreted in terms of the opposition between axes. In Figure 5.2, the blue color related to the U.S. ethanol policy in opposition to the green color which was about the Brazilian

green protocol. The topic on the top side of the red color is neutral because it is in a central position and not on the axes. This topic is mainly related to ethanol's benefits and contributions to reducing greenhouse emissions.

Figure 5.2 Factorial analysis of correspondence

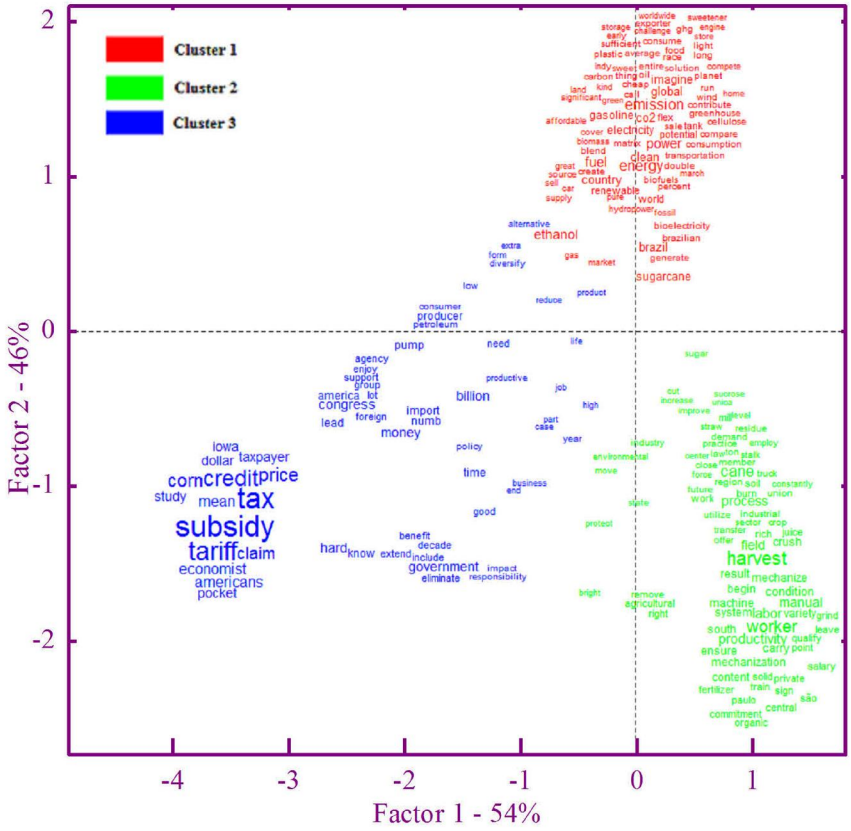
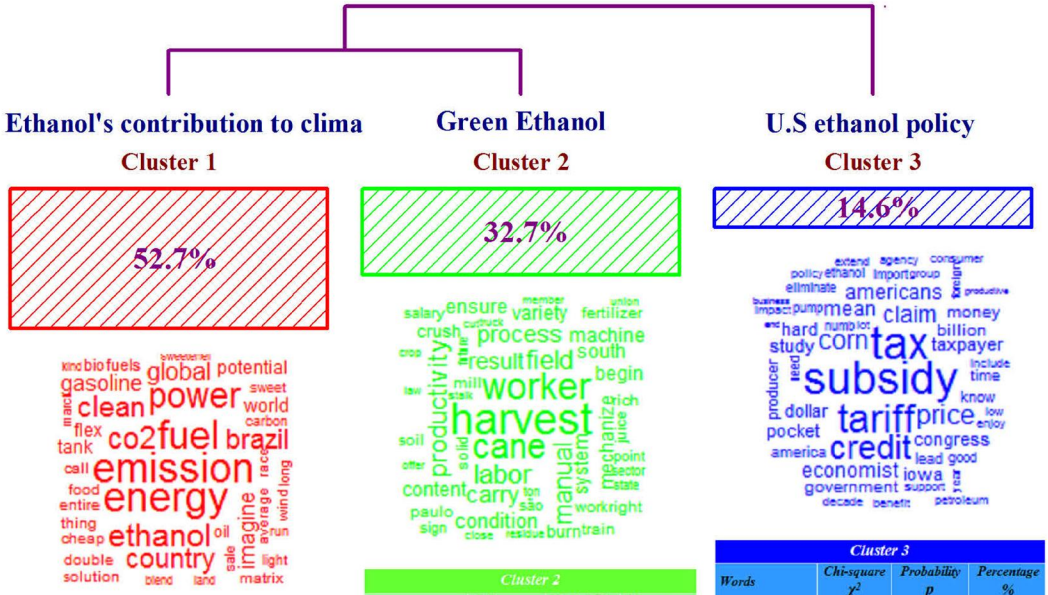


Figure 5.3 shows the DHC dendrogram. In this study, the DHC dendogram divided the data into three clusters with their respective percentages and chi-square values. In each cluster, the words with higher Chi-square values and higher probability allow us to infer the topic in this cluster. The first cluster comprises 108 classified segments, 52.7%, of a total of 205.With 67 classified segments, cluster 2 represents 32.7% of the total segments, and cluster 3, 14.6%, with a total of 30 segments. The chi-square column shows the result of the dependency test: the higher the chi-square, the more likely the hypothesis of dependence between word and cluster. According to this method, for an *error* of 5%, a theoretical chi-square value of 3.84 makes it possible to validate the dependence of two variables. Finally, "p" is the probability, the risk that the chi-square

dependency test is false: the lesser the "p" value, the lesser the margin of error of the dependency tests. This table provides the list of words significantly associated with this clusters according to the value of the chi-square. A chi-square greater than >10 provides very reliable results.

Thus, cluster 1 with the dominant words of "emission," "energy", "fuel," "ethanol" and "CO2" concerns the contribution of sugarcane ethanol to greenhouse emissions reductions. With the representative words of "harvest", "worker", "manual", "burn" and "mechanization", cluster 2 is about São Paulo's Agro-Environmental Protocol. Marked by the words "subsidy", "tax" and "tariff", cluster 3 is related to U.S policy and domestic market controls.

Figure 5.3 DHC dendrogram of the sugarcane marketing campaign



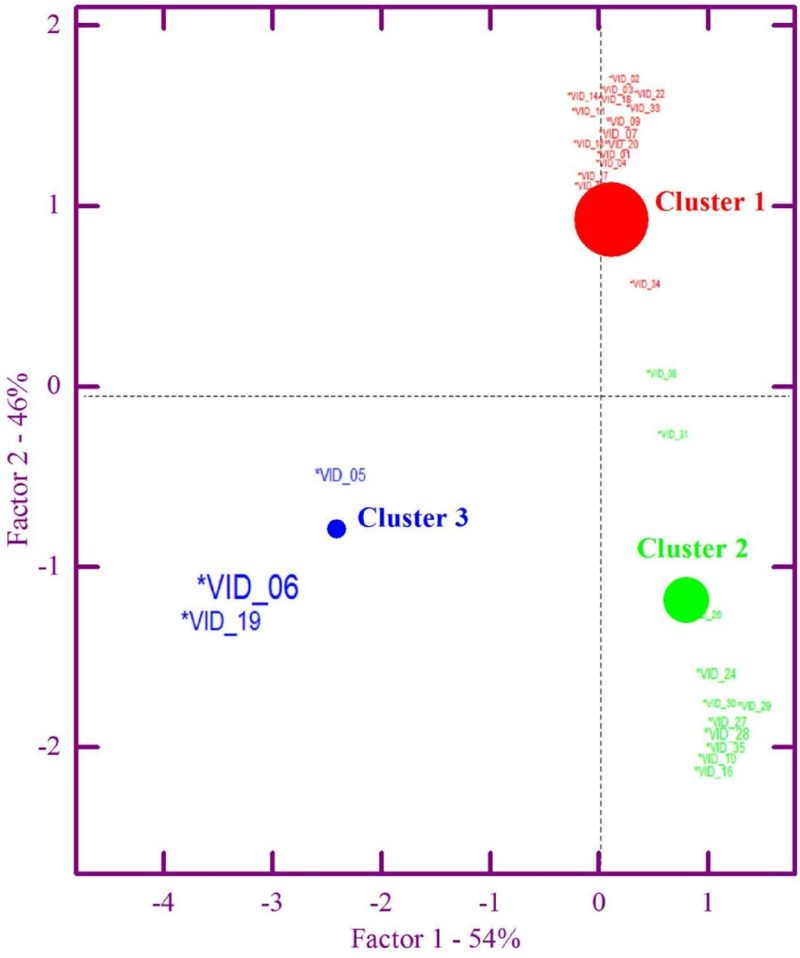
Cluster 1			
Words	*Chi-square* χ^2	*Probability* *p*	*Percentage* *%*
Emission	22.13	<0.0001	100
Energy	21.83	<0.0001	86.84
Fuel	20.7	<0.0001	86.49
Power	17.66	<0.0001	92
Ethanol	16.06	<0.0001	70.51
Co2	14.54	0.00014	100
Clean	14.45	0.00014	90.91
Country	13.18	0.00028	85.19
Brazil	12.82	0.00034	71.43
Global	12.47	0.00041	100
Electricity	10.44	0.00123	100
Gasoline	10.24	0.00137	85.71
Sugarcane	9.99	0.00158	65.52

Cluster 2			
Words	*Chi-square* χ^2	*Probability* *p*	*Percentage* *%*
Harvest	34.68	<0.0001	86.96
Worker	28.59	<0.0001	100
Cane	26.62	<0.0001	70.59
Labor	19.39	<0.0001	100
Productivity	19.39	<0.0001	100
Manual	17.15	<0.0001	100
Field	17.01	<0.0001	84.62
Process	16.15	<0.0001	76.47
Carry	14.93	0.00011	100
Result	13.52	0.00024	88.89
Condition	12.73	0.00036	100
Mechanize	11.37	0.00075	87.5
Variety	10.56	0.00116	100
Machine	10.56	0.00116	100
System	10.56	0.00116	100
Mechanization	10.56	0.00116	100

Cluster 3			
Words	*Chi-square* χ^2	*Probability* *p*	*Percentage* *%*
Subsidy	74.35	<0.0001	100
Tax	73.6	<0.0001	92.86
Tariff	61.32	<0.0001	100
Credit	48.56	<0.0001	100
Corn	36.06	<0.0001	100
Price	35.38	<0.0001	87.5
Claim	29.9	<0.0001	100
Economist	23.8	<0.0001	100
Americans	23.8	<0.0001	100
Congress	18.71	<0.0001	71.43
Taxpayer	17.76	<0.0001	100
Dollar	17.76	<0.0001	100
Pocket	17.76	<0.0001	100
Hard	17.53	<0.0001	80
Government	17.32	<0.0001	60
Money	15.27	<0.0001	62.5

Figure 5.4 shows the cluster analysis of factors and the position of the thirty-five videos. In this study, the cluster of factors was produced from the classification of DHC Dendrogram. The forms are colored according to the above mentioned clusters identified by means of the DHC method. This analysis allows us to better explain the hero, learning and horror stories. The interpretation of the cluster analysis is done, first, by interpreting the data in terms of their opposite positions along the axes. For example, in this case, cluster 2 opposes cluster 3. The cluster analysis is less systematic and depends in particular on the knowledge and the theoretical foundation of the researcher (IRAMUTEQ, 2017). “It is the researchers who are the arbiters of the meaning of results acquired through cluster analysis” (KETCHEN; SHOOK, 1996).

Figure 5.4 Cluster analysis



	Coord. Factor 1	Coord. Factor 2	Mass	Chi distance	Inertia
Cluster 1	0.113	0.921	0.536	0.599	0.192
Cluster 2	0.802	-1.183	0.328	0.945	0.293
Cluster 3	-2.410	-0.789	0.134	1.757	0.415

5.5 Discussion

Figures 5.1-5.4 show that the sugarcane industry's dominant storytelling plays to consumer desires for environmentally-friendly fuels by exalting the importance of ethanol as a renewable energy source. Since storytelling can be used to produce outcomes (GRANT; KEENOY; OSWICK, 1998), one can say that the sugarcane industry "deploys stories and discourses to pursue their plans and projects" (HARDY;

LAWRENCE; PHILLIPS, 1998) as businesses commonly do. The sector has strategically used the storytelling approach to communicate its "value creation" activities which can be considered socially innovative (SCHMITT, 2014). Despite criticism of sugarcane ethanol, mostly from NGOs and several experts close to them, in Brazil, ethanol is broadly considered "the right thing to do" (LEHTONEN, 2014).

Figure 5.4 best illustrates the three major stories in the sugarcane industry's narration. In light of Janda and Topouzi's (JANDA; TOPOUZI, 2015) story typology, cluster 1 is in line with the "hero story". It highlights the importance of ethanol as clean energy, renewable and sustainable biofuel, which helps reduce greenhouse gas emissions. The hero story is also used to celebrate the technology that the industry has generated, which is presented as impressive innovations that have yielded the variety of products and services generated from sugarcane such as bioelectricity, bio-plastic and the second generation cellulosic ethanol from the sugarcane bagasse. When extracting some sentences using the textual context tool of the two software programs to illustrate the hero story, which shows sugarcane ethanol energy technologies as sustainable, we found, for instance that: "Sugarcane ethanol is a sustainable alternative to fossil fuels" or "To produce ethanol, sugarcane uses only 0.5 percent of Brazil's territory" and "Sugarcane ethanol reduces GHG emissions by 90 percent on average compared to gasoline".

Learning stories are presented in cluster 2. As described by Janda and Topouzi, learning stories are more difficult and contentious. They do not provide a single truth and they call for participation (JANDA; TOPOUZI, 2015). Cluster 2 centers around the Agro-environmental protocol, a voluntary agreement established between UNICA, the Organization of Cane Planters in the center-south region of Brazil, and the government of state of São Paulo to end the use of fire in sugarcane harvesting and established the mechanization practices. Upon formalizing this agreement, companies receive the Green Ethanol Certificate.

The traditional Brazilian process of sugarcane harvesting is performed by workers who manually cut the cane by using the practice of pre-harvest burning (AGUIAR et

al., 2011; GASPARATOS; STROMBERG, 2012). This Agro-environmental protocol as is presented in the video "Mechanization of sugarcane harvesting in Brazil" was created to finish the pre-harvest burning practice and promote more sustainable production process that minimizes their negative impacts. The protocol features as an important achievement in the industry's environmental discourse, which emphasizes positive environmental aspects of the mechanization practices by force of its reduction of GHG emissions and the promotion of incorporation of new sustainable practices.

The learning story is also apparent in the advertising campaign "Ethanol: an intelligent attitude" that associated ethanol with other sustainable attitudes, such as planting trees or waste recycling. The idea was to facilitate the understanding of the importance of ethanol, which went beyond the price advantage compared to gasoline to emphasize environmental benefits. Its strategy was to show that the decision to use ethanol as fuel was a simple daily choice to make, a smart option to be encouraged. People are asked to participate in the task to save the planet by using ethanol and changing their consumer habits.

The "horror story" in this study is reflected in cluster 3, which is about domestic market controls, subsidies and tariffs that U.S. policy imposes on Brazilian ethanol. In this case, the villain of the horror story are uncontrollable market forces which one can always blame for anything that has gone wrong (ESHRAGHI; TAFFLER, 2015). As in the "What you need to know about ethanol policy" video, the U.S. Congress is presented as a villain because it taxes sugarcane ethanol but not oil and other energy sources, and because it's making it harder for Americans to use alternative fuel sources.

The U.S. trade policy on ethanol includes an ad valorem tariff of 2.5 percent as well as an import duty on ethanol of $0.54 per gallon (DUFFIELD; JOHANSSON; MEYER, 2015). "One of the objectives of the tariff is to ensure that the benefits of the domestic U.S. ethanol tax credit do not accrue to foreign producers" (ELOBEID et al., 2007). "Congress wanted to subsidize domestic ethanol and not imported ethanol, so the import barrier was created" (TYNER, 2008). However, as Loris (LORIS, 2017) notes the "biofuel policies were sold as being "green", today's high levels of subsidized biofuel

use injure consumers, damage the economy, and produce negative environmental effects.

The U.S government has granted subsidies to the agricultural sector since 1933, and for more than 30 years it maintains incentive programs for corn-ethanol producers (ELOBEID et al., 2007; TYNER, 2008). Thus, the "What you need to know about ethanol policy" video states that "understandably, corn-ethanol producers are lobbying hard to extend the perks they've enjoyed for three decades". The UNICAS' campaigns show that subsidies to the corn-ethanol industry are negative for Americans and that "greater access to clean, affordable and renewable fuels like sugarcane ethanol would actually help diversify U.S. energy supplies". The video ends with this slogan: "Tell Congress to remove the tariff and help Americans".

Furthermore, Figures 5.1 and 5.2 present topics that have been controversial for the sugarcane industry, topics related to ethanol expansion's adverse effects on forest conservation, and on "food" prices, including potential harmful impacts of indirect "land use change" driven by their expansion. The industry response to criticism and concerns about these impacts was spread through public communications and formation a "pro-ethanol alliance" integrating a broad group of industry, government, public and private research organizations, as well as individual researchers to produce a concerted effort to contest and "correct" the allegedly claims about Brazilian ethanol (LEHTONEN, 2014). In addition, new practices presented as social innovation were established and discourses used in campaigns appealing to national pride have helped the industry project an image of sugarcane ethanol as a "green", clean and renewable fuel.

However, Clapp and Fuchs (CLAPP; FUCHS, 2009) described the increasing ability of companies to exercise discursive power as a function of their political authority acquired by coalition-building with a heterogeneity of actors, mainly NGOs. They even sometimes create relevant NGOs if none existed and develop campaigns attempting to undermine the legitimacy of countervailing civil society and governmental actors.

International NGOs such as Greenpeace and Oxfam recognize the virtues of Brazilian ethanol. For instance, Oxfam states that Brazilian sugarcane ethanol, with its great greenhouse emission reduction potential, represented a 'special case' among the otherwise harmful ethanol fuels (OXFAM, 2008; LEHTONEN, 2014). WWF has actively engaged with the industry using roundtable processes to promote sustainable resource use (LEHTONEN, 2014). And the main discourse by the government highlights Brazil's pioneering use of sugarcane for power generation. As highlighted by the Secretary of Energy Planning of the Ministry of Mines and Energy "the use of sugarcane for energy only exists in Brazil, it's a national technology. We can plant this energy in the field and produce food without competing with one another, and preserving our ecosystems" (PORTAL BRASIL, 2015). Thus, the sugarcane industry's concerted efforts to build a coalition has been elemental in creating a positive image of the country's sugarcane ethanol as a clean and renewable fuel (LEHTONEN, 2014).

In general, the campaign sought to popularize ethanol consumption by highlighting the environmental, economic and social benefits, it as a renewable, low-carbon emitting energy source. In addition, since it was based on national technology, the campaign stressed that ethanol fuel production generated eight times more jobs compared to oil, contributing to the social and economic development of Brazil. Similar result is show by Malone et al.(MALONE et al., 2017), which for the case of Brazilian ethanol, the government developed a "national technology narrative" that invokes the connection between the improvement of the societal well-being with modern technology to produce ethanol.

The strategic importance of the sugarcane industry to the planet, renewable energy development, sustainability, tackling climate change, developing regions and job creation was emphatically communicated. Storytelling was used as a strategic resource to achieve social acceptance (LEHTONEN, 2014), and as an "important new rhetoric which makes sense of legitimation" (HARDY; LAWRENCE; PHILLIPS, 1998) to promote the sugarcane industry as a sustainable business.

5.6 Conclusions

The sugarcane ethanol industry's storytelling efforts integrates the tenets of hero stories when presenting its technology as inspiring, positive, 'home-made' and clever and as helping cut greenhouse gas emission and save the world from climate change. The learning story is used in communications urging consumers to choose and use ethanol on a daily basis. The horror story is used when communicating about U.S. policy of protectionism, in which such foreign subsidies and lobby practices appear as villains of the story.

Brazil's sugarcane industry's storytelling seeks to transmit to consumers the idea that ethanol is always advantageous because – irrespective of its price - it helps generate jobs and improves not only the environment but also the performance and durability of cars and the country's economic development. Ethanol is represented as a renewable energy fuel that helps mitigate climate change, highlighting technological advances that could enable the production of not only traditional ethanol but also of the second generation cellulosic ethanol from the sugarcane bagasse. Flex technology is presented as a source of national pride, since only Brazil has produced this kind of alternative fuel at such a scale. These technologies reduce emissions of GHG and are presented as the best commercial alternative to fossil fuels.

The sugarcane industry uses storytelling strategically, seeking to achieve their goals by urging consumers and society in general to help the environment through the consumption of "green" ethanol. Despite encountering some criticisms, the sugarcane industry polished its image by using campaigns to build its own moral legitimacy by presenting itself as socially responsible and its product as green and central to development of the country. Further research could analyze the discourses of social actors and groups who are opposed to the sugarcane ethanol to show how different actors use storytelling to communicate a particular topic and their ability to influence and engage audiences.

6. LAND-WATER-ENERGY NEXUS OF SUGARCANE ETHANOL PRODUCTION IN BRAZIL: POLICY DEBATES[7]

6.1 Introduction

The agricultural sector is strategically important for economic growth in developing countries (JOHNSON, 1993; AWOKUSE; XIE, 2015; MCARTHUR; MCCORD, 2017); it also contributes to social development, such as human well-being and poverty and hunger reduction (STRINGER; PINGALI, 2004; CHRISTIAENSEN; DEMERY; KUHL, 2011).In Brazil in 2016, the agricultural sector accounted for 46% of all exports, 26% of GDP, and 32% of jobs generated (BRAZILGOVNEWS, 2017). Sugarcane, in particular, is a key component of Brazilian agribusiness in terms of its contribution to the national economy, and it is also recognized as a promising crop for providing both food and bioenergy (Souza et al., 2015).

Bioenergy has received worldwide attention, primarily for enhancing energy security by alleviating fossil-fuel dependence and for contributing to the reduction of greenhouse gas (GHG) emissions(GOLDEMBERG, 2007; SOUZA et al., 2017). Bioenergy from sugarcane ethanol is a cornerstone of Brazil's ambitious pledge under the United Nations Framework Convention on Climate Change (UNFCCC), in which the country's main energy compromise is expanding the proportion of biofuel in the Brazilian energy matrix (BENITES-LAZARO; MELLO-THÉRY; LAHSEN, 2017). This means increasing the production of ethanol from 27 billion liters in 2017to 50 billion liters in 2030 (NOVACANA, 2018).With the aim of meeting this target, the Brazilian government launched the National Biofuels Policy (RenovaBio) in December 2017,to stimulate expanded production of bioenergy.

However, the literature indicates that crops grown for bioenergy[8] have negative environmental impacts. Two main practices causing these problems are expansion – the

[7] This chapter is based on the paper: Benites-Lazaro, L.L., et al. Land-Water-Energy Nexus of Sugarcane Ethanol Production in Brazil: Policy Debates.

[8]We use term biofuels and bioenergy interchangeably to refer ethanol energy from sugarcane.

extension of croplands and pastures into new areas, replacing natural ecosystems – and intensification– increasing the productivity of existing cropland, often through the use of improved cultivars, irrigation, fertilizers, and mechanization (FOLEY et al., 2011; RULLI et al., 2016). These practices have been linked to direct and indirect land use change and pressure on water resources (GERBENS-LEENES; HOEKSTRA, 2012; BERGTOLD et al., 2017; SILALERTRUKSA; GHEEWALA, 2018).Moreover, global trends– such as climate change and increased demand for water, energy, and food due to the rapid increase in population – are causing increased concern about the competition between land, water, and energy resources (HOFF, 2011; RULLI et al., 2016).Such competition is expected to become even more intense in the near future, as by 2050 global population is forecast to rise to 9 billion, demand for energy bynearly80%, and demand for water and food by over 50%(OECD/FAO, 2013b).

The competing needs for land and water resources of food and biofuel production are at the forefront of policy debates (HARVEY; PILGRIM, 2011; ROSEGRANT; MSANGI, 2014; RULLI et al., 2016).Recent debates are often based on justice, equity, and rights related-issues. Since water, food, and energy are key to meeting human needs (MIDDLETON et al., 2015), several food justice and food security discourses have emerged in the last years (LEE, 2013; SONNINO; MARSDEN; MORAGUES-FAUS, 2016). In relation to water, social movements against water plundering and water commodification are increasing; these movements demand construction of a new participatory management model (MEHTA; VELDWISCH; FRANCO, 2012; JACOBI; CIBIM; LEÃO, 2015). Concerns have also been raised about energy production and distribution, pointing out that attempts to ensure national energy security are typically centered around providing an adequate energy supply for economic growth (GOLDEMBERG, 2007; BELKE; DOBNIK; DREGER, 2011).

These debates depict the close relationship between water, food, and energy security and complex environmental, social, political, and economic matters (Benites-Lazaro et. al., 2018). Important decisions within each of these sectors are highly political and take place in arenas of unequal power relations: some sectors are more economically and politically important than others(JENSEN, 2013; MIDDLETON et al., 2015; WEITZ et

al., 2017).Due to the close linkages between sectors, this study uses a land-water-energy nexus approach to tackling the challenge of sugarcane ethanol sustainability.

Therefore, the main questions we raise is: did the policy debates and discourses of different actors, concerning the impacts of sugarcane ethanol on land and water, influence companies and decision-makers to formulate appropriate policy actions and measures for enhancing the efficient use of these resources? This has implications for identifying the main challenges to interconnected and collaborative governance and policy integration between sectors in ethanol production.

6.2 Literature review

6.2.1. Biofuel debates at the land-energy nexus

Due to the demand for biofuels, several debates regarding competition for land have emerged in recent years. Some center on increased land values in developing countries and the presence of large, foreign investments in land acquisitions: so-called land grabbing (BORRAS; MCMICHAEL; SCOONES, 2010; WILKINSON; HERRERA, 2010; BORRAS et al., 2012). Land grabbing mainly refers to some authors the process of converting lands previously dedicated to food production or forestry for domestic use to export-oriented food and biofuel production(PELUSO; LUND, 2011; BORRAS; FRANCO, 2012). Certain authors have framed land grabs as part of a narrative of global capitalist development and have placed land use changes within the context of the convergence of multiple crises, e.g., of food, energy, climate change, finance, and capital (BORRAS et al., 2012; MCMICHAEL, 2012).

Debates also have emerged around GHG emissions due to land use change, including from the expansion and intensification of sugarcane production (HAVLÍK et al., 2011; BENTO et al., 2018). For example, Bento et al. (2018) showed how GHG emissions are increasing due to large areas of low-intensity pasture are being converted to sugarcane, and the remaining pasture is becoming more management-intensive through the use of tilling and fertilizer.

Studies typically acknowledge two types of land use change driven by biofuels. One is direct land use change; this occurs when cropland, including non-feedstock agricultural lands, forests, and grasslands, is converted to biofuel feedstock production (DUNN et al., 2013; ALKIMIM; CLARKE, 2018).There are concerns that direct land use change to sugarcane production has increased soil degradation in terms of physical quality (CHERUBIN et al., 2016). The other type is indirect land use change, which refers to a larger pattern in which crops displaced by bioenergy production or other land uses are relocated to make up for the loss of food and feed, perhaps into native habitats (ANDRADE DE SÁ; PALMER; DI FALCO, 2013; FERREIRA; ALVES; SHIMABUKURO, 2015; BERGTOLD et al., 2017).

Several authors have expressed concern that indirect land use change (iLUC) could mean sugarcane expansion leads to deforestation in the Amazon via displacement of cattle to the forest frontier as a consequence of loss of other grazing land. For example, the study of Andrade de Sá et al. (2013) found a positive relationship between sugarcane expansion in São Paulo state and deforestation in the Amazon between1970 and 2006. Ferreira Filho and Horridge (2014), simulating sugarcane expansion between 2005 and 2020, found that every hectare of sugarcane expansion in south central Brazil results in a 0.14 ha decline in forest or natural vegetation and a 0.47-ha decline in pasture along the agricultural frontier in the Amazon region. Furthermore, the study of Ferreira et al. (2015) demonstrated that the expansion of sugarcane within the Atlantic Forest biome in the State of São Paulo was accompanied by significant changes in major land uses in this area, such as an increased cattle stocking rate and decline in milk production. In the tropical savanna region of Cerrado, Bergtold et al. (2017) showed that cropland in two states increased in area by 53% from 2005 to 2013 due to sugarcane for ethanol production, and land previously used for pasture or soybean production was displaced by sugarcane.

The area used for harvesting sugarcane in Brazil increased from 4.3 to 10.2 Mha from 1990 to 2016 (IBGE, 2018). This increase has been attributed to recent energy security strategies, investment opportunities, climate-related emission reduction policies, oil prices, and the advent of the flex-fuel vehicle in 2003. About 85% of Brazilian

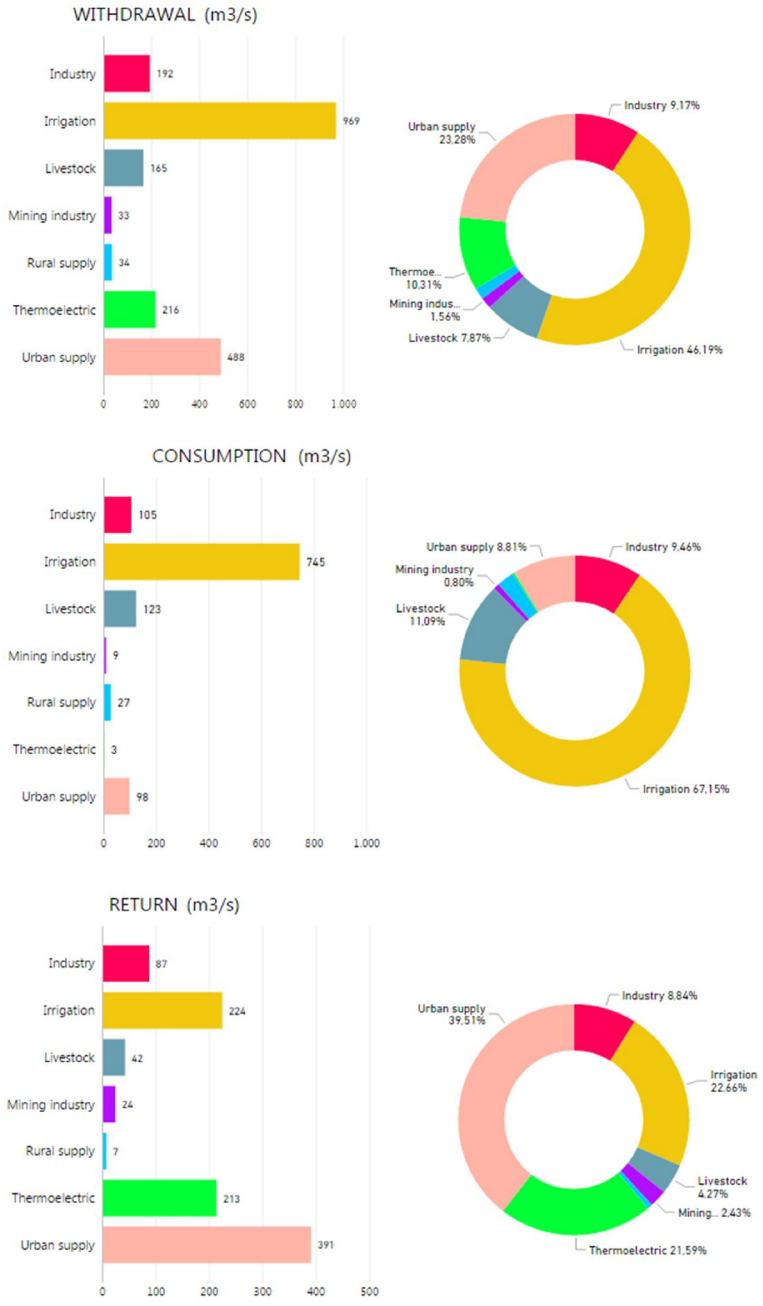
sugarcane, by volume, is produced in southern central Brazil (Parana, São Paulo, Rio de Janeiro, Minas Gerais, Espírito Santo, Mato Grosso do Sul, Goiás, and Mato Grosso states), with São Paulo state alone accounting for over 50% of the production (UNICA, 2017b; IBGE, 2018). RenovaBio, the government's climate-focused biofuels policy, aims to double domestic ethanol production, reaching 50 billion liters by 2030. This raises concerns about issues such as land use, availability of arable land, water, soil nutrients, and dependence on fossil resources such as agrochemicals.

6.**2.2. Biofuel debates at the water-energy nexus**

Various studies have highlighted the competing needs for land and water resources by food and biofuel production(FAO, 2011; RULLI et al., 2016).Water is needed to produce crops and some authors have labeled water as both a target and driver of land grabs(MEHTA; VELDWISCH; FRANCO, 2012; WILLIAMS et al., 2012). This raises the crucial questions of whether water is adequately abundant and available, whether unsustainable withdrawals will ultimately undermine land quality, or if water scarcity will drive unjust reallocations away from existing users (MEHTA; VELDWISCH; FRANCO, 2012; SCHULZ; IORIS, 2017).

According to a report of the Brazilian National Water Agency (ANA), the demand for water is increasing in 80% in the rate of total water withdrawal occurred in the last two decades. It is expected that by 2030, the rate of withdrawal will increase by a further 30% of the 2016 withdrawal rate. The total rate of water withdrawal in 2016 (Figure 6.1) was 2,057.8 m^3/s, of which 46.19% was for irrigation; total water consumed was 1,081.3 m^3, of which 67.15% was for irrigation, followed by11.09% for livestock and 8.8% for urban supply. The highest percentage of water return comes from urban supply, at 39.51%.As a high proportion of water demand is already from irrigation, the pattern of development of biofuel and other crops will have a serious impact on water withdrawals in coming years.

Figure 6.1. Rates of water (a) withdrawal, (b) consumption, and (c) return in Brazil, 2017.



Source: ANA (2017).

It is expected that increased crop production in coming years will be achieved through intensification, meaning irrigation will play an increasingly central role in crop productivity, and energy and water issues will be further intertwined (FAO, 2011). In Brazil, sugarcane crops are responsible for approximately 30% of total irrigated area,

and in 2016, the overall irrigated sugarcane crop was 45.8% in São Paulo, 22.3% in Goiás,19.4% in Minas Gerais, and 6.6% in Mato Grosso do Sul (AGÊNCIA NACIONAL DE ÁGUAS, 2017).

Studies of the Paranaíba river basin, located in the Center-West region of Brazil, have shown that irrigation management has great potential to increase sugarcane yield, thus limiting sugarcane expansion, and to reduce economic costs, thus enhancing the economic viability of sugarcane expansion (FACHINELLI; PEREIRA, 2015; SCARPARE et al., 2016b). Thus, it is unclear what the effect of irrigation will be on sugarcane expansion. However, there is an environmental cost associated with this practice: on average, 13m^3M of blue water footprint (SCARPARE et al., 2016b).Land use in the Paranaíba basin has changed due to the expansion of sugarcane, which has replaced pastures and soybean and corn production. Irrigation accounts for 89.4% of the water consumed in the basin, and the expansion of sugarcane has intensified this consumption (FACHINELLI; PEREIRA, 2015).

In recent years, particularly from 2013–2016, Brazil's south-central region is experiencing a chronic water shortage due to very low rainfall and increased water withdrawals (JACOBI; CIBIM; LEÃO, 2015; SCARPARE et al., 2016b). Increasing water scarcity and drought are expected as a consequence, creating fierce competition between agribusiness and other sectors of the economy (MANCOSU et al., 2015).The water shortage will also likely have socioeconomic impacts and reinforce conflicts over water use between various economic sectors and the population (JACOBI; CIBIM; LEÃO, 2015; MARENGO et al., 2015), requiring multi-stakeholder decision-making.

6.3 Materials and methods

The data sources used in this study were text documents addressing agricultural and agrarian, food security, climate change, water crisis, and biofuels-related issues. To consider the role of various stakeholders, we obtained documents from: Brazilians newspapers, which we labeled "MEDIA;"reports from non-governmental organizations and social movements, labeled "NGO;"government websites, labeled "GOV;" and

reports and website from sugarcane ethanol companies represented by the Brazilian Sugarcane Industry Association, labeled "UNICA."We obtained documents published between 2007 and 2017. This generated a large amount of text data to be analyzed, for which we used several procedures and tools commonly employed in text mining and machine learning.

First, we employed Latent Dirichlet Allocation (LDA), which is an unsupervised probabilistic model used to discover latent themes/topics and detect novel trends within large collections of documents. This enabled us to detect which themes were being focused on overall and by different actors, as well as change in discourse over time. We implemented LDA using MALLET version 2.0.8, a Java-based package for statistical natural language processing. LDA was described with the following notation:

p\(\beta _{1:K},\theta _{1:D},z_{1:D},w_{1:D})=\prod_{i=1}^{K}p(\beta _{i})\prod_{d=1}^{D}p(\theta_{d})(\prod_{n=1}^{N}p(z_{d,n}|\theta_{d})p(w_{d,n}|\beta _{1:K},z_{d,n}))

Here, $\beta_{1:K}$ represents topics, where each β_K is a distribution across all vocabulary. The topic proportions for document *d*is θ_d, where $\theta_{d,K}$ is the topic proportion for topic k in document *d*. The topic assignments for document *d*are Z_d, where $Z_{d,n}$ is the topic assignment or word *n* in document *d*. Finally, the observed words for document *d* are w_d, *w*here $w_{d,n}$ is word *n* in document *d*, which is an element from the fixed vocabulary (BLEI, 2012).

Second, we performed a discourse analysis using a mixed method that takes advantage of both qualitative and quantitative techniques by assuming that both the number of repetitions of words and exploratory lexical patterns play an important role in text analysis (BENITES-LAZARO, et al, 2018). This discourse analysis was carried out using T-Lab software and gave us information on correspondence between the themes. In correspondence analysis, the factors represented as an axis line can be considered classification principles and organizers of the relationships between the data. This technique allows us to group similar items, distinguish them from other items, and construct a kinship between the categories, such that items placed on opposite poles are the most different (LANCIA, 2012).Correspondence analysis by lemmas and variables

was also performed; this technique makes it possible to analyze the discursive structures by providing the elemental context of the text that facilitates the qualitative analysis by providing the "text and talk" context.

6.4. Results

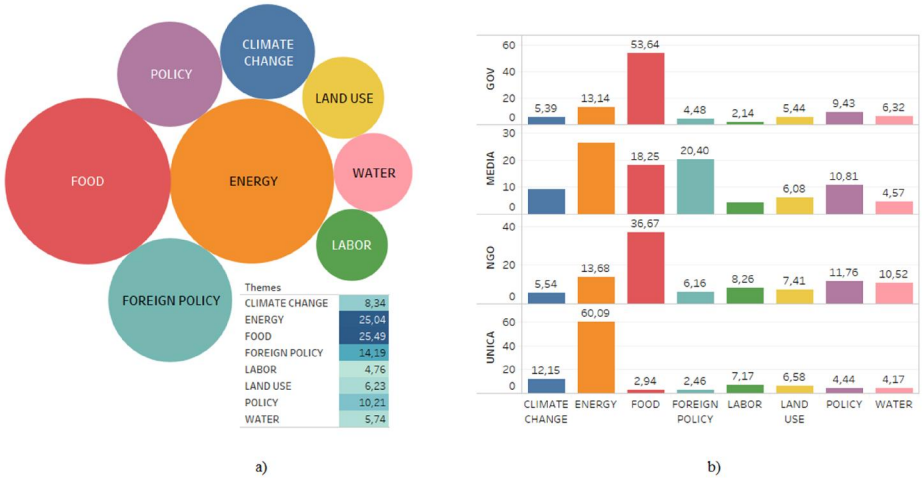
6.4.1. LDA-identified themes overall and by actor

Figure 6.2a) shows themes that were obtained from the corpus using LDA. The themes with the highest percentage in the corpus were "food" and "energy."Figure 6.2b) depicts themes to which each actor assigned major importance. The theme "food," related to several polices and a governmental program on food production and food security, was assigned the most importance in government documents. The theme "energy," related to biofuel production, mainly ethanol from sugarcane and its benefits to sustainable development and climate change, was given the highest importance by companies (UNICA). The theme "land use" included issues of the expansion of biofuel crops, deforestation and degradation, land availability, agricultural areas, land governance policies such as Agroecological Zoning (ZAE Cana), and the Forest Code. The theme "water" related to water consumption and use, water availability, irrigation systems, and water shortage. The themes "land use" and "water" were assigned relatively low importance by all four actors, although the NGOs gave them more importance than the other actors did.

The media gave the most attention to the theme "energy," followed by "foreign policy," which covers issues such as foreign trade, agricultural negotiations, trade agreements, trade barriers, non-tariff barriers, tariffs and subsidies, the Doha Round, foreign capital, foreign investments, commodities, and sugar, ethanol, agricultural, and agribusiness exports."Climate change" was used as a label for the climate negotiations in the context of the UNFCCC (COPs), Kyoto Protocol, Paris Agreement, UN Conference on Sustainable Development (e.g., Rio+20),mitigation and adaptation policies and measures to deal with extreme climate events, and reduction of greenhouse gas emissions. "Climate change" issues were most highlighted by the media, followed by

companies, and then NGOs. Finally, the theme "labor" related to rural workers, sugarcane cut workers, sugarcane work, slave labor conditions, labor practices, working conditions, occupational health and safety, training, and requalification. NGOs and then companies highlighted these issues the most.

Figure 6.2. Themes results of Latent Dirichlet Allocation analysis of text documents published 2007–2017.



6.4.2. LDA-identified themes over time

Figure 6.3 shows how the topics of land use, water, and energy were addressed by the actors during the last 11 years (2007–2017). In the following paragraphs, we give a brief overview of the discussions around each of these themes, beginning with land use, then energy, and lastly water.

In 2007, discussion of land use peaked, as national discourse focused on debating biofuels and food security and the competition for land between sugarcane and food crops. UNICA took the position that there is no true conflict between the expansion of biofuels and food production, as sugarcane production was using only 1.4% of the country's arable land. In 2011, the debates were marked by controversial discourses among the actors on the entry into force of the Forest Code, which was approved in May 2012.This important policy is the central piece of legislation regulating land use

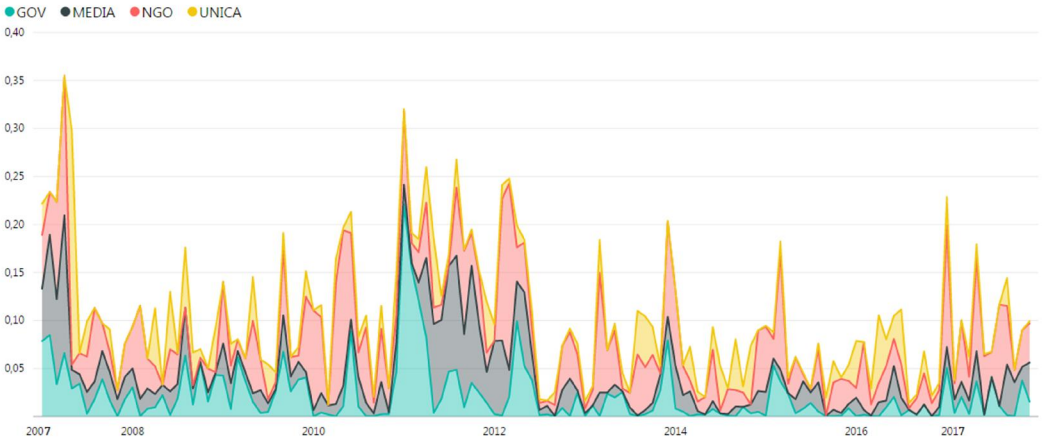
and management on private properties and had uncertain consequences for land-water issues. The Forest Code of 2012 incorporates important proposals for the protection and sustainable use of forests in harmonization between the productive use of land and the preservation of water, soil, and vegetation. Finally, in 2017, discourse focused on deforestation and the expansion of crop production in the Cerrado region.

The theme "energy" was of consistently high interest to UNICA in comparison to other actors. For instance, in 2012, UNICA's discourse included different issues within this theme, such as fuel prices and the elevation of the ethanol blend in gasoline from 20 to 25% to domestic ethanol production and reduce fuel imports. Furthermore, UNICA emphasized that its Renovação project, which is aimed at requalifying cane cutters, is recognized by the FAO as an example of an initiative that combines renewable energy production and social inclusion. Another issue highlighted by UNICA in 2012 was its increasing participation in Watersheds Committees. In 2017, the debates centered on the Renova Biopolicy, as the sugarcane ethanol sector demanded that the government pass a law recognizing the contribution of biofuels to reducing GHG emissions. The policy was introduced by Brazilian Environment Minister during the 23rd Conference of the Parties to the UNCCC (COP23), held in Germany in November 2017, as a pillar for the fulfillment of the commitments made by Brazil in the context of the Paris Agreement. Finally, on December 27, 2017, RenovaBio was passed into law, providing for the creation of mandatory targets for reduced GHG emissions for fuel distributors and the mandatory addition of biofuels to fossil fuels.

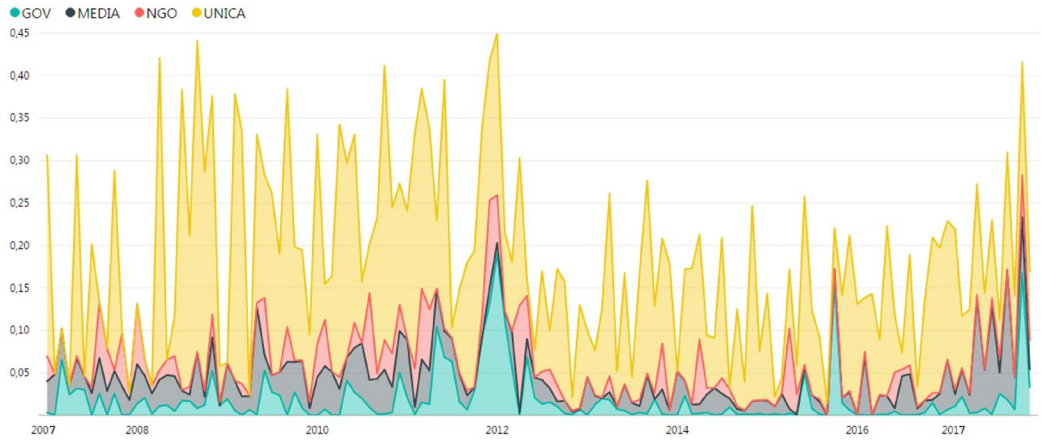
Interest in water peaked in 2015, reflecting the water crisis in the state of São Paulo, and again in 2017, due to the water crisis in other areas, such as Brasilia and Rio de Janeiro, where the majority of the Brazilian population is concentrated. In 2017, the revision of the National Water Resources Plan up to 2020 was published; the revised plan established the promotion of sustainable use and reuse of water among its priorities. Beside the imminent concern of water scarcity during the crisis, certain experts recognize a long-term hydrologic crisis in São Paulo, mainly due to the mainstream practice of transporting water from other areas for metropolitan use, which has created

interdependency in the territory and increased the pressure on rural areas (BRAGA; PORTO; SILVA, 2006; JACOBI; CIBIM; LEÃO, 2015).

Figure 6.3.Timeline of results of Latent Dirichlet Allocation analysis



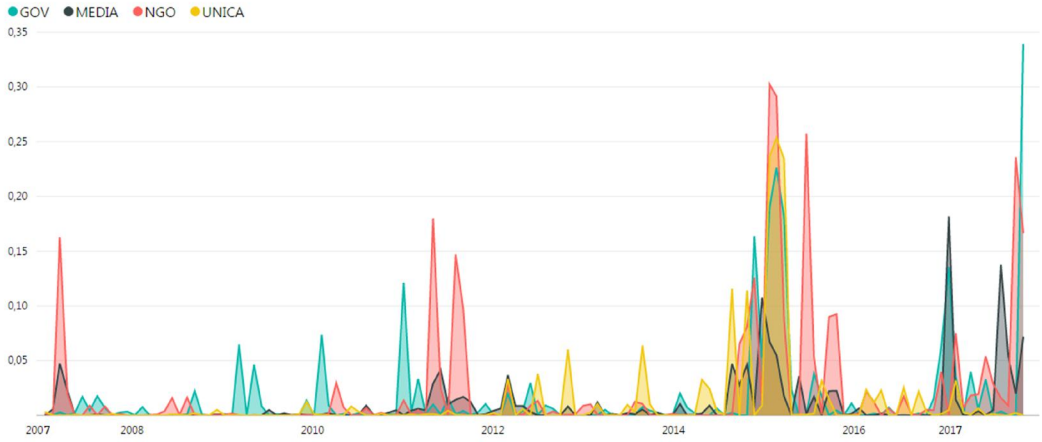
a) Land use



b) Energy

continue

Figure 6.3. Conclusion



c) Water

6.4.3. Correspondence analysis

Figure 6.4 depicts a correspondence analysis of the themes, which allows us to understand the proximity/distance or similarity/dissimilarity between the themes within the documents. As shown in Figure 6.4, the theme "foreign policy" is in opposition to "water," indicating the distance between these two themes. Table 6.1 illustrates these similarities numerically. For example, the low correspondence of "water" with the other themes provides insight into how water is related to other topics within policy debates and by actors.

Figure 6.4 Correspondence analysis of themes obtained from the results of Latent Dirichlet Allocation

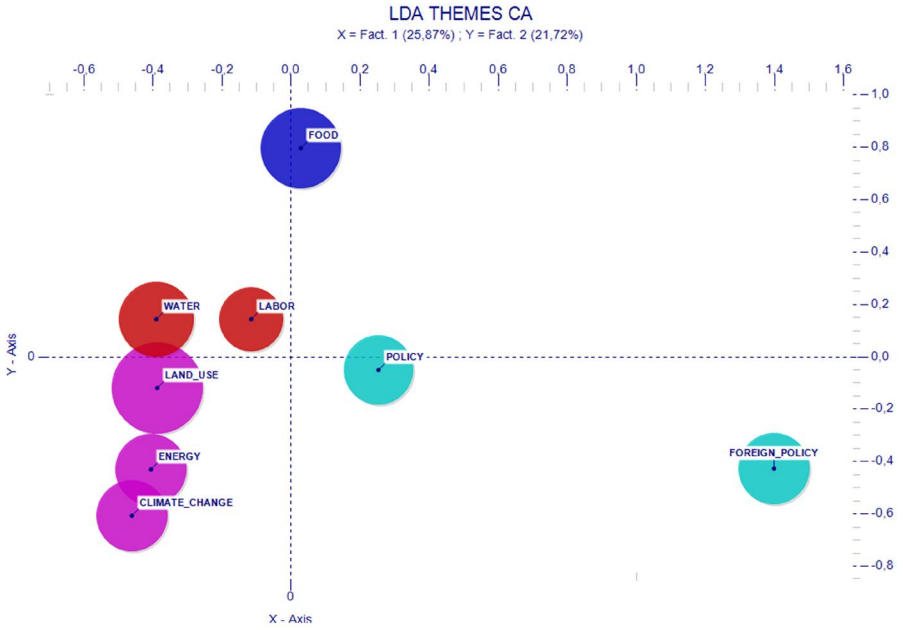


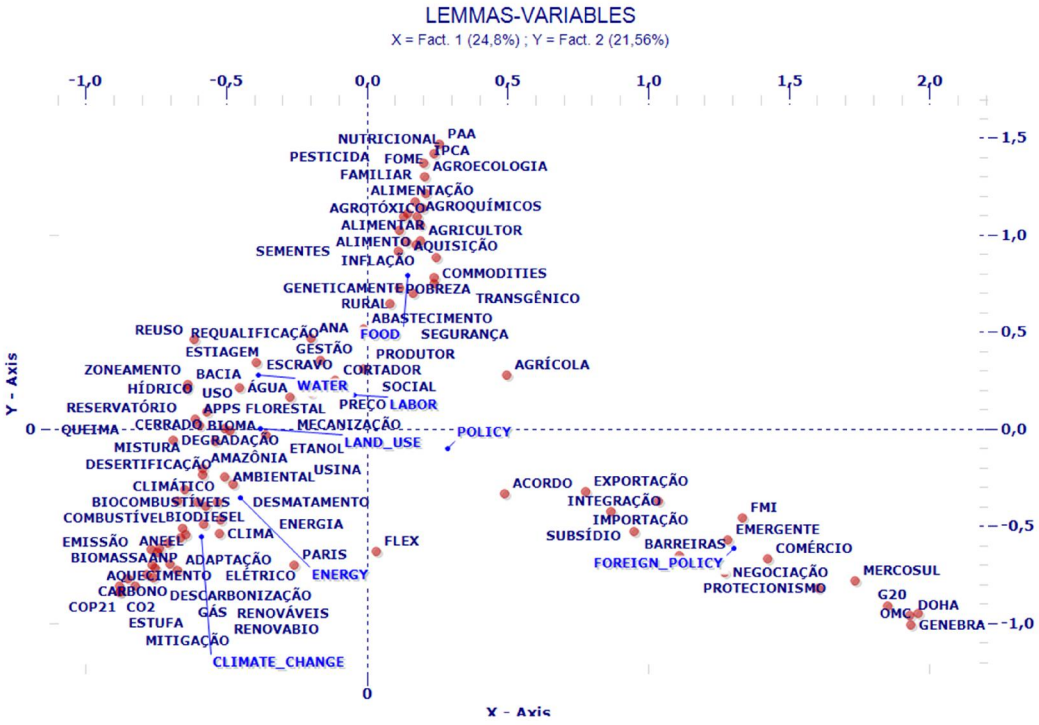
Table 6.1.Similarity of themes identified through correspondence analysis of text documents published 2007–2017 about biofuel production in Brazil.

Themes	CLIMATE CHANGE	ENERGY	FOOD	FOREIGN POLICY	LABOR	LAND USE	POLICY	WATER
CLIMATE CHANGE								
ENERGY	0,3430							
FOOD	0,3060	0,4210						
FOREIGN POLICY	0,2210	0,2750	0,3000					
LABOR	0,2050	0,3120	0,3270	0,1840				
LAND USE	0,2660	0,3060	0,3160	0,1480	0,2730			
POLICY	0,3530	0,4300	0,4730	0,4470	0,3850	0,3340		
WATER	0,1010	0,1120	0,1600	0,0050	0,0750	0,1100	0,1440	

Figure 6.5 shows the correspondence analysis by lemmas and variables. “Food” appears as a highlight in several government policies and programs, displaying the dominant

discourse whereby food security is a priority of the Brazilian government. Discourses from the government and companies, claiming that ethanol does not compete with the provision of food, are also evident; the other two actors also aligned with this discourse. The main concerns of the NGO actors were food prices and inflation, and the use of pesticides and transgenic organisms. On the theme "energy," the main discourse was about the positive contribution of ethanol to the environment and development, as well as national pride in Brazilian flex-fuel technology. The media's discourse on energy additionally included energy prices and the proportion of ethanol in fuel. The main discussion related to "land use" was about sugarcane expansion and resultant public policies such as ZAE Cana and the Environmental Protocol of the state of São Paulo.

Figure 6.5 Correspondence analysis of themes by lemmas and variables



6.5. Discussion

The primary research question of this study was whether the policy debates and discourses of different Brazilian social actors: Government, ONGs, Media and

sugarcane ethanol companies, concerning the impacts of sugarcane influenced appropriate policies for enhancing the efficient use of land and water resources. In the following paragraphs, we discuss the implications of our results for this question, firstly by discussing energy-land debates, then energy-water debates, and finally the nexus of all three issues.

6.5.1. Energy-land debates

The results show that, overall, debates regarding ethanol production led the government to adopt policies aimed at showing the sustainability of the industry. These legal frameworks contributed to legitimizing the expansion of sugarcane crops by providing guidelines for land allocation. Two major examples are the 2009 ZAE Cana and the 2008 São Paulo Agro environmental Zoning policy. These instruments were adopted as a result of debates on whether sugarcane expansion was causing deforestation in the Amazon and the land competition between ethanol and food.

The ZAE Cana defines which areas and regions are appropriate for large-scale sugarcane farming by providing technical guidance for sugarcane expansion according to soil, climate, and water requirements. It also excludes the expansion of sugarcane production into the Amazon and Pantanal biomes and the Upper Paraguay River Basin (MANZATTO et al., 2009). The main discourses around the ZAE Cana policy are that it "provides solid conditions to secure harmony among food, energy and ethanol production, and the environment."Regarding its goals, "ZAE Cana aims to guide the sustainable expansion of sugarcane production in the future and protect sensitive areas and native vegetation." It is thus positioned as being able to prevent adverse effects from land use change due to sugarcane production. Additionally, the discourse includes other demonstrations of sugarcane's sustainability, such as that sugarcane lands only "use 1% of the national territory" and that the industry is the largest sugar producer and exporter and the second largest ethanol producer in the world, using less than1% of land. ZAE Cana established an area of 65 million hectares, equivalent to7.5% of the Brazil's total area, as suitable for sugarcane cultivation. Thirty million hectares of these areas are in the central west region and 23 million in the southeast, which are also the

regions with the largest areas of sugarcane currently (Manzatto et al., 2009). The ZAE Cana established a total area suitable for the expansion of sugarcane cultivation in the state of São Paulo in 10,645,485.23million hectares (Manzatto et al., 2009).

However, the main concern expressed by actors regarding ZAE Cana is that it is just a technical tool that seeks to boost the expansion of sugarcane and create an opportunity for economic growth. Its objectives include offer sustainable economic alternatives to rural producers and provide subsidies for the planning of future development poles in rural areas. This perspective is similar to that of ALMEIDA, (2012), who in interviews with Brazilian specialists found that ZAE Cana is viewed as an indicative tool rather than a punitive measure. Furthermore, a study by Benites-Lazaro et al.(2018) showed that the sugarcane ethanol companies are mainly motivated to introduce sustainability regulations by the desire to have a good image in the foreign market. Thus, producers are likely to be incentivized to follow ZAE Cana guidelines to avoid the image that sugarcane is causing Amazonian deforestation (ALMEIDA, 2012).

The importance to sugarcane producers of having a sustainable image was demonstrated by the recent debates of March 28, 2018 that occurred when the Brazilian Senate tried to vote on a bill to lift the ban on the cultivation of sugarcane for ethanol fuel in the Amazon rainforest. The bill has been roundly condemned by environmentalists, and even UNICA, which reinforced its opposition to the bill and defended compliance with the ZAE Cana. This policy orientation has guaranteed the recognition of the sustainability of the sugar and ethanol industry in the national and foreign markets. UNICA raised concerns that the bill can tarnish the industry's reputation for sustainability and jeopardize existing markets and the value of Brazilian products. The main discourse from the industry association is that "ethanol cannot have its image linked to deforestation" (UNICA, 2017b).

UNICA maintained a similar discourse during discussions of the Forest Code, stating "Brazil will advance in the production of biofuels with a modern and improved Forest Code, without deforestation occurring in native forests." From UNICA's point of view the promotion for approval of the Forest Code is for the reason that doing so improves

legal security for Brazilian agriculture, from the family farm to the industrial agricultural level. However, for critics, mainly some ONGs, who campaigned intensely against the approval of the Forest Code, claimed that it will further enable deforestation and is too lenient on land owners. There was also a group (the so-called ruralist bloc of the Brazilian Congress, which represent some agribusiness companies) that believed the Code is a barrier to agricultural development.

The Brazilian Forest Code provided for the creation of the Program for Environmental Compliance to promote restoration of private lands that must be legally set aside for conservation, including riparian areas. However, is appointed that PRA implementation has been slow, and the protection and restoration of degraded areas is far from a reality (POCEWICZ; GARCIA, 2016). The Forest Code also designated environmentally sensitive areas as Areas of Permanent Preservation (APPs, also known as water-APPs) aiming to conserve water resources and prevent soil erosion (SOARES-FILHO et al., 2014). As POCEWICZ; GARCIA (2016) refer, in spite of existing knowledge about the impact of deforestation on water supply, and that the new code would be aggravating this impact on water resources and aquatic systems have received much less attention by the Brazilian government, the structure, implementation, and enforcement of water laws are weak.

6.5.2. Energy-water debates

Regarding water use in ethanol production, the results showed increasing concern about water over time and debates over water contamination by pesticides. The issue of water contamination can be related to the intensification of sugarcane production and the consequent increase of use of agrochemicals, which, in general, result in contamination of water resources. One main discourse from the NGOs was that monocultures of sugarcane or soya and contamination of soils and water resources with agricultural inputs are points of warning. As shown in Figure 6.5, the words *"agrotóxico," "pesticida"* and *"agroquímicos,"* which are related to the use of agrochemicals and

pesticides in crops production, appeared in debates about research, production, and use of non-synthetic pesticides of natural origin.

On the other hand, UNICA has tried to deny discourses that the sugarcane ethanol industry is a major consumer of water. This accusation, according to UNICA, is fueled by the water withdrawal values practiced by the sector in the past to deal with the industrial process; they assert that over the last decades, water withdrawal has been steadily declining due to reuse practices. Another discourse of UNICA is that sugarcane producers, in particular, in the Center-South (the sugarcane region), do not irrigate the full crop areas with water. The use of irrigation is only in some specific regions, and it is done by rescue and additional irrigation, usually using industrial process effluents(CNI, 2013).UNICA believes that wastewater reuse initiatives in reservoir irrigation contribute to the management of water, avoiding new requirements for authorization for water withdrawal (UNICA, 2018).UNICA has adopted water-related voluntary standards, such as the Environmental Protocol, which defines technical guidelines for protecting the water sources of the rural areas of the sugarcane enterprise and restoring surrounding vegetation; it also requires the proposition and implementation of technical plans for conserving water resources and minimizing water consumption(SMA, 2018). Another voluntary standard adopted by UNICA is the Bonsucro certification, which identifies companies that implement business practices aimed to stop water pollution and deal with waste and effluent effectively (BONSUCRO, 2017b).

The discourse of the government in its 2017 National Water Agency report is identical to that of UNICA, indicating that in the Center-South region water is not used for full irrigation of sugarcane fields. Irrigation occurs only in certain regions, where there is water rescue or supplemental irrigation, normally using wastewater from industrial processes (AGÊNCIA NACIONAL DE ÁGUAS, 2017). However, some studies, such as that by Fachinelli and Pereira (2015) showed that water was consumed for irrigation; for example, in Paranaíba river basin is around 89%, and the expansion of sugarcane could intensify this consumption. The State Plan for Water Resources 2016–2019 of the state of São Paulo indicates that the consumption and availability of water may be

aggravated given the trend of expansion of irrigation as a means of increasing the productivity of grain crops. For instance, according to this report, water from the "hydrographic region" of Vertente Paulista of Rio Grande is predominantly used for agricultural purposes (88.9%), of which, the sugarcane crop is 40%.The sugarcane in this region occupied the fertile soils, and the less fertile soils was destined for pasture (SIGRH, 2017).

Table 6.1 shows the low correlation of "water" with other themes; this fact can be attributed to the fact that the four actors studied showed little concern or interest in water issues, due to the national narrative of water abundance. The resource abundance of water, land, and territory associated with a good tropical climate was a foundation appropriated for the growth and expansion of agroenergy and agribusiness, with only the "sky being the limit," as a former minister of agriculture pointed out (RODRIGUES, 2006). Furthermore, MARTIRANI; PERES (2016) and SCHULZ; IORIS (2017) found that the dominant perception of Brazilians that water is an abundant resource – as often espoused by members of the political and economic elite – has created a lack of awareness and in action around water conservation and management and contributed to poor water governance.

As shown in Figure 6.3, the water crisis in São Paulo in 2015 was a defining event for the theme of water, separating the discourse into two periods. This water shortage event, which occurred in one of the most important Brazilian states, led to a call for action and the beginning of the deconstruction of the abundance narrative. Water ceased to be an issue that interests only a small group of academics and civil society activists, and it began to capture general interest. Thus, a paradigm shift was observed in the discourse around water use: to consider it not as an abundant commodity but as an expensive limited good, the lack of which could potentially endanger businesses (WBCSD, 2012; CNI, 2013). This paradigm shift is believed to have led to a change in corporate water management practices. According to the Brazilian National Confederation of Industries(CNI, 2013), these can be an important means of introducing rationalized water use to the business sphere while contributing to increased water security. Furthermore, it is recommended that financial institutions have been conserved to be

gradually incorporating elements of water management in their valuation portfolio. Indeed, there is international recognition of the central role of water resources as a relevant constraint in economic development, because of the potential cross-territorial interdependency with other sectors, such as energy and food (HOFF, 2011).

However, some criticisms have been leveled at the management and governance of water due to its tendency for technocracy (SOUSA; FIDELMAN, 2009), based on the notions of efficiency and economic gains that have arisen through the association with business process management. The use of instruments controlled by Watershed Committees (*Comitê da Bacia Hidrográfica)* is a main factor of inequality in water governance, as these committees are dominated by a socio-economic elite with technical training (Sousa and Fidelman,2009). Thus, those who hold technical knowledge can take advantage of their privileged situation and override common interest. Moreover, BENITES-LAZARO et al. (20018) demonstrated that UNICA has attempted to participate in the Committees to influence management instruments in order to safeguard corporate interests. In contrast, the UNICA discourse is that their presence in the colleges of water management, especially those involving regions where there are mills around the basins, shows the importance that the sugar-energy sector attributes to the rational use of water (UNICA, 2018).

6.5.3. Land-water-energy nexus

Regarding the land-water-energy nexus can be illustrative the debates on sugarcane expansion in the Cerrado biome. The government, specifically the Brazilian Environmental Ministry, indicated that between 2002 and 2008, Cerrado had an average annual deforestation equivalent to 14,200 km². Between 2010 and 2011, the rate of deforestation was 6,469 km². The main reason for this is agribusinesses expanding crop production, including sugarcane. The NGO actors, mainly social movements, started a "campaign in defense of the Cerrado" in 2016, aiming to alert the society of the impacts of the destruction of the Cerrado on biodiversity and regional cultures and communities. Its latest campaign slogan was "Without Cerrado, Without Water, Without Life." The campaign highlights the role that the Cerrado region plays in supplying water, given

that is the “cradle of the waters,” as it includes three large Brazilian aquifers. The campaign also points out that the water crisis faced in the most populous and economically and politically important states– São Paulo, Rio de Janeiro, Brasilia and Goiás – is likely strongly influenced by deforestation in the Cerrado biome.

A study by SPERA et al. (2016) showed that the Cerrado biome was the focus of intensive agricultural expansion between 2003 and 2013, over 2.3 million ha of land were newly cultivated, and a majority of natural land was cleared. These large-scale land-use changes affected the water balance in the region. Furthermore, government documents such as the National Energy Planand the ZAE Cana have identified Cerrado as an area suitable for the expansion of sugarcane activity: [of] the remaining Cerrado, 88.4% is suitable for growing soybeans, and 68.7% for sugarcane, crops for which demand is expected to grow in the coming decades (SANT’ANNA et al., 2016; STRASSBURG et al., 2017). Problematically, legal protection of the area remains weak; despite the inclusion of the Cerrado biome in the discourse of several actors and public agencies, little concrete action has been taken. Only 7.5% of the Cerrado biome is legally protected, compared with 46% of the Amazon rainforest. As a result,40% of the remaining natural vegetation is available for legal deforestation (STRASSBURG et al., 2017).

The scarcities associated with sugarcane production cannot be managed without the recognition of substantial trade-offs among different sectors that have traditionally been placed in the silos of land and water availability. In reality, these issues are not merely local matters but are global, complex, and will unfold at the territorial scales. In this sense they must be considered not only as a technical challenge: there is a need to incorporate the political dimension of such a nexus of interdependencies (ARTIOLI; ACUTO; MCARTHUR, 2017).

In this sense, the results indicate the need for change in societal perception about the importance of the interdependence between land conservation and water. For instance, a study by Jacobi et al. (2015) about the perception of water scarcity in São Paulostate in 2014 found that 72% of population identified reduction in rainfall as the main cause of

the water crisis; complex problems related to land use, spatial planning, and policies for the protection of natural resources were not mentioned.

6.6. Conclusions

The results of this study provide evidence of the importance of policies that recognize the inseparable nexus between resource use, including water and land use, and energy production. However, the study also shows that little progress has been made towards incorporating land-water, energy-land, and energy-water linkages in the Brazilian policy framework. The land-energy linkage became important only with growing interest in biofuels, and when large areas of land began to be allocated for the production of energy instead of food. The Brazilian government established the ZAE Cana to provide technical guidance for sugarcane expansion and encourage higher investment in this sector. Despite this, the main discourse around the ZAE Cana is that provides solid conditions to secure harmony among food, energy and ethanol production, and the environment. Nonetheless, in practice there is a general lack of coordination between government agencies and actors, which led to competition between directing land and water towards energy or towards food production.

The land-water linkage is an increasing concern, and debates are at an early stage regarding the rapid growth of agrochemical applications in farmland and its adverse impacts on water resources and the general environment. Our results showed that water in Brazil is ancillary to other interests, so its use was determined by economic or property rights, rather than environmental concerns. Moreover, the relatively isolated position of the themes of water and land in our correspondence analysis indicated a lack of political discourse considering the overlap of these highly interdependent sectors (energy-land-water), despite the country's complete and adequate environmental legal system. However, the organizational conditions under which these legal requirements must be implemented and enforced are, at best, precarious. The absolute primacy that Brazilian governments have given throughout history to "economic development at all costs" has placed environmental issues, including water and soil preservation, far from national priorities.

However, global transformational trends, such as climate change and the increasing competition or land and water resources by food and biofuel production, require these resources to be protected in a broader environmental context, as resources are becoming scarcer and interconnections between them are thus strengthening. This increases the need for policies that can cope with the interdependence among land-water-energy-food and recognize these resources as essential and intrinsic elements of human development and sustainability. In the sugarcane sector, land-water-energy nexus management measures can improve sustainability by reducing trade-offs and generating additional benefits that outweigh the transaction costs associated with greater policy integration.

The findings of this study reinforce the need for identifying integrative governance structures. Thus, future research based on the results of this study should focus on analyzing the climate-water-energy and food nexus, as well as the challenges and opportunities of coherent policies and interdependence between sectors in Brazil.

7. QUALITATIVE MODEL OF WATER-ENERGY-LAND NEXUS TO ASSESS SUGARCANE ETHANOL PRODUCTION IN BRAZIL[9]

7.1 Introduction

The emerging literature on nexus approach (BAZILIAN ET AL., 2011; HOFF, 2011; MIDDLETON ET AL., 2015; GIATTI ET AL., 2016) appoints that understand the links between water-energy-land (WEL) in the context of climate change is important, not only to ensure sustainable management, but also to avoid future conflicts. For example, it is widely perceived that climate change will affect watersheds, which will cause a dispute with other agents over the use of this resource that will be scarce, which even will affect the growth of this sector. However, understanding these links is not an easy task. The WEL are complex and dynamic concepts. While there is a solid body of research on each component, there is a little research on the WEL nexus or its implications for development. In addition, the debate on some components of the WEL is politically sensitive such as the use of water, expansion of the sugarcane, etc.

Some companies declare its increasing awareness with the environment issues. However, its corporate initiatives just is addressing in one of the sector of the nexus. For this reason the Bonn conference called to urgent action to adopt nexus thinking to view the interdependences and connections between the water-energy-food sectors (Hoffmann, 2011). From the business side, the World Economic Forum called to identify the current gaps in the knowledge of sustainability and evaluate how they might influence business practices, proposing key sustainability solutions that must be addressed to inform the practices and activities of the companies (WORLD ECONOMIC FORUM, 2011).

In the sugarcane ethanol industry, in particular, despite, there are already several voluntary schemes of sustainability certification based on economic, environmental and social considerations of its production process. However, climate change places new challenges for the industry when is analyzed its sustainability from the nexus approach,

[9] This chapter is based on the paper: Benites-Lazaro, L.L. et al. Qualitative model of water-energy-land nexus to assess sugarcane ethanol production in Brazil.

which can be related to the sugarcane expansion to other areas due to soil degradation that will lead to a dispute with areas dedicated to the food crop, negative environmental effects associated with the indirect change of land use, and water consumption.

7.2 Material and method

7.2.1 Nexus sectors

The nexus research focuses on a better understanding of the implications and the potential magnitude of water stress for energy production considering the problems of agriculture and food security. These three sectors are interconnected, thus, policy decisions and corporate actions in one area can have a profound impact on others. The nexus approach main objective is to generate innovative and evidence-based operational tools to help evaluate the economic, environmental and social compensation of water restrictions in energy expansion plans, energy security and food security.

There are several initiatives to develop an analytical framework on water-energy-food nexus, in particular in the evaluation of methodologies, such as those carried out by the World Business Council for Sustainable Development (WBCSD), the Stockholm Environment Institute, the World Resources Institute, FAO with a focus on the agrifood chain and the UNECE in transboundary basins, just to mention a few.

In this study, the model was constructed from the review of the specialized literature, selecting a list of topics related to each linkage of the WEL nexus, which shown in the Figure 7.1.
Adaptation to Climate Change involves effective water governance, vulnerability assessment on biofuel production and efficient use of land:

I. **Climate impacts on water resources**: Water stress: Basin hydrographic variability, Droughts, Floods, Water scarcity, Shortage groundwater recharge rates, freshwater availability and demand.

II. **Climate impacts on bioenergy production**: Vulnerability of sugarcane harvest for ethanol production, Life cycle impact assessment, Market scenarios, Scenario analysis.

III. **Climate impacts on Land Use**: Desertification, Deforestation, Soil erosion, Soil degradation.

The water resources sector is strategic and has an impact on all socioeconomic sectors. Hence, water management gains preponderant importance, especially with regard to its conservation in the face of extreme climatic events marked by the scarcity of water in the generation of energy, and in agricultural planning, this last sector is one of the largest consumers of water, for its irrigation practices:

IV. **Water management to climate change adaptation**: Water reuse, recycling water, Runoff, Drainage, Water storage, capture and store the extra water, Water conservation, Water use efficiency.

V. **Water needed for energy production**: Water for energy generation, Water for biofuels, Water consumed for biofuel, water footprint of bioelectricity.

VI. **Water needed for Land Use**: Irrigated agriculture, water demand for irrigation, sustainable water use, water use efficiency

The use of renewable energies is crucial for the mitigation of climate change. Energy is also required for water to be available for human use and consumption. The main energy consumers in modern agriculture are mechanization practices, the agrochemical and irrigation. This makes the joint management of both water and energy resources necessary:

VII. **Energy to climate change adaptation**: Reduction emission, Production bioelectricity, Energy efficiency, energy recovery, energy planning.

VIII. **Energy needed for water resources**: Wastewater treatment, Water treatment, Water distribution, Water irrigation.

IX. **Energy need for Land Use:** Mechanization, fertilization, pesticide, irrigation.

In the face of extreme climatic events, it is necessary to plan the use of the land, being the monitoring of the water quality of a basin one of its vital variables, the sustainable management of the use of chemical products in agriculture and the conservation of the use of the ground minimizing its degradation:

X. **Land Use to climate change adaptation**: Land Use planning, adapting watershed, Land-Use patterns, Land Use policy, Land Use optimization.

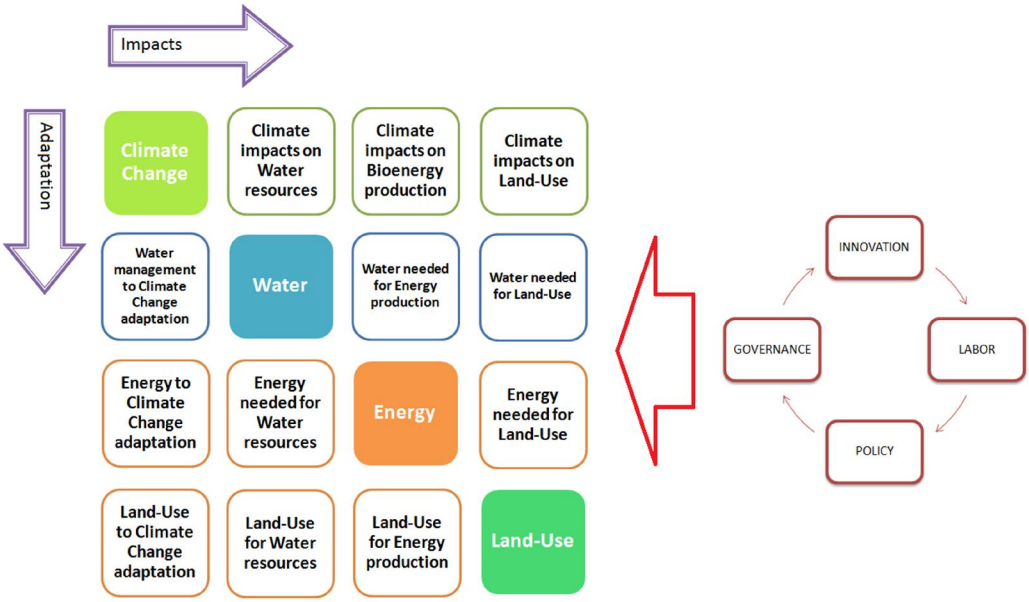
XI. **Land Use for water resources**: Reduces deforrestation, Water quality: pesticide contamination, Land use change, Expansion of rain-water storage, pasture water supply, Recycling and reuse of wastewater, agricultural water conservation, water recycling.

XII. **Land Use for energy production**: Land for energy generation, Sugarcane expansion, Area cultivated for biofuel, land footprint of sugarcane, carbon footprint of sugarcane.

Among the main actors that favor or hinder the development of the nexus are technological development, innovation, governance of the WEL sectors, human capital management and the implementation of public policies:

Influence factor: Innovation & Technology – Governance – Labor – Legislation – Policies.

Figure 7.1 Themes to construct the qualitative model WEL nexus by each linkage among the topics climate change – water-energy-land-use. The influence factor such as governance, innovation, labor and policy are considered.



7.2.2 Materials

In this study we constructed two c*orpus* in text format: one to train the model and another to evaluate the Nexus of ethanol, this latter is also used to validate the model. To train the model we use the abstract of the scientific publications on ethanol. These are a good source of reliable and complete data on the state of the art, since it covers all the multidisciplinary areas of research on ethanol. The compilation of the abstract includes the period from the year 1980 to March 2018, with 2251 abstracts present in the Scopus database and 4473 in the Elsevier editor's ScienceDirect database. For the construction of this corpus, the duplicate abstracts were eliminated and those that were not possible to obtain their keywords, totaling 6702 abstract.

The second corpus serves both to validate the model and to evaluate the Nexus of ethanol. This consists of a wide collection of literature related to the scientific article on ethanol in Brazil, books, and business reports.

Through the use of OpenRefine open source software were cleaned, standardized and ordered converting the database consisting of a set of semi-structured files, for a structured corpus so that it can be interpreted by the program. For the calculation of the similarity indexes, supervised LDA, extraction of elementary contexts using the Bayes algorithm by means of the TLAB software tools.

7.2.3 Method

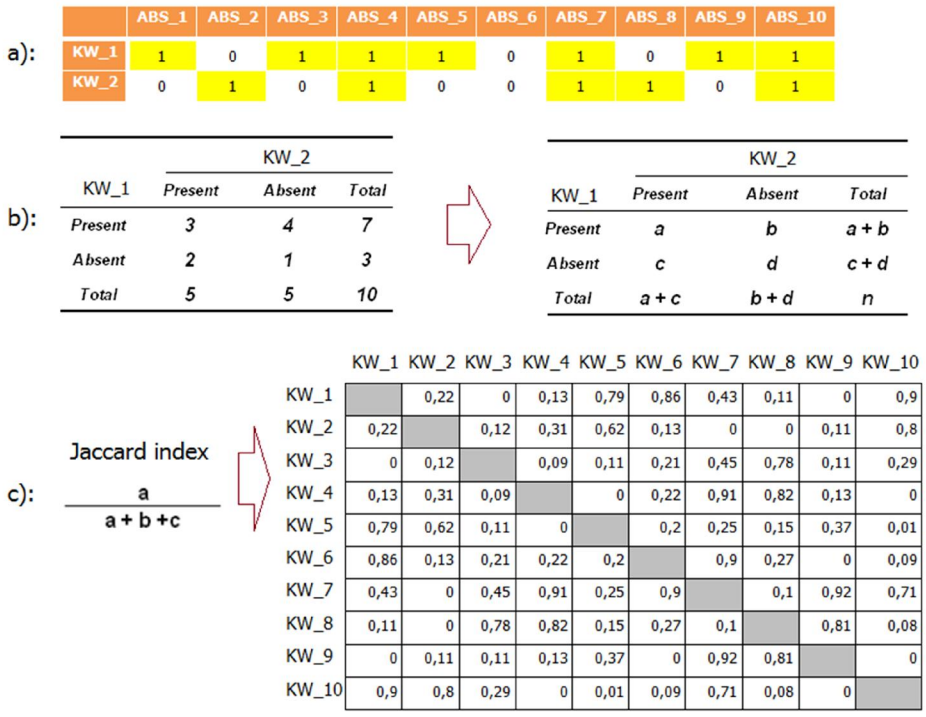
a) Association of keywords

Statistical methods of textual data analysis, such as multidimensional scaling, correspondence analysis, factor analysis and cluster analysis, are based on the use of the similarity matrix (or distance) between the words that make up the text. Indexes of similarity are frequently used in the search and retrieval of information representing the words (or documents) in a vector space. In text mining, the similarity is applied to the object of establishing a similarity metric between texts. These distances can be calculated in different ways: the most used we have the Cosine index, Dice index, Jaccar index, second order index. In general, these indices are based on comparisons of occurrence and non-occurrence of words within a context unit. In text analysis, occurrences are the quantities that result from the calculation of how many times (frequencies) each keyword is repeated within the corpus or within a unit of context (which would be the abstracts). On the other hand, co-occurrences are the quantities that result from the computation of the number of times that two or more keywords coincide in the same abstract.

The computation of the indexes of association (or proximity) allows us to find the relationships of co-occurrence and similarity/dissimilarity between the keywords, which allows determining the real meaning of the context in which they act. In the case of non-co-occurrence among the keywords, the association index is equal to 0. The results obtained using some of these similarity coefficients showed uniform results for the keywords that have statistical significance ($p \leq 0,5$), minimal variations between them are only presented in the values of the coefficients. In this study, was used the Jaccard index

is used, whose value is obtained from a formula that includes values of co-occurrence and occurrence (Figure 7.2).

Figure 7.2. Example of the calculation of the Jaccard association index for 10 keywords. In this study, the association matrix is 2090 x 2090.



The figure shows an example of the steps to create the association matrix. In a) we have a table of two keywords (KW_1 and KW_2), and 10 Abstract (ABS_1 to ABS_10) where the data are of binary type that registers the presence / absence of the keywords in the abstracts. By occurrence it is understood when a keyword is present in an abstract and co-occurrence when the two keywords are present in the same abstract at the same time (this is the case of ABS_4, ABS_7 and ABS_10). Then these data are represented in (b) by a table of absences and presences, which is generalized by the letters of the alphabet. In (c) the formula of the Jaccard index that is used to construct the association matrix is shown. These matrices reach dimensions of hundreds of rows and columns that are used for the construction of the different multivariate statistics methods, such as MDS maps, factor analysis, correspondence or cluster analysis.

b) Multidimensional Scaling Method (MDS) - is a statistical technique that allows the analysis of square matrices that contain the values of proximity (similarity) constructed from the computation of some index of association (like Jaccard's),

providing a visual representation (MDS map) of the relationships between the data within a space of reduced dimensions. In this paper we use the Sammon method to represent the relationships between keywords. The degree of correspondence between the distances, between the points obtained by the MDS map and those of the input matrix, is measured (inverse) by a stress function. The lower the stress value (e.g. <0.10), the greater the quality of the adjustment obtained. The use of MDS maps allows a better understanding of the context and the relationships between the keywords.

c) Supervised learning and thematic modeling of the water-energy-food nexus

In Natural Language Processing (NLP), supervised learning is a technique to derive a function from training data. The training data consist of pairs of vectors, a component of the pair are the input data and the other, the desired results. The output of the function can be a numeric value (as in regression problems) or a class label (as in classification). The objective of supervised learning is to create a function capable of predicting the value corresponding to any valid input object after having seen a series of examples, training data. For this, it has to generalize from the data presented to the situations not previously seen.

Supervised learning generates a function that transforms the input data into the desired results. To solve our problem of supervised learning - construction of nexus linkages, we implemented the following steps:

a) Construction of the database that serves as examples of model training. In this study they are the keywords of the abstract of the scientific articles.
b) Determine the input function of the representation of the learned function. The accuracy of the learned function depends to a large extent on how the input object is represented. The entry object is vectors of keyword chains, which contains a series of characteristics that describe the object, these vectors are the results of the distance calculation between the keywords using the similarity coefficients.

c) Determine the structure of the appropriate function to solve the problem and the corresponding learning technique. As it is a classification problem, the function to be modeled will be a chain of keywords that describe the object (nexus themes), by using the LDA algorithm in its supervised mode.
d) Complete the design. Using the selected vector-keywords was executed the supervised learning algorithm LDA, during the modeling a new chain of keywords are created this time as a result of the application of the probabilistic algorithm LDA (BLEI et al. 2003, 2012).
e) After adjustment and learning of the vectors, the performance of the algorithm is measured using a test set independent of the training (abstracts), this test set is the new corpus, for which using the probabilistic algorithm of Naive Bayes, we extract the elementary contexts for each vector and confer if these contexts describe the modeled object.

d) Markov chain algorithm

The most used methods in natural language processing is the modeling of n-grams to check if the probability that an automated translation is correct, predict the next most likely word to occur in a sentence, the automatic generation of texts from speech, spell-correction automation, etc. (BROWN, 2011).

N-gram is a contiguous sequence of n-words in a given sequence of text. From a textual document we can elaborate a list of n-grams from their content by finding pairs of words that are next to each other. From that list of n-grams we can count the number of occurrences of each n-gram. This count determines the frequency with which a n-gram occurs throughout the document. In large amount of documents (big data) to carry out this process of analysis of n-grams is by using probability theory and Markov Assumption (Markov Chain Monte Carlo method), which allows us to make a simplification by assuming that the future states of our model only depend on its actual state. This assumption means that we can reduce our conditional probabilities so that they are approximately equal for that to be the case. More generally, we can estimate

the probability of occurrence of a sentence by the probabilities of each part that compose it.

Markov Chain applied to the analysis of sequences: A Markovian chain is constituted by a sequence of events, generally indicated as states, characterized by two properties: The set of events and their possible outcomes is finite and the result of each event depends exclusively from the immediately previous event with the consequence that each transition from one event to another corresponds to a probability value.

In the scientific field, the Markov chains model is used to analyze the successions of economic, biological, physical events, etc. In the field of linguistic studies, its applications are aimed at the possible combinations of the various units of analysis in the axis of syntagmatic relations (one unit after another), which is used to retrieve textual information or in the prediction of words (GERALD; GENDRON, 2015).

In this study, the Markov chains acts on the sequences of the relations between lexical units present in the corpus in analysis of Nexus themes. First, square tables are created in which the occurrences of thematic transitions are represented, that is, quantities that indicate the number of times in which a theme precedes (or follows) the other. Subsequently, the occurrences of the transitions are transformed into probability values (Markov chains). Finally, the new vectors created by latent Dirchelet allocation modeling allow us to create categorized thematic dictionaries that we use for the construction of a "Qualitative Analysis Model" that will be applied to the new corpus based in the database (bibliographic collection) with relevant information on the thematic of nexus and ethanol. For this end is used NLP techniques, this thematic analysis model allows us to explore the relationships between the Nexus themes through a Markovian analysis, which elements are the keywords (context units) obtained through the supervised LDA classification. The computation of the adjacency matrix of the keywords on this new corpus, based on its probability values, allows us to create a network analysis of our "Theme Model" to be interpreted through the application of graph theory. Cluster analysis of the "Themes Model" is also performed using the BKM algorithm.

7.3. Analysis and results

7.3.1. Scientific publications on sugarcane ethanol in Brazil

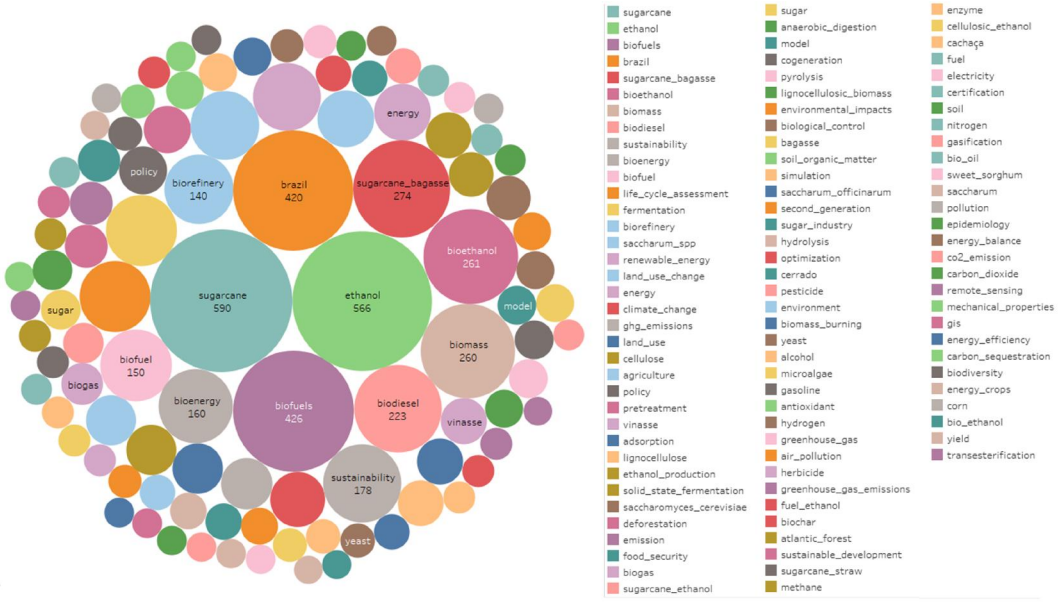
The Bioenergy Research Program (BIOEN) financed by the São Paulo State Research Founding Agency (FAPESP). The objectives of this program is to generate new knowledge, train highly qualified human resources and articulate research and development activities in Bioenergy in Brazil, for this purpose it has a large network of academic and industrial laboratories, which includes five groups: Biomass for Bioenergy (with focus on sugarcane); Biofuels Manufacturing Process Division; Division of Biorefineries and Alcohol Chemistry; Division of Ethanol Applications for Automotive Engines: internal combustion engines and fuel cells; Research Division on Socio-economic, Environmental, and Land Use Impacts (BIOEN, 2018).

The areas where the BIOEN Research Projects are inserted are: Agronomy, Agricultural Engineering, Botany, Ecology, Economy, Biophysics, Biochemistry, Genetics, Microbiology, Interdisciplinary, Food Science and Technology, Engineering, Physics, Geosciences, Mathematics, Chemistry.

All this research has generated an expressive scientific production that is reflected in patents, master and doctoral theses and articles in indexed scientific present in databases such as WoS, Scopus and ScienceDirect, mainly.

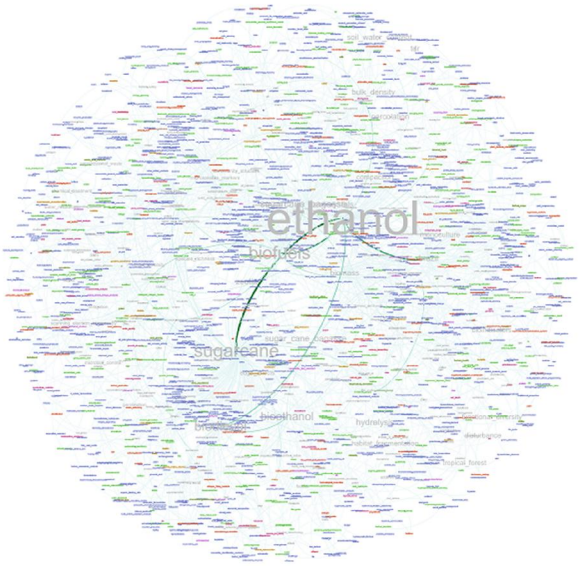
The Figure 7.3 depicts the result of the collection of abstracts, and Figure 7.4 the network of the abstracts. From the number of occurrences (Figure 7.3) and the measure of number of connections between centrality (Figure 7.4) is observed that the subjects with the highest occurrences and ligations are those related to ethanol, sugarcane, biofuels, sugarcane bagasse and biodiesel, this means that these topics are the most discussed in the scientific publications on ethanol, which covers cross-disciplinary interdisciplinary areas from climate sciences, biological sciences, agricultural sciences, to fields of the social area such as governance, innovation and public policies.

Figure 7.3 Occurrences of keywords in scientific publications on ethanol



The top 100: *sugarcane* (590), *ethanol* (566), *biofuels* (426), *brazil* (420), *sugarcane_bagasse* (274), *bioethanol* (261), biomass (260), biodiesel (223), sustainability (178), bioenergy (160), biofuel (150), life_cycle_assessment (149), fermentation (147), biorefinery (140), saccharum_spp (138), renewable_energy (134), land_use_change (96), energy (94), climate_change (88), ghg_emissions (77), land_use (74), cellulose (73), agriculture (73), policy (67), pretreatment (65), vinasse (63), adsorption (62), lignocellulose (61), ethanol_production (61), solid_state_fermentation (58), saccharomyces_cerevisiae (57), deforestation (55), emission (54), food_security (52), biogas (51), sugarcane_ethanol (48), sugar (47), anaerobic_digestion (46), model (45), cogeneration (45), pyrolysis (44), lignocellulosic_biomass (43), environmental_impacts (43), biological_control (43), bagasse (43), soil_organic_matter (42), simulation (42), saccharum_officinarum (42), second_generation (40), sugar_industry (39), hydrolysis (39), optimization (38), cerrado (38), pesticide (37), environment (37), biomass_burning (37), yeast (36), alcohol (35), microalgae (34), gasoline (34), antioxidant (34), hydrogen (33), greenhouse_gas (32), air_pollution (32), herbicide (31), greenhouse_gas_emissions (31), fuel_ethanol (31), biochar (31), atlantic_forest (31), sustainable_development (30), sugarcane_straw (30), methane (30), enzyme (30), cellulosic_ethanol (30), cachaça (30), fuel (29), electricity (29), certification (29), soil (28), nitrogen (28), gasification (28), bio_oil (28), sweet_sorghum (27), saccharum (27), pollution (27), epidemiology (27), energy_balance (27), co2_emission (27), carbon_dioxide (27), remote_sensing (26), mechanical_properties (26), gis (26), energy_efficiency (26), carbon_sequestration (26), biodiversity (26), energy_crops (25), corn (25), bio_ethanol (25), yield (24), transesterification (24).

Figure 7.4. Network of keywords of the articles (2090 unique keywords), the table to the side indicates the frequency and the two measures of centrality: closeness and between, of the first 28 keywords.



Label	Frequency	Closeness centrality	Between centrality
ethanol	566.0	50.0	0.326
sugarcane	590.0	51.0	0.301
biofuels	425.0	51.0	0.281
sugarcane_bagasse	274.0	51.0	0.263
brazil	420.0	51.0	0.260
biodiesel	223.0	49.0	0.249
biofuel	150.0	51.0	0.239
fermentation	147.0	51.0	0.238
biomass	260.0	52.0	0.233
cellulose	70.0	51.0	0.233
optimization	38.0	51.0	0.232
air_pollution	31.0	51.0	0.231
alcohol	35.0	51.0	0.231
hydrogen	33.0	51.0	0.231
sugar	47.0	51.0	0.231
sustainable_development	30.0	51.0	0.230
alcohol_drinking	7.0	51.0	0.230
co2_emission	27.0	51.0	0.230
experience_curve	8.0	51.0	0.230
sugarcane_biorefinery	15.0	51.0	0.230
sugar_industry	38.0	51.0	0.230
gasoline	34.0	51.0	0.230
flex_fuel	14.0	51.0	0.230
cge	8.0	51.0	0.230
sugarcane_molasses	11.0	51.0	0.230
social_impacts	21.0	51.0	0.230
lead	8.0	51.0	0.230
transportation_sector	4.0	51.0	0.230

In a disaggregated way, we show the association network of the keywords related to the themes Water (Figure 7.5) and Food (Figure 7.6).

The figures (7.3 - 7.6) show that the themes addressed and linked to a specific topic from scientific articles are a good starting point for the construction of our input vectors to construct our model.

Figure 7.5. Network of keywords of the articles (2090 unique keywords), the table to the side indicates the frequency and the two measures of centrality: closeness and between, of the first 28 keywords.

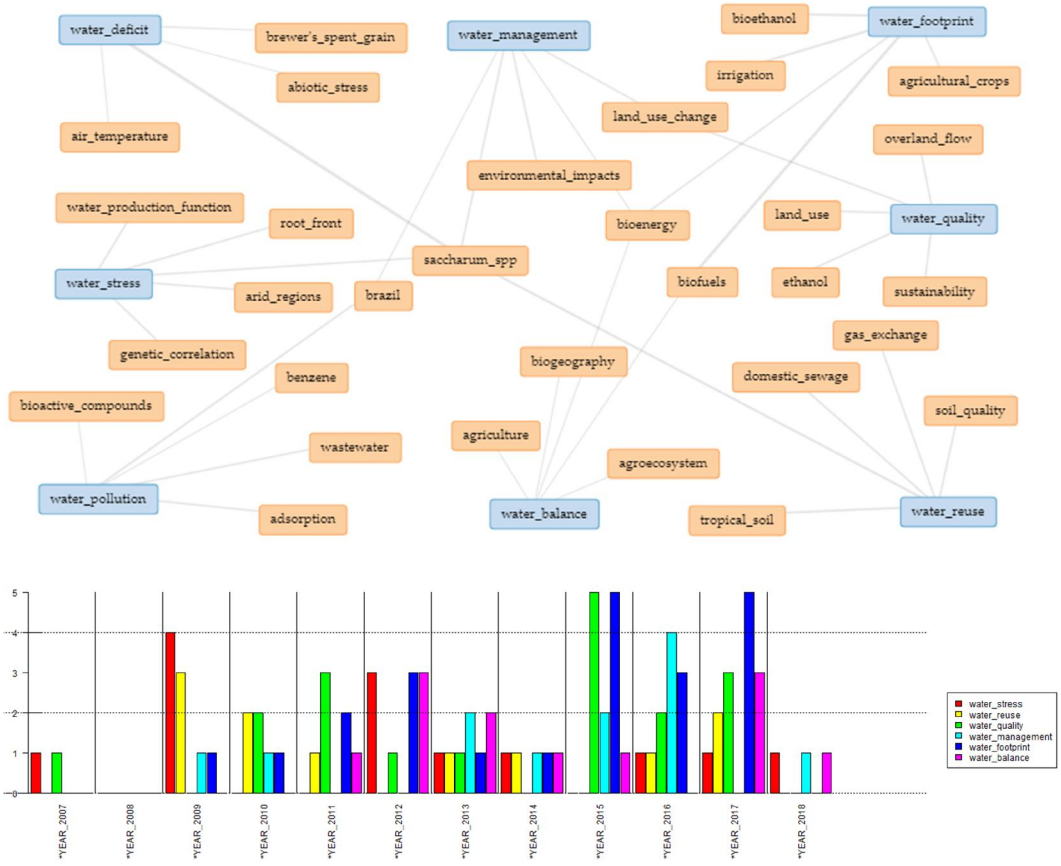
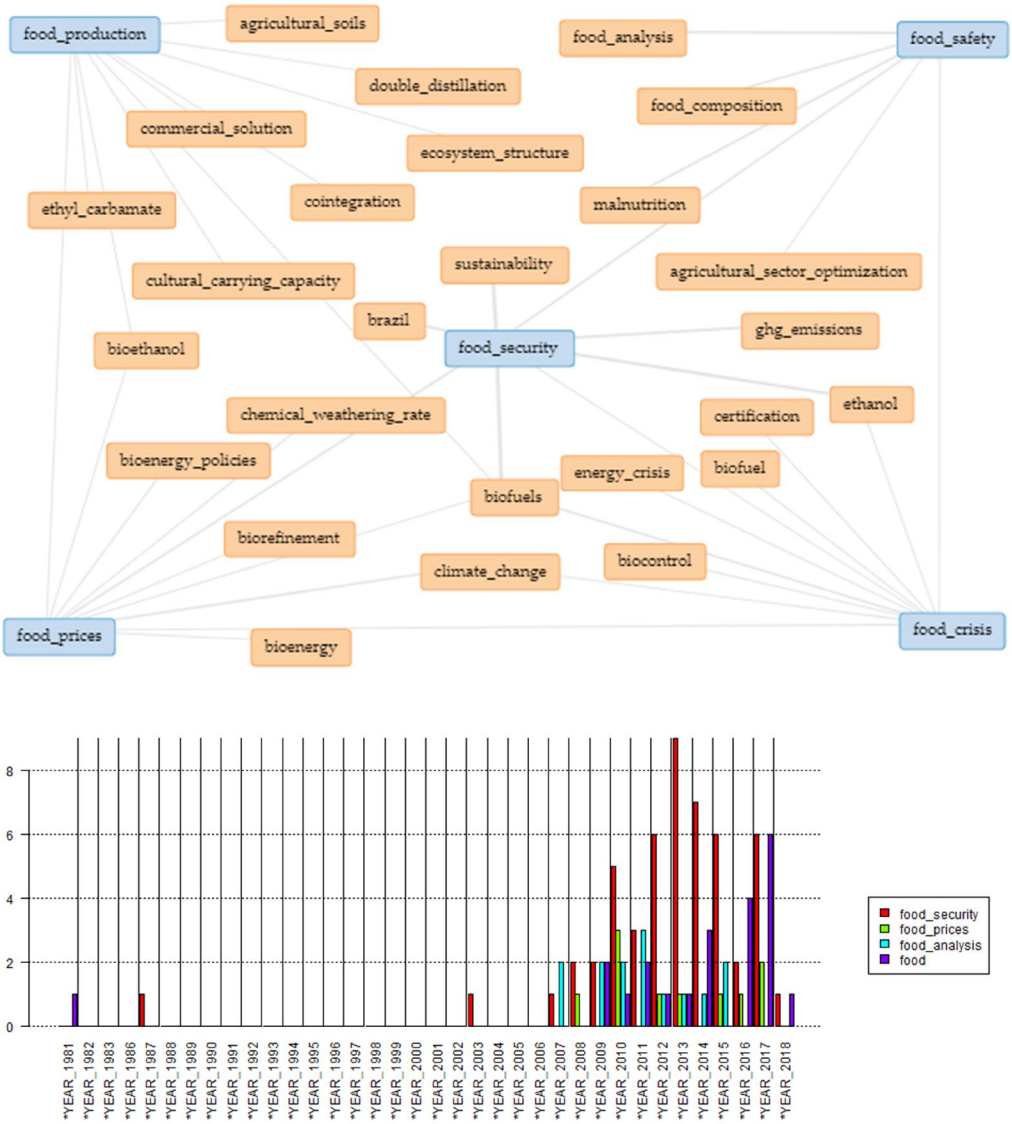


Figure 7.6 Network keywords related to food theme.



The words in blue color are the main keyword and the words in orange are subsequent neighboring keywords with direct links to the main keyword. The figure of the timeline depict when the theme food were most addressed. This network map allows us to have knowledge about the state of the research on the theme food. By linking in the first order keywords (blue color) we can infer the topics treated in the research and also of topics that are not present in the indexed databases about scientific publications.

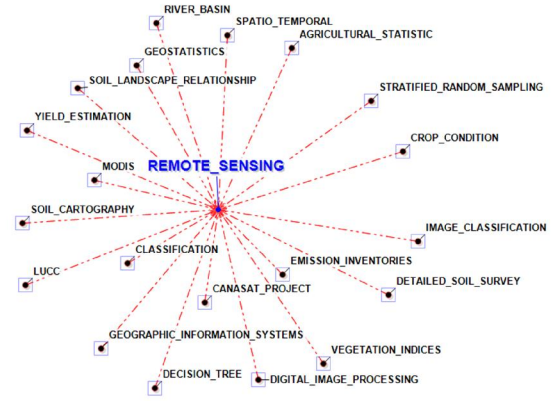
7.3.2. Construction of the input vectors using the Jaccard similarity index.

To construct the input vectors we use the keywords of the abstracts of the scientific publications obtained from the Scopus and ScienceDirect database, which are organized in rows respecting the date of their publication, from the most recent (March 2018) to the oldest (year 1980).

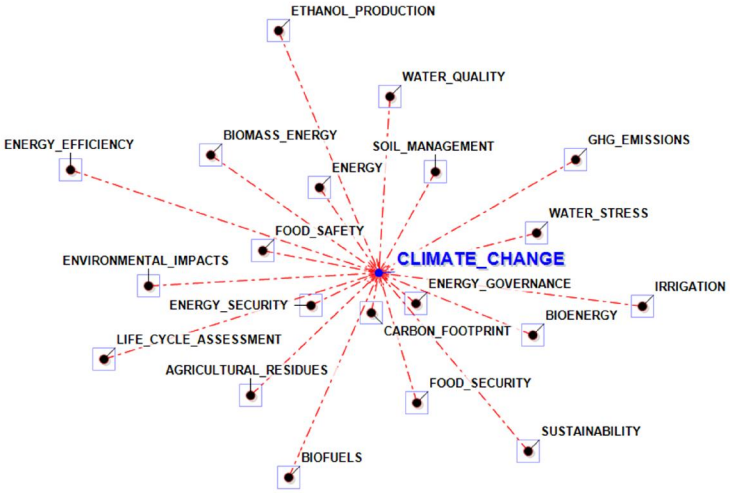
The length of the keyword (number of words) is limited by the software, with a maximum of 5 words joined by for each keyword. The average relevance of the closest keywords is calculated using the Jaccard similarity coefficient.

In the radial diagram (Figure 7.7), the selected keywords are placed in the center. The neighboring keywords are distributed around it, each one at a distance proportional to its degree of association. The table to the side presents the relations of occurrences and co-occurrences of this keyword with its closest neighbors, where KEYWORD_A is the selected keyword, KEYWORD_B the keywords associated with KEYWORD_A; COEFF is the value of the Jaccard association index, CE_B is the total of the elementary contexts in which each associated keyword B is present, CE_AB is the total of the elementary contexts in which the keywords "A" and "B" are associated (co-occurrences), CHI2 is the value of the chi-square ($\chi 2$) to verify the degree of significance of the co-occurrences, and (p) is the probability associated to each value of the chi-square.

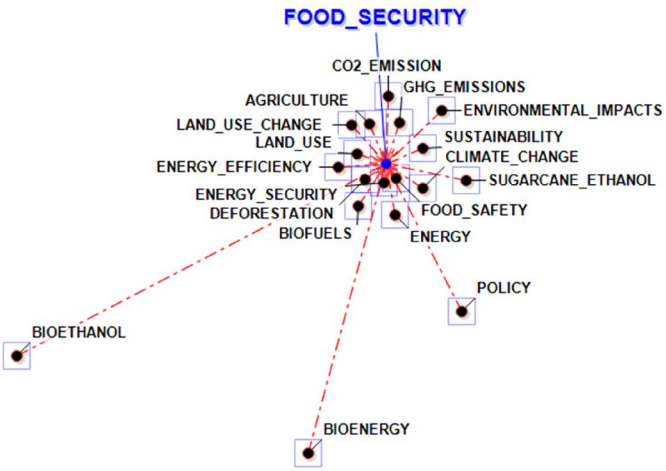
Figure 7.7 Radial diagram of Keyword Remote_Sensing, Climate_Change, Food_Security partnership



KEYWORD_A: REMOTE_SENSING					
KEYWORD_B	COEFF	CE_B	CE_AB	CHI2	(p)
EMISSION_INVENTORIES	0,08	2	2	513,15	0,000
CANASAT_PROJECT	0,07	4	2	254,66	0,000
CLASSIFICATION	0,07	5	2	202,96	0,000
MODIS	0,06	10	2	99,57	0,000
GEOSTATISTICS	0,04	24	2	39,30	0,000
AGRICULTURAL_STATISTIC	0,04	1	1	256,54	0,000
CROP_CONDITION	0,04	1	1	256,54	0,000
DETAILED_SOIL_SURVEY	0,04	1	1	256,54	0,000
DIGITAL_IMAGE_PROCESSING	0,04	1	1	256,54	0,000
GEOGRAPHIC_INFORMATION_SYSTEMS	0,04	1	1	256,54	0,000
SOIL_CARTOGRAPHY	0,04	1	1	256,54	0,000
SOIL_LANDSCAPE_RELATIONSHIP	0,04	1	1	256,54	0,000
SPATIO_TEMPORAL	0,04	1	1	256,54	0,000
STRATIFIED_RANDOM_SAMPLING	0,04	1	1	256,54	0,000
IMAGE_CLASSIFICATION	0,04	2	1	127,29	0,000
VEGETATION_INDICES	0,04	2	1	127,29	0,000
DECISION_TREE	0,04	3	1	84,21	0,000
LUCC	0,04	3	1	84,21	0,000
YIELD_ESTIMATION	0,04	3	1	84,21	0,000
RIVER_BASIN	0,03	4	1	62,67	0,000
CROP_COEFFICIENT	0,03	5	1	49,75	0,000
LAND_COVER	0,03	5	1	49,75	0,000
LEAF_AREA_INDEX	0,03	5	1	49,75	0,000
BIOMASS_BURNING	0,03	37	2	24,21	0,000
COOPERATIVE	0,03	6	1	41,14	0,000
LAND_USE	0,03	75	3	25,58	0,000



KEYWORD: CLIMATE_CHANGE		
	Subset 1	Subset 2
ENERGY_GOVERNANCE	0,5175346	0,4824654
CARBON_FOOTPRINT	0,4018545	0,5981455
ENERGY_SECURITY	0,3663312	0,6336688
FOOD_SAFETY	0,2490279	0,7509721
ENERGY	0,2238837	0,7761163
SOIL_MANAGEMENT	0,1963684	0,8036316
WATER_STRESS	0,1769054	0,8230946
BIOENERGY	0,1672312	0,8327688
FOOD_SECURITY	0,1593931	0,8406069
AGRICULTURAL_RESIDUES	0,1389914	0,8610086
ENVIRONMENTAL_IMPACTS	0,1286822	0,8713178
BIOMASS_ENERGY	0,1267162	0,8732838
WATER_QUALITY	0,1210318	0,8789682
GHG_EMISSIONS	0,1172956	0,8827044
IRRIGATION	0,1104329	0,8895671
SUSTAINABILITY	0,1020899	0,8979101
BIOFUELS	0,09906896	0,9009311
LIFE_CYCLE_ASSESSMENT	0,09877785	0,9012222
ENERGY_EFFICIENCY	0,08751477	0,9124852
ETHANOL_PRODUCTION	0,08436376	0,9156362



KEYWORD: FOOD_SECURITY		
	Subset 1	Subset 2
FOOD_SAFETY	0,4234996	0,5765004
ENERGY_SECURITY	0,3110407	0,6889593
DEFORESTATION	0,274167	0,725833
LAND_USE	0,2310712	0,7689288
AGRICULTURE	0,1873641	0,8126359
GHG_EMISSIONS	0,1855463	0,8144537
SUSTAINABILITY	0,1773064	0,8226936
CLIMATE_CHANGE	0,1593931	0,8406069
ENERGY	0,1535831	0,8464169
BIOFUELS	0,1519723	0,8480277
ENERGY_EFFICIENCY	0,1470296	0,8529704
LAND_USE_CHANGE	0,1466589	0,8533411
CO2_EMISSION	0,1210318	0,8789682
ENVIRONMENTAL_IMPACTS	0,09704855	0,9029515
SUGARCANE_ETHANOL	0,08423267	0,9157673
POLICY	0,04713054	0,9528695
BIOENERGY	0,02688934	0,9731107
BIOETHANOL	0,01713876	0,9828612

The figure depict the occurrence and co-occurrence relationships with respect to the nearest keywords. All neighboring Keywords present statistical significance ($p \leq 0,05$).

7.4 Construction of the qualitative model indicators

Repeating this process above described for each keyword related to the nexus theme (water-energy-land), we construct the input vectors that will be used in the LDA modeling, where new vectors are created, this time using probabilistic methods, its results are shown in the following table:

Table. 7.2 Construction of indicators from the result of the nexus keywords-themes WEL applying LDA topical modeling.

LINKAGE NEXUS	INPUT VECTOR	OUTPUT LDA KEYWORDS - VECTOR
Climate impacts on water resources:	**Water stress**	Water stress, irrigation, deep soil, energy balance, ethanol production, water consumption, water footprint, water quality, water soil management, water use efficiency, bioethanol, climate change, risks mitigation
	Water scarcity	Water scarcity, water footprint, bioenergy, agricultural crops, climate change, economy, food production, virtual water, water, water availability
Climate impacts on bioenergy production:	**Market scenarios**	Bioenergy, fuel ethanol, international trade
	Market variables	Brazil, climatic variability, ethanol trade
	Scenario analysis	Industrial symbiosis, brazil, business model, climate change, electricity, bioethanol, life cycle assessment
Climate impacts on land use	**Deforestation**	Agricultural expansion, amazon, atlantic forest, dynamic effects, beef, biodiesel, bioenergy, biofuels, carbon sequestration, cattle intensification, cerrado, land use policy, legal amazon, legislation, low carbon transitions, redd, , soy, soybean, sugarcane expansion, water quality
	Soil erosion	Biodiesel, bioethanol, energy, model, watershed, soil organic matter, sustainability, sediment granulometry, sediment transport sector, ghg emissions, land use change, biofuels

continue

Table 7.2 - Continuation

Water management to climate change adaptation:	**Water reuse**	Domestic sewage, hydroponic system, subsurface drip, sustainability, treatment, wastewater irrigation
	Water use efficiency	Drip irrigation, fertirrigation, nitrogen use efficiency, subsurface drip irrigation, water management
	Water management	Drip irrigation, hydro repellency index, irrigation, river basin, subsurface drip irrigation, water balance, water deficit, water use efficiency
Water needed for energy production	**Water Footprint of bioelectricity**	Bioenergy, biodiesel, bioenergy, bioethanol, biofuels, biomass, energy, energy crops, soil water balance, sugarcane, sugarcane ethanol, sustainability, virtual water, blue water, water balance, water quality, water quality objective
	Water consumed for biofuel	Cellulose, energy planning, ethanol, green process, simulation, sugarcane, sugarcane mills, sustainability, water quality
Water needed for land use:	**Irrigated agriculture**	Agriculture, crop coefficient, cultivar selection, crop modelling, crop rotation, deep soil, dssat, drip irrigation, irrigation management, irrigation in sugarcane, energy balance, energy crops, life cycle assessment, nitrogen, saccharum spp, sugar industry, sugarcane, sugarcane ethanol, sustainability, variability, water deficit, water footprint, water management
	Water use efficiency	Bioenergy, biofuels, carbon dioxide, crop evapotranspiration, drip irrigation, energy crops, fertirrigation, nitrogen, nitrogen use efficiency, productivity, renewable, saccharum spp, subsurface drip irrigation, water management, water stress

continue

Table 7.2 - Continuation

Energy to climate change adaptation:	**Energy eficiency**	Agroethanol industry, bio energy, biodiesel, bioethanol, biofuels, biorefinery, brazilian biodiesel program, climate change, co2 emission, cogeneration, consumption rate, electricity from biomass, energy security, energy transition renewable energy sources, renewable fuel, smart grid, socioeconomic effects, sugarcane, sustainability, sustainable development, transport sector modes, energy intensity, sectorial analysis
	Energy recovery	Anaerobic digestion, bioenergy generation, biogas, economic benefits, stillage
	Energy plannig	Bioenergy, biomass, biomass energy, biorefinery, cellulose, energy market, fuel, green process, life cycle assessment, liquid biofuels, livestock, productivity, renewable energy, simulation, sugarcane bagasse ethanol Sugarcane mills, supply chain, sustainable energy development, waste management, wastewater, water consumption, biodiesel policy
Energy needed for water resources:	**Wastewater treatment**	Adsorption, anaerobic digestion, biogas, gasification, recovery, waste management, water pollution, water reuse, microalgae cultivation, biomaterials, microalgae strain development
	Water treatment	Filtration, sedimentation, ultrafiltration
Energy need for land use:	**Mechanization**	harvest route, harvesting machine, mechanical cultural practices, mechanical cultivation, mechanization, mechanically harvested, mechanical harvesting, traffic
	Irrigation	irrigation, water stress, depp soil, water footprint, water deficit, dssat, drip irrigation
	Fertilization and Pestiside management	fertilization, fertilizer, fertirrigation, nitrogen, micronutrients, nutrient, cultivar, diesel consumption, pesticide, toxicity, pollution,

continue

Table 7.2 - Continuation

Land use to climate change adaptation:	**Land-Use planning**	Atlantic forest, ecosystem functioning, environmental certification, high diversity reforestations
	Land-Use policy	Amazon, deforestation, land use optimization, production possibility frontier, soybean, sustainable agriculture, tropical conservation river basin, forest code
	Land-Use optimization	Land use policy, production possibility frontier, sustainable agriculture, tropical conservation
Land use for water resources:	**Water quality**	Ground water, integrated economic hydrologic modeling, land use, land use change, nitrogen balance, nonpoint pollution, nonpoint source pollution, river basin, sewage treatment, water balance, water consumption, water footprint, water quantity, watershed management, herbicide, pesticide, anaerobic treatment, water quality objective, water quality parameters, organic pollutants
	Management conservation soil	Management practices, management strategies , precision agriculture, spatial variability, biodiversity hotspot Control, demand, environmental impacts, genetic improvement, land use change, selection strategies, soil organic matter, straw removal, n fixing crop, reduced tillage, n2 fixation, n balance, stabilized fertilizer, nitrogen use efficiency, nitrogefertilization, soil nitrogen supply, water soil management
	WATER REUSE	Rainwater doc storage, surface water, dissolved organic carbon, rainwater, domestic sewage, wastewater irrigation, wastewater bioremediation
Land use for energy production	**Sugarcane expansion**	Co2 emission, deforestation, economic growth, ethanol production, food security, labor market, land availability, social impacts, soil management, soil organic matter, sustainability, sustainable development, sustainable management, sugarcane harvest
	SUGARCANE HARVEST	Air pollution, green harvest, mechanization, no burning, soil compaction, soil quality, sustainability

continue

Table 7.2 - Continuation

Land use for energy production	**Land footprint**	Bio conversion methods, biomass, ethanol, farm to fuel, lca, lignocellulose, sustainability
	Carbon footprint	Agricultural systems, bioethanol, biofuels, climate change, co2 emission, environmental sustainability, ethanol production, fertilization, filter cake, ghg emissions, land use change, sugarcane cultivation, sustainable production, variability, vinasse
Influences Factors	**Governance**	Governance, better sugarcane initiative, bonsucro iniciativa, sustainability certifications, certified by bonsucro, certificate of conformity, code of conduct, fuel completão, national commitment, ethanol summit, global reporting initiative, global sugar alliance, gri global reporting, project agora, renewal project, agricultural protocol, renovabio, corporate environmental responsibility, social fuel seal, green energy seal
	Public policy	Public policy, public administration, family bag, brazil without miseria, fight against hunger, combating poverty, public consultation, consumer defense, social development, human rights, eradication of poverty, eradicate hunger, hunger zero, social inclusion, social justice, environmental license, regulation mark, school lunch, satellite monitoring, energy planning, strategic planning, action plan, decenal plan, energy policy, growth acceleration program, biodiesel program, renovabio, road transport, rota 2030, inovar-auto
	Technology Innovation	Technology, jet bioquerosene, scientific community, esalq, first generation ethanol, second generation ethanol, fapesp, finep, innovation inpe, agricultural machinery, genetical enhancement, flex-fuel engines, flex-fuel technology
	Legislation	Legislation, legislative assembly, public hearing, chamber of deputies, political scenario, committee, brazilian congress, decree law, agropecuary parliamentary front, work justice, environmental legislation, law 10,848, agricultural law, lobby, mp 613, mp 635, audit office

continue

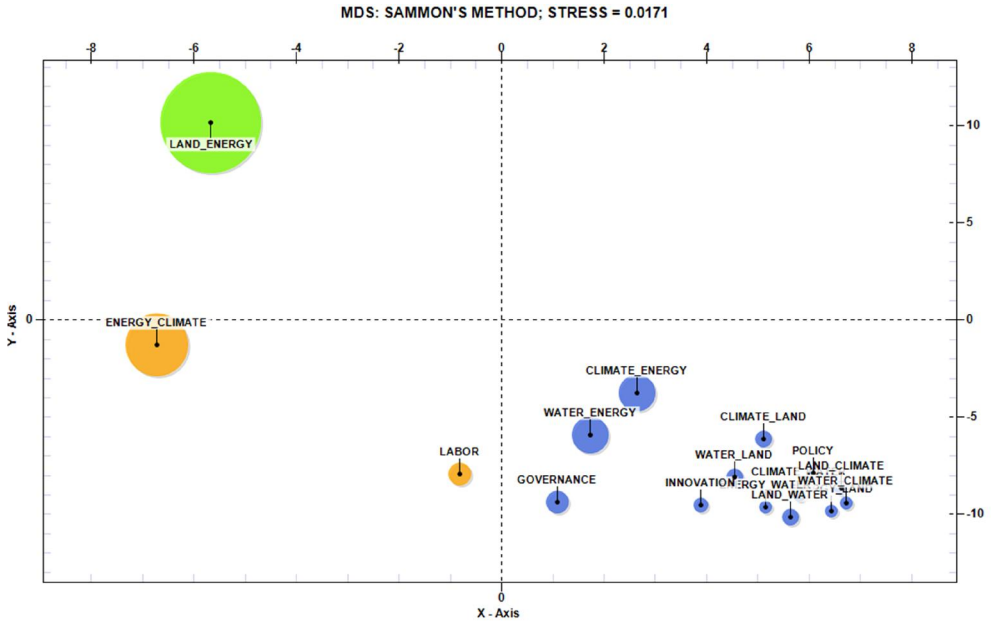
Table 7.2 – Conclusion.

Influences Factors	**Labor**	Labor, work conditions, recruitment, cancer cutters, requalification courses, rural employees, cane harvest operators, labor practices, health at work, occupational health, safety of workers, cana workers, cut workers, sector workers, workers in agriculture, rural workers, slavery, child labor, work on sugar cane, training and requirement

7.5 Application of the model – indicators

Based on the indicators (thematic dictionaries) Table 7.2, we applied to the second corpus to test the model. Figure 7.8 shows the MDS map of the themes from the new corpus.

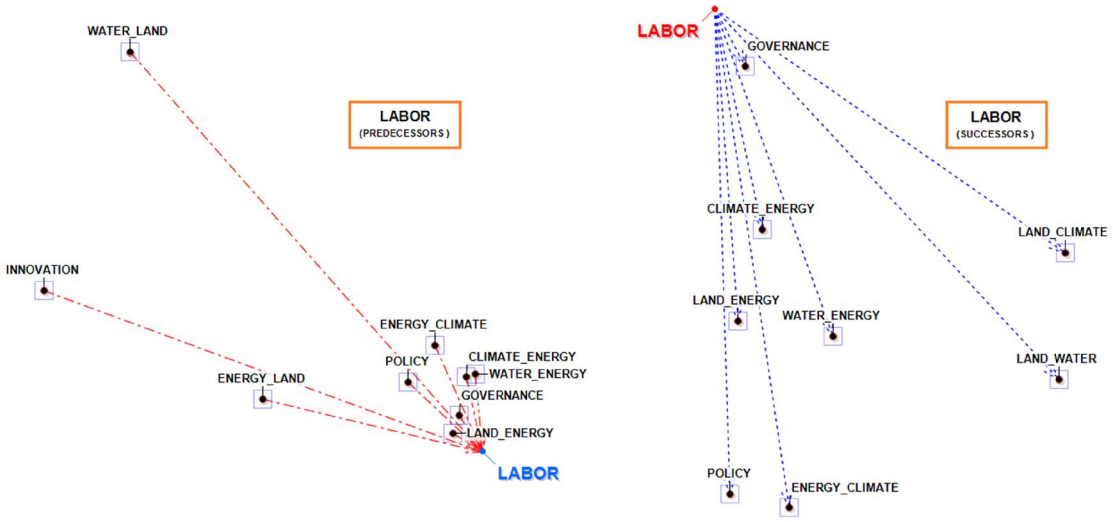
Figure 7.8 MDS map of the themes.



The theme lad use-energy is predominant in the map and is related to sustainability, biomasse, land-use change, soil_management, food_security, ethanol, sugarcane (this covers a large sub area life_cycle_assessment).

Figure 7.9 shows the Markov Chain algorithm that was obtained from a series of chains of states (probabilities of events) associated to the nexus themes. As an example we show the probability of events associated with the theme LABOR (Figure 7.9). The table shows the sorted list of predecessors (the first) and successors (the second). The list is in descending order according to the probability values ("PROB"), for example, the probability that "GOVERNANCE" will follow "LABOR" is equal to 0.06, that represent 6%.

Figure 7.9 Markov Chain of the theme labor that show a series of most probable events for the theme LABOR.



PROB	PREDECESSOR
0,04	LAND_ENERGY
0,04	GOVERNANCE
0,02	CLIMATE_ENERGY
0,02	WATER_ENERGY
0,01	ENERGY_CLIMATE
0,01	POLICY
0,01	ENERGY_LAND
0,00	INNOVATION
0,00	WATER_LAND

SUCCESSOR	PROB
GOVERNANCE	0,06
CLIMATE_ENERGY	0,03
LAND_ENERGY	0,03
POLICY	0,02
ENERGY_CLIMATE	0,01
WATER_ENERGY	0,01
LAND_CLIMATE	0,01
LAND_WATER	0,01

In the graph, the themes that are closer to the LABOR are those that have the higher probability of coming before (predecessors) and after (successors).

From the adjacency matrix we performed a network map of the nexus themes according to their probability range (Figure 7.10), the results of the metrics using graph theory are shown in the Table 7.3. According to the graph theory, the predecessors and the successors of each node (Themes NEXUS) can be represented by means of arrows (arcs) coming to (in-degree = types of predecessors) or going out (out-degree = types of successors). According to their ratio (successors/predecessors), it is possible to verify the semantic variety engendered by each node in point: if the ratio is greater than 1, the node is defined "source", if the ratio is equal to 1, the node is defined "relay" and if the ratio is lower than 1, the node is defined “well”.

Figure 7.10 Hierarchical map Markov Chain network themes Nexus.

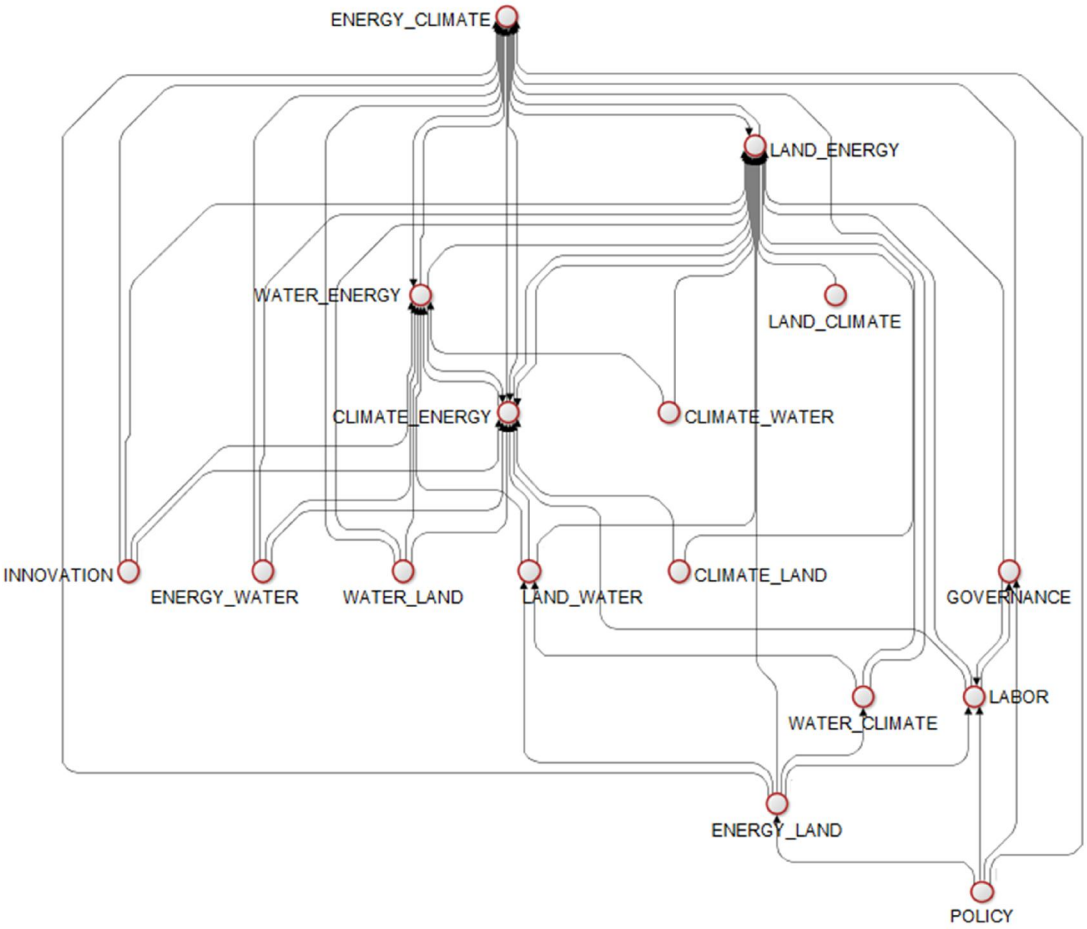


Table 7.3. Results of network analysis metrics, centrality and prestige index.

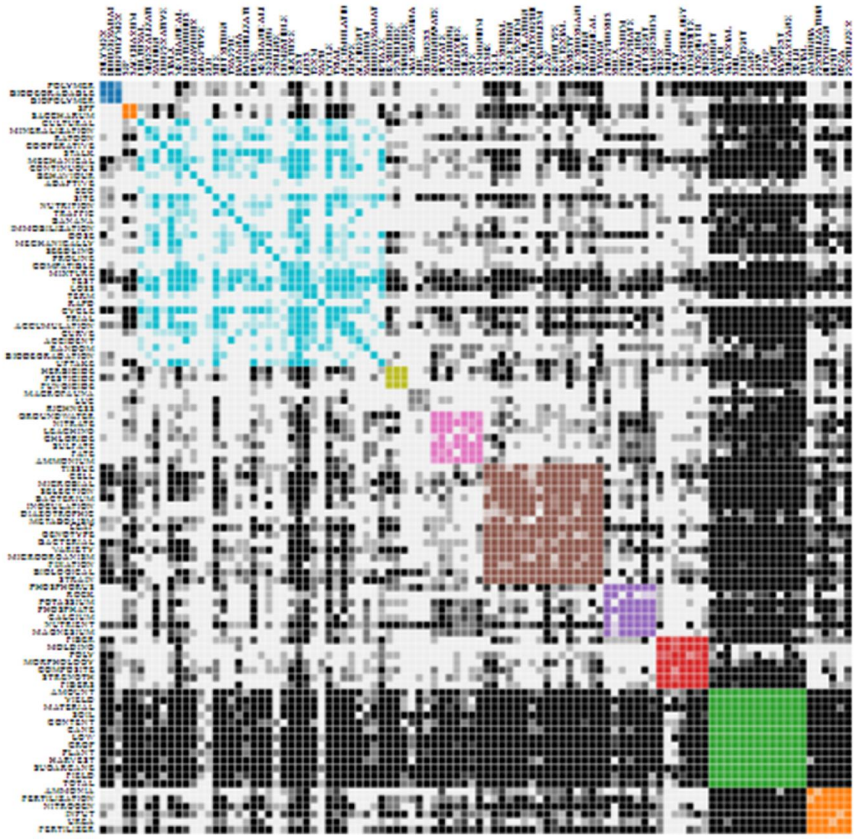
	DEGREE CENTRALITY		CLOSENESS CENTRALITY		BETWEENESS CENTRALITY		ECCENTRICITY CENTRALITY		PAGERANK	
Node	DC	%DC	CC	%CC	BC	%BC'	EC=EC'	%EC	PRP	%PRP
1	0.0652	65.2	0.2	20	5.5	2.61	1	100	0.2387	23.87
2	0.0434	43.4	0.12	12	0	0	0.5	50	0.0093	0.93
3	0.0434	43.4	0.15	15	0	0	0.5	50	0.0093	0.93
4	0.0652	65.2	0.2	20	39.1	18.65	1	100	0.234	23.45
5	0.1087	10.8	0.3	30	0	0	0.5	50	0.0093	0.93
6	0.0869	86.9	0.13	13.33	0	0	1	100	0.0093	0.93
7	0.0652	65.2	0.15	15	0.66	0.31	0.5	50	0.0160	16.02
8	0.0869	86.9	0.13	13.33	0	0	1	100	0.0093	0.93
9	0.0652	65.2	0.15	15	65.83	31.34	0.5	50	0.0234	23.47
10	0.0217	21.7	0.06	66.66	0	0	0.33	33.33	0.0093	0.93
11	0.0434	43.4	0.15	15	64.16	30.55	0.5	50	0.2298	22.98
12	0.0652	65.2	0.06	66.66	15.83	0.75	0.5	50	0.0140	14.075
13	0.0217	21.7	0.02	22.22	0	0	0.33	33.33	0.0093	0.93
14	0.0652	65.2	0.03	33.33	0	0	0.5	50	0.0109	10.96
15	0.0652	65.2	0.2	20	13.33	0.63	1	100	0.1574	15.74
16	0.0869	86.9	0	0	0	0	1	100	0.0093	0.93
	Max DC' = 0.1087 (node 5) Min DC' = 0.0217 (node 10)		Max CC = 0.3 (node 5) Min CC = 0 (node 16)		Max BC' = 0.03 (node 9) Min BC' = 0 (node 2)		Max EC = 1 (node 1) Min EC = 0.33 (node 10)		Max PRP = 0.23 (node 1) Min PRP = 0.009 (node 2)	

Node 1: CLIMATE_ENERGY, Node 2: CLIMATE_LAND, Node 3: CLIMATE_WATER, Node 4: ENERGY_CLIMATE, Node 5: ENERGY_LAND, Node 6: ENERGY_WATER, Node 7: GOVERNANCE, Node 8: INNOVATION, Node 9: LABOR, Node 10: LAND_CLIMATE, Node 11: LAND_ENERGY, Node 12: LAND_WATER, Node 13: POLICY, Node 14: WATER_CLIMATE, Node 15: WATER_ENERGY, Node 16: WATER_LAND.

DEGREE CENTRALITY (DC): quantifies the number of links that a node has with the others (outgoing nodes). In the theory of social networks, this index measures the activity of the actor (popularity). In our network, the highest DC score is held by the ENERGY_LAND node, which is directly associated with energy consumption by modern agriculture, encompassing activities such as mechanization, the use of fertilizers and irrigation. This measure reflects what was most talked about in the corpus. The lowest DC is for the LAND_CLIMATE node that is associated with the planning of

land use, as a form of adaptation to climate change, its low DC score reflects that it is a subject that is not present in the corpus.

Figure 7.11 Cluster analysis of the energy-land themes.



The topics dealt with are mechanization, the use of pesticides and fertilizers for the sowing of sugarcane. Also on soil fertilization, fixation of nutrients such as nitrogen.

CLOSENESS CENTRALITY (CC): this index focuses on how close each node is to all the other nodes in the network. The nodes with high central proximity are those that can reach many other nodes in a few steps, CC measures the accessibility of a node in the network, such as the ability to interact quickly with others.

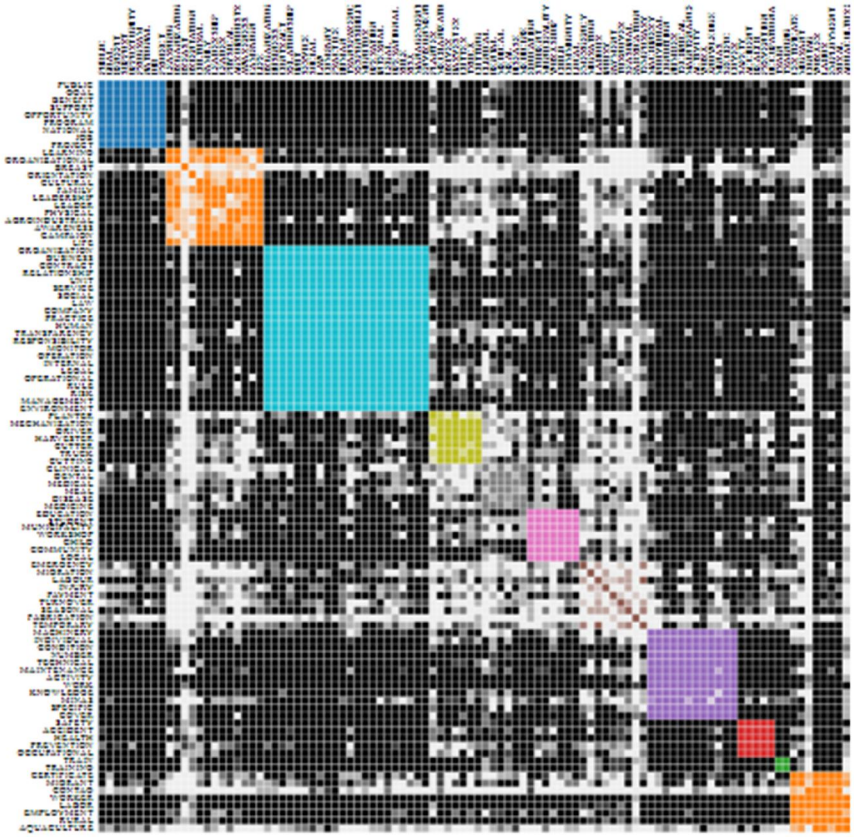
In our network, the maximum CC score has the ENERGY_LAND node, this means that this topic is always present when we talk about the other Nexus topics. The minimum CC score is for the WATER_LAND node that is associated with the sustainable use of

water in agriculture and water efficiency, this low CC index reflects that it is a topic that is rarely discussed in the corpus.

BETWEENESS CENTRALITY (BC): is a measure that quantifies the frequency or the number of times that a node acts as a bridge along the shortest path between two other nodes, it measures the intermediation capacity of a node.

LABOR is the node with the highest BC score, when it comes to issues related to GOVERNANCE and POLICY, this issue is of central importance (serving as a link). The lowest score BC has the topic CLIMATE_LAND that is related to climate impacts on the land, such as desertification or deforestation. This low score means that this node is a separate issue on its own within the corpus.

Figure 7.12. Cluster analysis of the labor theme.

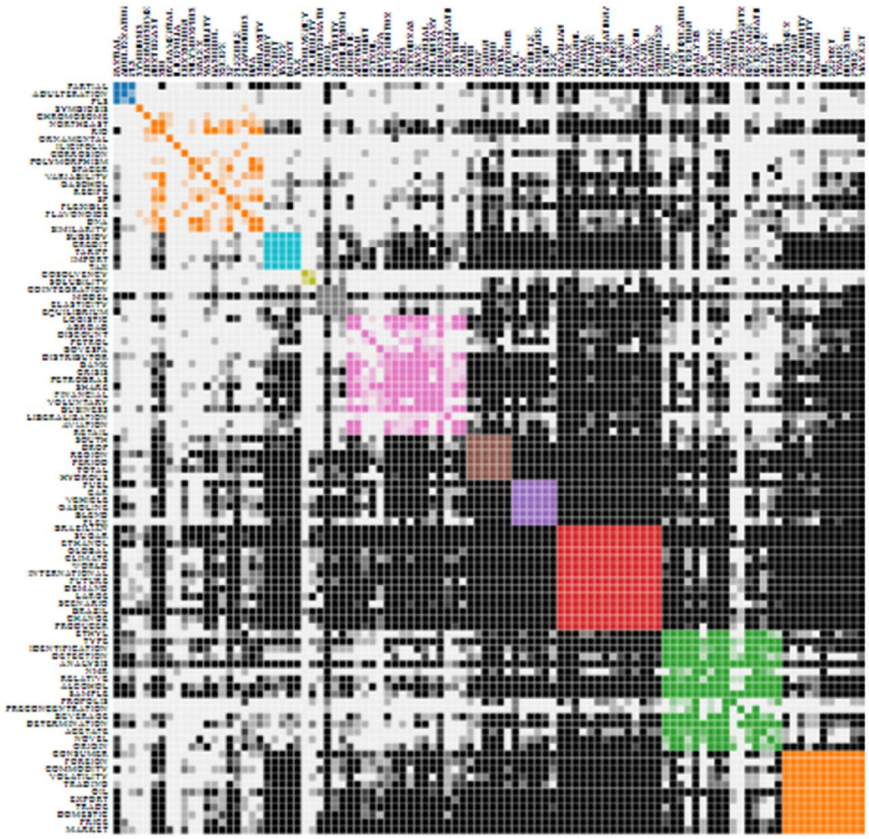


The topics covered are workers in the field, mechanization, requalification programs, occupational health and labor legislation.

ECCENTRICITY CENTRALITY (EC): this index reflects how close each node is to each other and, therefore, it is located in the center of the network. Nodes with high EC score have short distances to other nodes in the graph and, therefore, are closer to the center of the network. Low-score nodes EC have longer distances pointing to the "edge" of the network. In our network the highest EC score has the CLIMATE_ENERGY theme that is related to the vulnerability of the sugarcane harvest for the production of biofuel, this high score reflects that the sugarcane harvest theme is of central position throughout the corpus. The low EC score of LAND_CLIMATE reflects that it is treated in isolation throughout the corpus.

PAGERANK PRESTIGE (PRP): this index expresses the classification of importance for each node within the network. The high score is PRP is for the CLIMATE_ENERGY node, this theme have central importance throughout the corpus because it is linked to the production of renewable energy (ethanol), in the graph you can see that this topic is very active what is reflected in the input links as output that counts. The low PRP score is for the CLIMATE_LAND node that is related to desertification and deforestation, these issues are not preponderant in the study of ethanol, since sugar cane seeding is not linked to them.

Figure 7.13 Cluster analysis of the Climate-Energy themes.



Themes that stand out are about the future of biofuels consumption, the external market, import tariffs and the fossil energy market.

7.6. Conclusions

In this study, we demonstrate that using NLP algorithms such as LDA topic modeling, it is possible to construct thematic classification dictionaries from the existing specialized literature (scientific articles). These dictionaries can serve as qualitative indicators to evaluate the state of the art of themes, for instance, governance is found, management over an economic field, such is the case of the Ethanol Nexus.

One of the limitations of this model is that it depends on the source from which the dictionary is constructed, which has to be robust, extensive and especially reliable. Future studies based on this result can be perform a combined study with qualitative and quantitative indicators and make a more comprehensive evaluation of the nexus theme.

Water, energy and land-use are linked in the production of biofuels. Understanding these linkages is important to promote more effective policies that can influence positive outcomes and contribute for the sustainability issues in the sugarcane ethanol production, and benefit other sectors by take into account their synergies and trade-offs. This study was articulated an analytical framework based on a variety of empirical qualitative indicators constructed from the specialized literature on the issue. We examine the relationship between water-energy-land of the Brazilian sugarcane ethanol production in the context of climate change. Then, we identify governance gaps by addressing the problems of WEL nexus. The results show that using NLP algorithms such as LDA topic modeling it is possible to construct thematic classification dictionaries from the existing specialized literature (scientific articles).

8. FINAL CONSIDERATIONS AND PROPOSALS FOR FUTURE RESEARCH

8.1.**Finding**

The findings of this study emphasizes that sugarcane industry as political actors on water-energy-food (land) issues, not just neutral providers of finances and technology, further as a major player in policy debates. The broader extent of their political mobilization, rule-setting and discourse power is clearly illustrated in the study reported in the six Articles, as was described below:

8.2. Business non-market strategies and the use of dimensions of power of the sugarcane ethanol companies.

a) Instrumental power

As reported in Article "The political dynamics of agribusiness in Brazil: Business citizenship and lobbying" the industry in focus had close linkages or direct positions at Brazilian government. The results showed that the sugarcane ethanol industry were supported by the government in several interventions, received heavy subsidies, regulations and constant incentives. These policy-influencing mechanisms were preceded for intense political mobilization such as lobbying and campaigns finance for the approval of the desired measures for the sector.

The study indicates that incentives and policies related to sugarcane ethanol was resulted from an intense political mobilization, for instance at the time of Proálcool program, the main association of sugarcane producers, Copersucar used its influence with the decision-makers to defend its position and its invocation in favor of economic profitability by introducing ethanol into the energy matrix. Today, the main organization that represent sugarcane ethanol companies, UNICA beyond using their access to decision-making circles, it made a great institutional channel of communication to highlight about the importance of RenovaBio as an essential initiative for the implementation of the Paris Agreement, and the reduction of greenhouses gas emissions.

b) Structural power

As reported in Article "Sustainability and governance of the sugarcane ethanol companies in Brazil: Topic modeling analysis of CSR reporting" reveals the active participation, especially through UNICA, in implementing the rule-setting agenda for the sector, establishing codes of conduct through initiatives and certifications that support the sustainability of biofuel production. One channel by which UNICA and the sugarcane companies exercise their structural power is through the cooperation and participatory governance in the form of PPPs, for example, the establishment of the Agro-environmental Protocol, the participation in the committee of Bonsucro in Brazil, the National Commitment, the Renovação program, and the UNICA participation in the State Water Council and the river basin committees in São Paulo state. This mode of ethanol governance has established its legitimacy through the participation of multi-stakeholders agents. Particularly with regard to the standards and certification schemes such as RSB - Roundtable on Sustainable Biomaterials (formerly Roundtable on Sustainable Biofuels) and Bonsucro provides sustainability compliance of sugarcane and ethanol production.

c) Discursive power

As reported in Article "Business storytelling about energy and climate change: The case of Brazil's ethanol industry" depicted how the sugarcane ethanol industry constructed their discourses that portray the industry as a sustainable business and ethanol as a "green hero", a green, renewable energy that helps reduce greenhouses gas emissions and thus saves humanity from climate change.

The article showed that Brazil's sugarcane industry's storytelling seeks to transmit to consumers the idea that ethanol is always advantageous because – irrespective of its price - it helps generate jobs and improves not only the environment but also the performance and durability of cars and the country's economic development. Ethanol is represented as a renewable energy fuel that helps mitigate climate change, highlighting technological advances that could enable the production of not only traditional ethanol but also of the second generation cellulosic ethanol from the sugarcane bagasse. Flex

technology is presented as a source of national pride, since only Brazil has produced this kind of alternative fuel at such a scale. These technologies reduce emissions of GHG and are presented as the best commercial alternative to fossil fuels.

8.3. The policy debates on water-energy-food (land) issues and the participation of the sugarcane ethanol companies

The article "Land-water-energy nexus of sugarcane ethanol production in Brazil: Policy debates" aimed to show whether the policy debates and discourses of different Brazilian social actors: Sugarcane ethanol companies, Government, ONGs, and Media concerning the impacts of sugarcane ethanol production influenced appropriate policies for enhancing the efficient use of land and water resources. The results of the study showed that although the discourses has evolved over time in response to certain events, the discussions and resultant public policies do not take into account the interdependence between water-land and energy sectors. It was verified also that companies in this sector play an important role in framing public concerns how this bioenergy production will compete with scarce land and water resources, and in debating biofuels and food security and the competition for land between sugarcane and food crops. UNICA took the position that there is no true conflict between the expansion of biofuels and food production, as sugarcane production was using only 1.4% of the country's arable land.

Furthermore, was verified that some debates regarding ethanol production led the government to adopt policies aimed at showing the sustainability of the industry. These legal frameworks contributed to legitimizing the expansion of sugarcane crops by providing guidelines for land allocation. Two major examples are the 2009 ZAE Cana and the 2008 São Paulo Agro environmental Zoning policy. These instruments were adopted as a result of debates on whether sugarcane expansion was causing deforestation in the Amazon and the land competition between ethanol and food.

8.4. Qualitative model of water-energy-land nexus to assess sugarcane ethanol production in Brazil

Water, energy and land-use are linked in the production of biofuels. Understanding these linkages is important to promote more effective policies that can influence positive outcomes and contribute for the sustainability issues in the sugarcane ethanol production, and benefit other sectors by take into account their synergies and trade-offs. This study aims to articulate an analytical framework about the relations, based on a variety of empirical qualitative indicators constructed from the specialized literature on the issue. We examine the relationship between water-energy-land of the Brazilian sugarcane ethanol production in the context of climate change. Then, we identify governance gaps by addressing the problems of WEL nexus. The results show that using NLP algorithms such as LDA topic modeling it is possible to construct thematic classification dictionaries from the existing specialized literature (scientific articles).

8.5. Proposals for future research

From the results there will be possibilities for future studies, these can be:

1. Related to public policies studies may be addressed to carry out a public analysis of government program and policies on the nexus sectors to identify the predominance of one sector over the other.
2. From the business study, can be expanded the application of the three-dimensional theory to other and more controversial sectors such as soy, or agrochemical sector.
3. The nexus approach is just an emerging issue that deserves to be investigated in future studies such as the construction of qualitative and quantitative indicators for its evaluation.
4. Future studies would be addressing these qualitative indicators together with quantitative indicators to evaluate the nexus using a decision tree model or mutil-criteria decision analysis.

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