Contents lists available at ScienceDirect

Global Environmental Change

Framing the frontier – Tracing issues related to soybean expansion in transnational public spheres

Finn Mempel [a,*], Esteve Corbera [a,b]

[a] *Institute of Environmental Science and Technology, Universitat Autònoma de Barcelona, Campus UAB, 08193 Bellaterra, Barcelona, Spain*
[b] *Institució Catalana de Recerca i Estudis Avançats (ICREA), Pg. Lluís Companys 23, Barcelona, Spain*

A R T I C L E   I N F O

A B S T R A C T

Rapid soybean expansion in South America has been linked to numerous socio-environmental problems, including deforestation in sensitive biomes. As a major importing region of soybeans, wider public awareness has also put pressure on the European Union. Different governance initiatives involving various groups of stakeholders have sought to address these issues. However, what is identified as a relevant problem, as a region of interest or which actors are mentioned in this context are all matters of claims-making processes between different groups and mediated through various channels of communication. This study uses a text-mining approach to trace the construction of socio-ecological problems related to soybean expansion and the actors and regions linked with these issues in public discourse. The focus lies on print media from the European Union, but several additional sources are included to investigate the similarities and differences between various communication channels and regions. These include newspaper articles from producing countries and international news agencies, scientific abstracts, corporate statements, and reports from advocacy groups gathered from the mid-1990s to 2020. The results show that European mass media have shifted their focus from consumer labeling, health, and concerns over genetically modified organisms towards more distant or abstract phenomena, such as deforestation and climate change. This has been accompanied with a broader view on different stakeholders, but also with a strong regional focus on the Amazon biome. There has also been much less attention on direct concerns for communities in producing regions, such as land conflicts or disputes over intellectual property rights. We conclude that while European public spheres appear to become more receptive to issues related to impacts in sourcing regions, there remains a narrow focus on specific problems and regions, which reflects a fundamental asymmetry in different stakeholders' ability to shape transnational deliberations and resulting governance processes.

1. Introduction

Since the early 20th century, soybeans have evolved from a regional food crop into one of the world's most important agricultural commodities (Du Bois, 2018). Within the past 50 years, soybean production has increased almost tenfold and soy now ranks among the four leading crops worldwide in terms of overall area harvested (FAO, 2018). The crop's high protein and fat contents make it valuable for a number of different end-uses, but the main driver has been an increasing global demand for livestock feed, particularly in Europe and China (Oliveira and Schneider, 2016).

Within the last decades, the expansion of soy production has mainly taken place in South America, where it thrived within a context of structural adjustment policies, deregulation and a general embrace of biotechnology and large agribusiness (Leguizamón, 2020; Neiman and Blanco, 2020). While applauded as an economic success story by some, this expansion has also been criticized for its negative socio-environmental impacts, as the soybean frontier has expanded into highly sensitive and biodiverse biomes. Studies have pointed to patterns of landholding concentration, rural displacement, deforestation, soil degradation, food insecurity and health hazards (Goldsmith, 2017; Leguizamón, 2014; McKay and Colque, 2016; Pengue, 2009).

As media outlets and NGOs from the Global North have increasingly publicized these issues and called on governments, corporations, and consumers to act, political pressure has mounted. New governance mechanisms have been put in place, including many examples of what

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has been termed *private food law* (van der Meulen, 2011), such as certification schemes, private standards or multi-stakeholder round-tables. These often single out individual agricultural commodities and associated social or environmental problems. Further, several international agreements have targeted the issues associated with soybeans among other forest-risk commodities (FRCs) and the European Union (EU) is currently assessing policy options to address tropical deforestation linked to its imports (Bager et al., 2020; European Parliament, 2020).

These new governance processes are neither entirely embedded in political entities, nor truly global (Lenschow et al., 2016), they are flow-based rather than territorial (Sikor et al., 2013) and often involve different institutional layers and actors. While the effectiveness of these measures has often been addressed by research (e.g., Garrett et al., 2016; Lambin et al., 2018), the role of communication and discursive exchanges in constructing and framing the problems provoking these measures has received much less attention (Persson and Mertz, 2019).

Elgert (2012) has demonstrated how certain actors and coalitions have framed issues related to soybean expansion rather narrowly to promote a particular way of addressing them with specific governance instruments, such as certification schemes. Our contribution takes a broader perspective to trace the evolution of how different socio-ecological problems in relation to the surge of global soybean production and trade have circulated in public discourse since the late 1990s. To do so, we mobilize public sphere theory as a conceptual framework and use a text mining approach to analyze a large text corpus comprised of different sources. Our focus remains on the EU journalistic field as the center of public discourse within one of the primary soy importing regions.

In this article we ask: What differences exist between these fields in terms of the prevalence of certain topics? Which topics prevail at different time periods? How are these topics linked to each other and to the mentions of certain actors and geographic regions? By addressing these questions, we hope to provide insight on how the concerns of different groups in relation to soybean expansion have circulated through public discourse, particularly in importing regions such as the EU, and then shaped the ways in which transnational governance initiatives, such as certification schemes, zero-deforestation commitments, or multi-stakeholder roundtables, have targeted particular problems in sourcing regions. Further, we hope to demonstrate the utility of applying public sphere theory and text mining approaches when studying processes of land use change and environmental governance.

In the following sections we locate our research within the field of environmental communication and introduce public sphere theory as our framework of analysis. We provide an overview of text mining and topic modeling as the toolbox applied in our methods. We then continue to provide a detailed overview of our methods and present our findings.

2. Environmental communication, public spheres, and text mining

2.1. Environmental communication and public sphere theory

Studies on the discursive processes shaping public perception of environmental problems can be found in the field of environmental communication (Pezzullo and Cox, 2018), which emerged in the 1980s (Cox and Depoe, 2015). The field has long studied environmental problems as not merely materially produced, but rather as socially and discursively constructed through processes of claims-making and contestation, mediated through different public arenas or forums, such as mass media (Hansen, 2015b).

A useful theoretical underpinning when studying communicative processes and their role in shaping governance mechanisms regulating global commodities is public sphere theory (Habermas, 1989). The concept of a public sphere is intimately tied to the theory of deliberative democracy and describes a net of communicative processes, which spans throughout society and through which its members rationally debate the issues affecting their lives.

Beyond its application as an analytical framework, public sphere theory also has a strong normative foundation in relation to the functioning of deliberative democracy. Evolving public spheres can be evaluated according to their inclusiveness to all members and minority groups within a given polity (legitimacy) and according to their effectiveness at translating public opinion into political debate and binding legislation (efficacy) (Fraser and Nash, 2014).

While traditionally applied at the level of individual nation-states, Fraser (2009) has pointed out the need to use these criteria for deliberative processes on a transnational level, since economic globalization has subjected people across individual nation-states to the same governance institutions and rendered them susceptible to the outcomes of the same value chains and decisions taken by the same transnationally operating actors.

In this article, we adopt a conceptualization of issue-oriented, networked, transnationalizing public spheres, which are porous to communicative flows across polities (Fraser and Nash, 2014). As in the later revision of Habermas' original theory (Habermas, 1996), we consider mass media as crucial to the functioning of modern public spheres. This central role of mass media in deciding on what are being considered key issues in public spheres is also assumed in media effect models such as agenda setting or priming (Scheufele and Tewksbury, 2007).

Following Benson (2009) in his mapping of public spheres using Bourdieu's field theory, we understand the journalistic field to be at the center of a given public sphere, interacting with and mediating between other fields, including the academic, the political, the economic and the advocacy fields. It is important to note that the assumed centrality of mass media should not be understood as a normative assessment of their function in public discourse. In fact, many traditions in mass communication theory, such as mass society theory or the critical cultural trend have understood mass media as promoters of hegemonic elitist worldviews (Baran and Davis, 2011).

2.2. Text mining and topic modeling

Empirical studies in the field of environmental communication have traditionally relied on the same approaches to text analysis (or other forms of communication) as the social sciences more broadly. These differ substantially in their mode of analysis (quantitative, qualitative, or mixed methods) and their level of analysis (e.g., textual, contextual, or sociological), but generally all involve the acquisition, selection, careful reading and manual coding of texts, sometimes using several independent coders.

The widespread use of social media, the ongoing digitalization of archival material, the creation of specialized online databases for news, academic articles and press wires have provided an abundance of available text material about virtually any topic and from a variety of sources. While this provides unprecedented access to texts and other forms of communication, it also represents a major challenge for traditional approaches to text analysis. Manual coding of large volumes of texts is only feasible by applying selective filters and sampling methods or by hiring many additional coders, resulting in high project costs (Grimmer and Stewart, 2013). However, the increasing processing capacity available to researchers even on personal computers has enabled the use of novel methods and applications leveraging computer algorithms, often referred to as text mining (Ignatow and Mihalcea, 2017). These had been developed in the field of computer science and are now successively being added to the toolbox of the social sciences, alongside traditional methods of text analysis.

More than just a way of dealing with the challenges of big data, the use of algorithms for language processing and supervised or unsupervised text classification also provides a means to counter the regularly raised issue of human bias in traditional text analysis. However, mathematical models for language and text used in these methods are by

nature simplified representations. Text mining should therefore not be seen as replacing but rather as complementing traditional content analysis (Grimmer and Stewart, 2013). Further, even unsupervised methods still are susceptible to bias, both, though choices in the selection of parameters or interpretation of output, and the reductionist approach to language ingrained in their algorithms.

Originating with the groundbreaking work of Blei et al. (2003), topic models are a rather popular tool among text mining methods. They are a statistical framework developed in computer science research and used to identify the underlying ("*latent*") topics in a text corpus (Wesslen, 2018). Topic models are unsupervised machine learning algorithms, which do not depend on training datasets, but provide classifications according to patterns identified within the data itself. Topic models typically use a document-term matrix (DTM) as input, which lists relative term frequencies for all documents. This representation of documents ignores the original order of words and is therefore commonly referred to as a *bag-of-words* (BoW) model.

Topic models treat individual texts as being generated by drawing the distributions of topics in each document as well as the distribution of words in each topic from an underlying probability distribution (Günther and Quandt, 2016). By reverse engineering the generation of a given text corpus according to this model, topic models provide the user with a representation of every document as a weighted mix of topics (mixed membership model) and every topic as a weighted mix of words.

It is common practice to perform pre-processing and filtering steps on a text corpus prior to the application of a topic model. Tokenization refers to the process of breaking down text documents into smaller units (tokens), which become the basis for further analysis. In the case of topic modeling, tokens are typically words and compound multi-word expressions. Common processing steps include trimming, lemmatization, named entity recognition (NER) and co-reference resolution. These are further explained in the methods section below.

Numerous studies have applied topic modeling and other text mining approaches to analyze communicative processes linked to environmental issues, most notably climate change. Topic modeling has been applied to show how media attention to climate change has generally increased but at significantly different rates across countries (Schmidt et al., 2013). It has helped to demonstrate how specific national framings of climate change reflect different countries' specific local contexts, despite it being a global phenomenon (Vu et al., 2019). Further, Boussalis and Coan (2016) show the persistence of climate change denial among a group of conservative think tanks and Bohr (2020) demonstrates the importance of outlet bias as a contextual factor in U.S. media coverage on climate change.
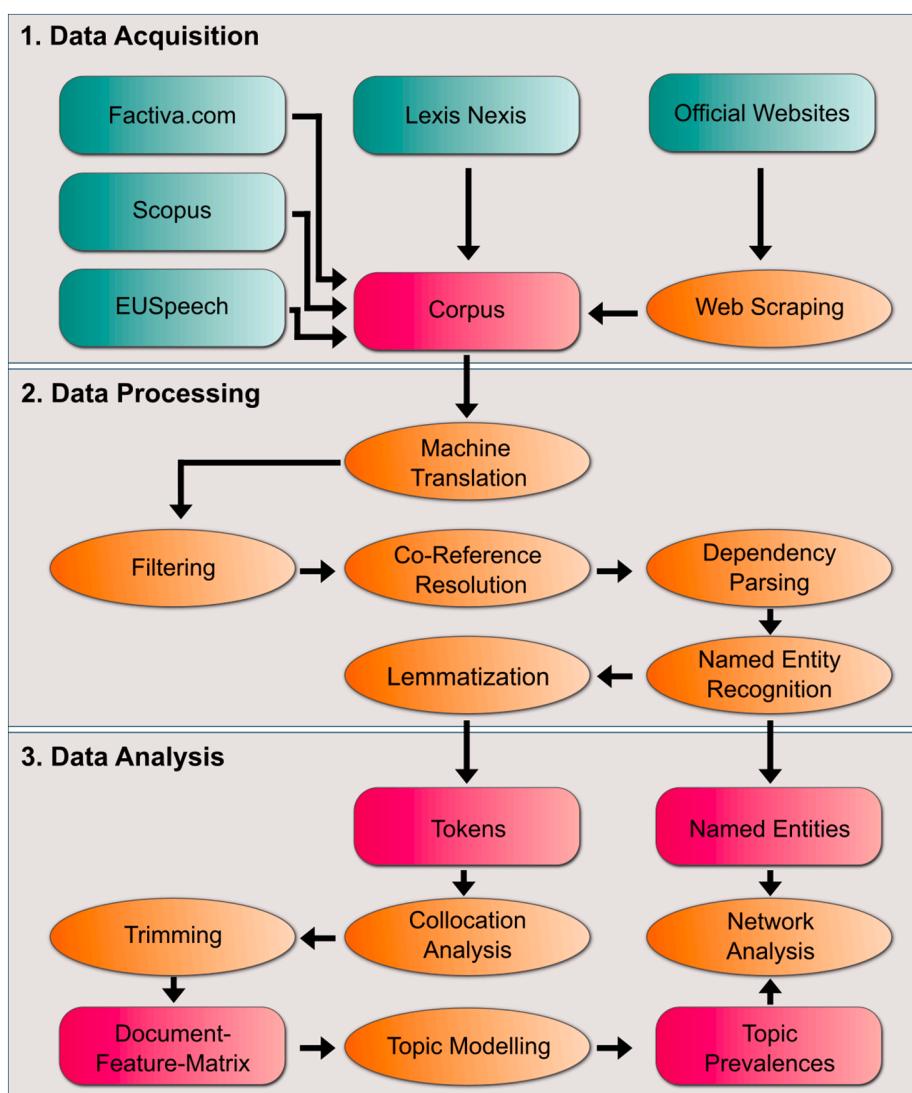

Fig. 1. Flow diagram illustrating major components of data acquisition, processing and analysis.

3. Methods

The entire process of data acquisition, processing, topic-modeling, and analysis is illustrated as a flow diagram in Fig. 1 and described in detail below.

3.1. Data acquisition – Building the corpus

Following our conceptualization of networked public spheres, we generated a text corpus by integrating several different types of documents, grouped into a nested categorization as illustrated in Table 1. All sources were selected according to availability during our study period (1997–2020). For the journalistic field we aimed to select news media of record with relatively high circulations and preferably national editions. Corporate actors were selected to represent different stakeholders along the soy value chain. For the advocacy field, we aimed to include both, large international NGOs, which have directly collaborated with roundtables and other business initiatives, and movements or organizations working closer with local communities and peasants.

News articles were sourced from Factiva (Dow Jones and Company, 2020) and Lexis Nexis (Lexis Nexis, 2020). We collected press releases via Web Scraping from the websites of several corporate actors, NGOs, social movements, and the EU Commission. EU political speeches were taken from Schumacher et al. (2016). We downloaded journal abstracts from scopus.com. Search strings and filtering criteria are listed in the supplementary material. For the year 2020, data collection stopped on May 1st for all sources included.

In total, the text corpus consists of 32,540 documents, which are distributed according to field and region as illustrated in Fig. 2. The journalistic field represents the center of our analysis and is represented with the largest number of documents (21,831). The other fields mainly serve for comparative purposes and contribute fewer documents. Within the journalistic field, print media from the EU constitute the largest fraction (6232 Documents). More details are provided in the supplementary material.

3.2. Data processing

Before computing the topic model, several processing steps were performed. The first step was to translate all non-English documents from their source language into English. We used the ModernMT machine-translation API (ModernMT, 2020), which provides a context-aware translation algorithm. While machine-translation is never free of errors, here we mostly rely on the translation of important individual key terms. Grammatical structure is irrelevant for the topic modeling procedure, which does not consider the order of words, but only their

Table 1
List of sources, nested according to field and region.

| Field	Region	Country	Language	Name	Type
Journalistic Field	European Union	U.K.	English	*The Times*	News articles
				The Guardian	
				The Independent	
		Germany	German	*Sueddeutsche Zeitung*	
				Der Spiegel	
				taz	
		France	French	*Le Monde*	
				Le Figaro	
				Libération	
		Spain	Spanish	*El Mundo*	
				ABC	
				La Vanguardia	
		Italy	Italian	*Corriere della Sera*	
				La Stampa	
				La Repubblica	
	Latin America	Brazil	Portuguese	*O Globo*	
				O Estado de S.P.	
				Folha de S.P.	
		Argentina	Spanish	*La Nación*	
				Clarín	
				La voz del Interior	
	North America	USA	English	*The Wall Street Journal*	
				The New York Times	
				The Washington Post	
	Transnational	USA	English	*Associated Press*	
		U.K.		*Reuters*	
		France		*Agence France Presse*	
		Germany		*DPA*	
		Spain		*EFE*	
		U.K.		*Press Association*	
		China		*Xinhua Agency*	
Business Field	North America	USA	English	*Monsanto*	Press Releases
				ADM	
	European Union	Belgium		*FEFAC*	
		Netherlands		*ForFarmer Group*	
	Latin America	Brazil	Portuguese	*Aprosoja Brasil*	
Advocacy Field	Transnational	Switzerland	English	*World Wildlife Fund (WWF)*	Press Releases
		USA		*World Resource Institute (WRI)*	
		Netherlands		*Transnational Institute (TNI)*	
		Spain		*GRAIN*	
		Simbabwe		*Via Campesina*	
		Netherlands		*Friends of the Earth (FoE)*	
Political Field	European Union		English	*EU Speech Corpus*	Political Speeches
		Belgium		*Bulletin Quotdien Europe*	Print media articles
		Belgium		*EU Commission*	Press Releases
Academic Field	Transnational	–	English	–	Journal article abstracts
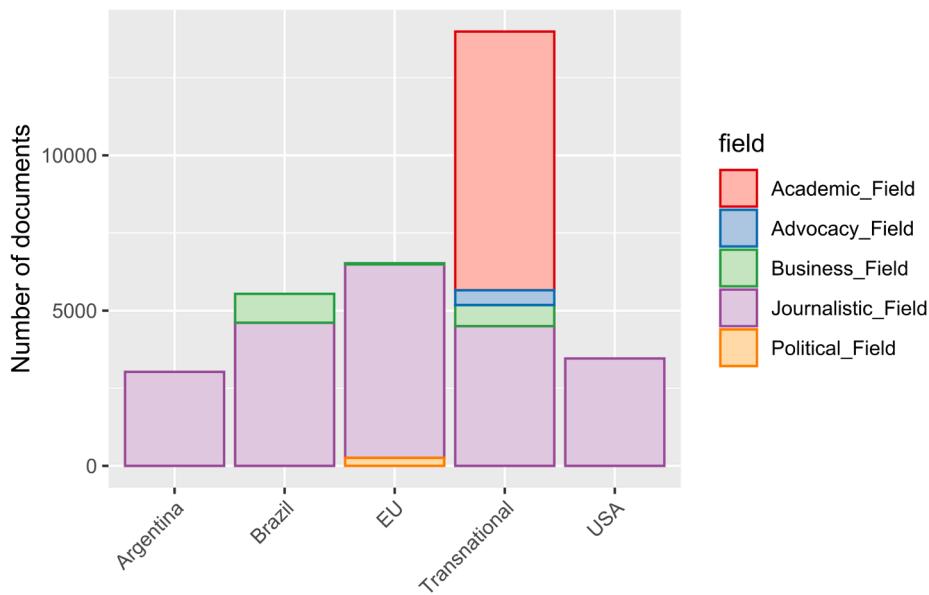
Fig. 2. Distribution of documents according to region and field.

frequency. However, this machine-translation approach still introduces an unquantifiable degree of error and may be highly problematic for more nuanced text-mining approaches (e.g., sentiment analysis or metaphor detection).

Subsequently, we applied several filters to the corpus to remove irrelevant documents and duplicates (see supplementary material). We then used the natural language processing (NLP) library *SpaCy* (Honnibal and Johnson, 2015) and the *neuralcoref* package (Clark and Manning, 2016) to resolve all documents for co-references, replacing all mentions referring to the same real-world entity with the entity's name. This is helpful, since an entity may be referred to many times in a text, but only named once.

We also identified and extracted real-world entities using *SpaCy's* Named Entity Recognition (NER) function. These were removed and collected separately for further analysis. The rationale behind this is to generate latent topics independent of any mentions of organizations or locations. This way, the co-occurrence of topics and these entities can be analyzed separately.

Finally, only nouns, verbs, adjectives, and adverbs were included as input tokens for the topic model. The tokens were lemmatized (transformed to their noninflected dictionary form) with the lemmatizer provided by *SpaCy's* English language model.

3.3. Topic modeling

In our study, we used the Structural Topic Model (STM), based on the work by Roberts et al. (2014). STM is a probabilistic model, in which both the terms associated with topics and topic proportions for each document are approximated as latent variables. We implemented the STM model using the open-source *stm* package available for the statistical computing environment R (Roberts et al., 2019). When converting our text corpus into a DTM to feed into the topic model, we performed a collocation analysis to represent multi-word expressions (see supplementary material).

An advantage that STM provides over other topic modeling approaches is the possibility to include document metadata as covariates for the topic model. Here, we included field, region, and year of publication as covariates. When computing the topic model, one important consideration is the selection of an appropriate number of topics (the model parameter *K*). The selection of this parameter will depend on the underlying research aim and the merit of the resulting topics should

always be evaluated manually. There are also various metrics designed to automatically find an appropriate range for *K*. After running the STM with several different setups and comparing the output and a set of test statistics (see supplementary material), we settled on a model with 80 topics, which provided sufficient detail while not overclustering.

Researchers have pointed to the need to validate any use of automated text analysis (Grimmer and Stewart, 2013). We establish semantic validity by labeling topics, taking into consideration highly associated words and documents dominated by each topic and by mapping topics via hierarchical clustering. Following (Quinn et al., 2010), we introduce a measure of construct validity by comparing the evolution of prevalence of selected topics over time with external events, which would be expected to lead to public debate of the given topics. Further, following the approach introduced by (Chang et al., 2009), we introduce a supervised element, comparing topic model outputs to the judgement of human coders (see supplementary material).

3.4. Data analysis

Presented with the model output, we labeled topics according to a manual inspection of the terms most prevalent for each and the 20 documents with the highest relative share of a given topic. Subsequently, we selected the most relevant topics for our analysis and merged similar topics by summing their prevalence.

We then performed a network analysis based on the co-occurrence between the individual topics and between the extracted entities and topics. For this purpose, we computed cosine similarities between the prevalence vectors of all issues and entities and used the similarity measures as edge weights for the network. Additionally, measures of closeness centrality for all topics are found in the supplementary material.

Lastly, for one key topic ("Deforestation") we selected all documents, in which this topic was the most prevalent one. For each year in our study period we then calculated a measure of "keyness" (Bondi and Scott, 2010), i.e. comparing a target group (documents from the given year) to a reference group (documents from all prior years). This approach provides key terms for each year, which are more frequently used than in previous years. We performed this analysis separately for documents from the EU journalistic field, Brazilian journalistic field, and transnational news agencies. We then identified one year, in which this topic appears to be dominated by similar key terms across these three

sources. We further identified months which showed peaks in prevalence of the given topic for each source. To analyze the specific content of documents for the selected year and for those months, we calculated co-occurrence networks for each, including both, tokens and named entities.

4. Results

4.1. Topic model output and validation

The entire output from our topic model, including overall topic prevalence and top contributing terms for all 80 topics are provided in the supplementary material. Labeling of topics provided initial support for semantic validity, as most topics were easily categorized. The results from our manual labeling and grouping of the latent topics identified by the STM are illustrated in Table 2, including short descriptions of the selected topics or topic groups, the number of constituent topics, and topic prevalence over the entire corpus. Of the initial 80 topics, 29 were selected and grouped into 20 topics, reflecting relevant issues. The remaining 51 topics were excluded from the analysis. The selected topics represent about 40% of the overall topic prevalence across the entire corpus.

Hierarchical clustering of word weight vectors resulted in meaningful clusters around certain topic categories, even though in a few cases related topics form separate clusters, likely due to differences in vocabulary between fields (see supplementary material). The correspondence found between the judgement of human coders and our topic model is generally encouraging. Mean model precision (comparing assignment of words to topics) was found to be 88.75 percent and the mean topic log odds (comparing assignment of topics to documents) was calculated at -0.52, both at high significance levels (P < 0.001). When considering only selected topics, model precision increased to 93.1 percent (see supplementary material). With respect to construct validity, Section 4.6. establishes solid correspondence between selected topics and key real-life events.

4.2. Dominant topics vary across fields

The upper graph in Fig. 3 illustrates topic prevalence for all fields included in our analysis. Topic prevalence varies quite significantly between fields. In fact, the most dominant topic is different for each field. The academic abstracts included show relatively high prevalence values for the topics Pest Management (10.68%), Soil Management (7.84%), Land Use Change (7.05%) and Biofuels (7.04%). The documents included from the advocacy field are dominated by issues around the Global Food System (19.40%) and also show the largest relative shares of prevalence for Deforestation (6.06%), issues around Seeds & Patents (6.47%), Land Conflicts (5.65%) and Climate Change & GG Emissions (3.56%). The Business field shows low prevalence for most of our selected topics, apart from issues dealing with Harvests & Weather (8.90%), as well as the concerns of Producers & Landowners (3.26%).

The journalistic field shows a more even distribution of prevalence between the selected topics compared to the other fields. It presents the highest relative prevalence for Diets & Health (4.96%) and compared to the other fields, it also shows relatively high levels of prevalence for Trade Disputes (4.25%) and Consumers & Food Labeling (1.77%). The political field (EU) is dominated by concerns about GMOs (20.91%) and to a lesser extend Trade Disputes (4.35%) and Diets & Health (3.07%).

4.3. Topic prevalence varies across print media

The graph at the bottom of Fig. 3 provides the same information, restricted to the journalistic field and grouped by regions from which print media were collected. The Argentinian print media has a rather unique profile of topic prevalence, being dominated mostly by topics related to Harvests & Weather (15.42%), Producers & Landowners

Table 2
Selected topics and topic groups.

Topic	Description	Number of topics	Prevalence in Corpus (%)
Diets & Health	These topics deal with different relationships between food items' nutrients and health, such as concerns over different types of fat.	4	4.34
Pest Management	These topics deal with the management of pests affecting soybeans, such as the aphid Aphis glycines Matsumura, pod borers or whiteflies.	3	3.21
Deforestation	This issue is about the loss of forest area in different biomes.	2	2.97
Trade Disputes	This topic deals with protectionist measures, such as tariffs, imposed between different countries and the consequences for trade patterns (e.g. in soybeans), different economic sectors and international relations.	1	2.91
Biofuels	These topics deals with the use of soybeans among other plants as feedstock for biofuels and the implications for direct and indirect emissions from combustion engines.	2	2.7
Harvest & Weather	This topic deals with weather patterns, such as droughts and floods and how they affect yields in various agricultural areas producing soybeans.	1	2.61
Land Use Change & Environmental Impact	This topic deals with land use change and associated environmental impact.	1	2.23
Soil Management	This topic deals with the management of soil structural properties and nutrients through agricultural inputs or cropping practices and the respective impact on soybean yields.	1	2.19
Meat & Animal Feed	These topics deal with concerns over different impacts of meat consumption and the search for different protein meals (e.g. oilseed cakes or fish-meal) for animal feed and the respective trade-offs when substituting between them. Further, there are accounts of consumers' and businesses' attempts to substitute meat products with plant based alternatives.	2	2.09
Climate Change & GG Emissions	These topics deal with greenhouse gas emissions and the threat of climate change.	2	1.85
Economic Crisis	This topic deals with economic and financial crises, inflation, debt and unemployment.	1	1.69
Producers & Landowners	This topic deals with the economic and social	1	1.46

(continued on next page)

Table 2 (*continued*)

Topic	Description	Number of topics	Prevalence in Corpus (%)
	environment for farmers and landowners.		
Consumers & Food Labeling	This topic deals with consumers' concern concerning various food items and their production, as well as the debate on food labeling.	1	1.4
GMOs	This topic deals with biotechnology applications in agriculture and the various concerns about genetically modified organisms, such as roundup-ready soybeans.	1	1.29
Water Resource Management	This topic deals with water resources, hydrological alterations and issues related to water availability, distribution and quality.	1	1.11
Global Food System	This topic deals with the challenges of global agriculture and food systems, particularly in feeding the world's population, overcoming hunger and malnutrition and preventing food price hikes.	1	1.06
Land Conflicts	This topic deals with conflicts over land as a result of agribusiness expansion. Main themes include the concern over livelihoods and rights of peasants and indigenous populations and the struggles of social movements in defending these rights.	1	1.03
Pesticides & Health	This topic deals with the use of pesticides and associated health concerns, such as cancer and infertility.	1	0.95
Seeds & Patents	This topic deals with farmers' use of patented GMO seed and the legal disputes over intellectual property rights when saving and reproducing seeds.	1	0.78
Wildlife & Biodiversity	This topic deals with threats to wildlife, endangered species, biodiversity loss and the struggle of conservationists.	1	0.68
Other (excluded)	A range of topics excluded from the analysis. These are mainly topics dealing with trade statistics, commodity market updates, but also general "nonsense" topics reflecting the use of specific vocabulary not related to any particular issue.	51	61.43

(9.51%) and Economic Crisis (4.50%). The selected newspapers from Argentina also show a relatively high prevalence of issues related to Seeds & Patents (1.83%), compared to the other regions.

The included Brazilian print media sources show a high relative prevalence of issues relating to Deforestation (9.82%), Economic Crisis (4.62%) and Land Conflicts (3.47%) compared to the other regions. For EU print media, international news agencies and the US print media, topic prevalence shows more comparable patterns: relatively large prevalence values for topics relating to Trade Disputes and Diets & Health. EU print media show the highest relative prevalence shares for

Diets & Health (9.30%) and Climate Change (2.84%) among all regions. For international news agencies Trade Disputes (8.68%) dominates and the US print media have the highest prevalence for Consumers & Food Labeling (1.45%) among all regions.

4.4. Zooming into the EU print media

Fig. 4 illustrates the evolution of the co-occurrence network of our selected topics in the EU journalistic Field through five distinct time intervals between 1997 and 2020, as well as for the entire study period. Further, Fig. 5 shows the evolution of prevalence for selected topics by year. One can observe that EU print media articles in the late 1990s, which mentioned soybeans were dominated by topics dealing with Diets & Health, GMOs, Consumers & Food labeling and to a lesser degree, Meat & Animal Feed.

These topics occur in relative isolation and there are only a few strong co-occurrence values between these and other topics (e.g., between Pesticide & Health and Seeds & Patents). Over time, these topics show a declining trend; though Diets & Health remains among the most prevalent topics, GMOs is among the least prevalent in the last time interval. Since the early and mid-2000 s, Deforestation and Climate Change & GG Emission gain prevalence, with their highest shown values for the period between 2007 and 2011 but remain relevant until 2020. Between 2017 and 2020, Trade Disputes becomes the most prevalent topic.

4.5. A focus on the Amazon and more diverse stakeholders

Regarding the extracted named entities in the EU journalistic field, Fig. 6 illustrates the evolution of mentioned entities, filtered to include four of the biomes, in which soybean expansion has taken place within the last decades. The graph is organized as a bipartide network to show how the mentions of biomes are linked with topics (using cosine similarities between the prevalence in all documents). The Amazon biome is by far the most mentioned throughout the study period and also shows the strongest associations with most topics, particularly Deforestation. Other associations become progressively relevant since the early 2000s, namely Land Conflicts, Land Use Change & Impacts and Climate Change.

Mentions of the Cerrado and Atlantic forest occur since the early 2000s and in the case of the Gran Chaco since 2007. These biomes are mainly associated with Deforestation, Wildlife & Biodiversity, Land Use Change and Impacts, Land Conflicts (in the case of the Gran Chaco and Cerrado) and Water Resource Management (in the case of the Atlantic Forest). However, both the number of mentions and the degree of association with our topics is less significant than for the Amazon biome throughout our study period.

For other fields, the picture changes. For instance, in the advocacy field (graph provided in the supplementary material), the Amazon biome is only as dominant as in the EU journalistic field for the time interval 2007–2011. At other times (2017–2020), mentions of the Cerrado are comparably prevalent. Further, for Land Conflicts the association is strongest with the Cerrado biome. In the EU political field only the Amazon biome is referred to at all.

Fig. 7 illustrates the evolution of entities representing organizations or institutions mentioned in the EU journalistic field and their associations with our 20 topics as a bipartide network graph. For each time interval, the 20 most prevalent entities are selected. In order to enhance readability, only edges within the upper 12.5% quantile in terms of their weights were plotted. We observe that for the entire study period, the EU is the most prevalent entity mentioned in this category, followed by several companies, NGOs, government institutions and intergovernmental organizations. When looking at the evolution over time, there are three clearly dominating entities in the late 1990s: the EU, the biotech company Monsanto and the NGO Greenpeace. All these show associations with GMOs and Consumers & Food Labeling, two of the dominant topics of that time interval.
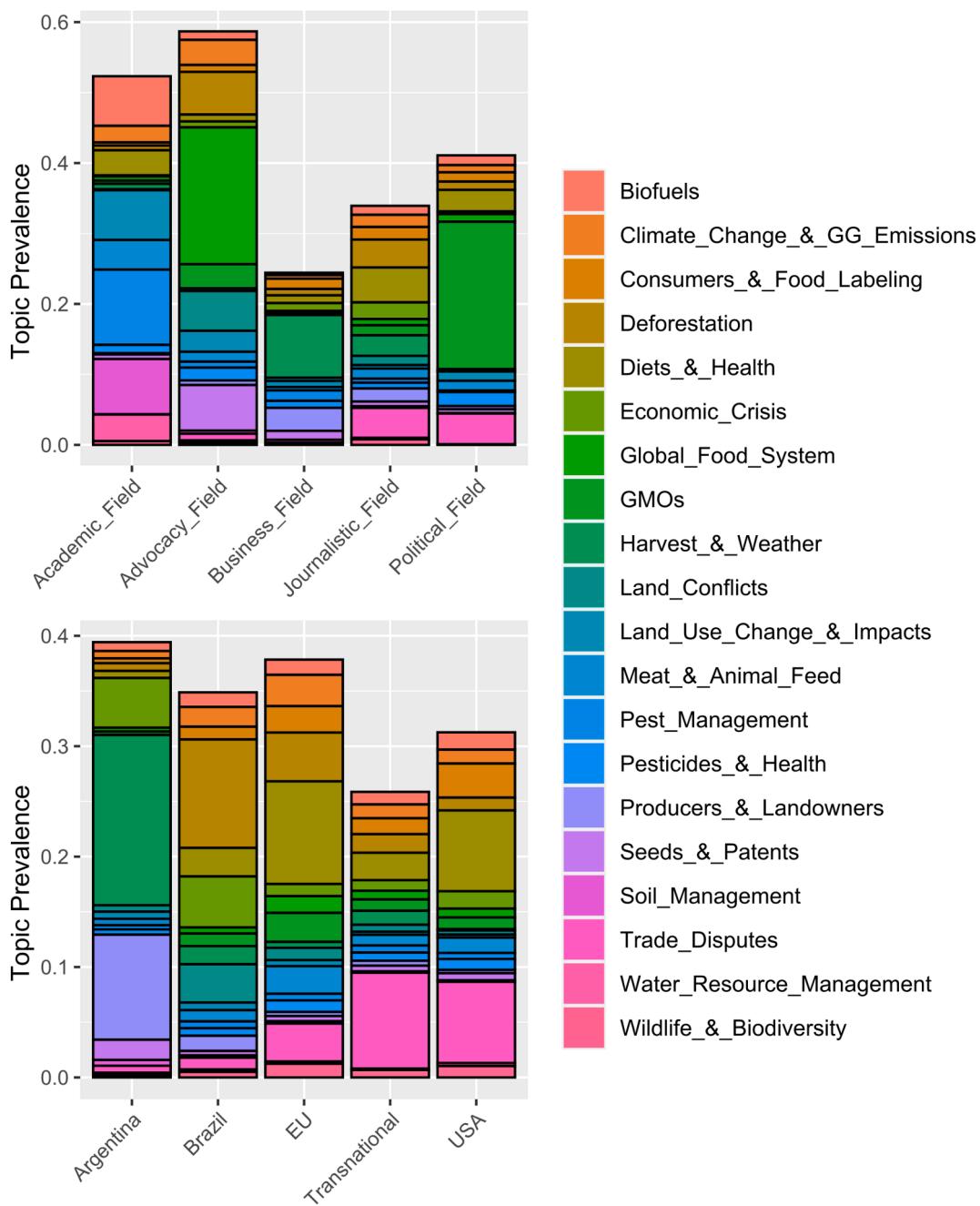
Fig. 3. Topic prevalence by field (upper graph) and by region for journalistic field (lower graph).

We further want to point to the following observations: as the focus on GMOs and Consumers shifts towards Deforestation and Climate Change, the prevalence of entities from the biotech industry (e.g., Monsanto and Novartis) fades and gives way to grain traders (e.g., Cargill), food processing industry (e.g., Unilever), retailers (e.g., Tesco) and food chains (e.g., McDonald's). Further, mentions of NGOs are also mainly associated with Deforestation and Climate Change since the mid-2000 s. In the most recent time interval (2017–2020), the association between the topic Deforestation and mentions of the EU is included within the 12.5% edge weight quantile for the first time, simultaneously with the appearance of the Mercosur trade bloc among the 20 top entities.

4.6. Topic prevalence corresponds to key real-life events

When cross-checking the evolution of topic prevalence in EU print media with real-life events, we found strong links between peaks of topic prevalence and certain key events or developments (Fig. 8).

Starting with the topic Meat & Animal Feed, the strong increase in prevalence in the years 2000 and 2001 occurs at a time when the EU Commission debated and subsequently decided on a full ban on meat and bone meal (MBM). Feeding MBM to animals had been accompanied by ethical concerns and linked to the outbreaks of Bovine spongiform encephalopathy (BSE) since the late 1980s. The ban was implemented in 2001 and led to an increase in demand for other protein sources in animal feed, such as soybean cake. This interpretation is further confirmed by the strong links between the topic and the entities EU and the European Commission for 1997–2001 (Fig. 7).
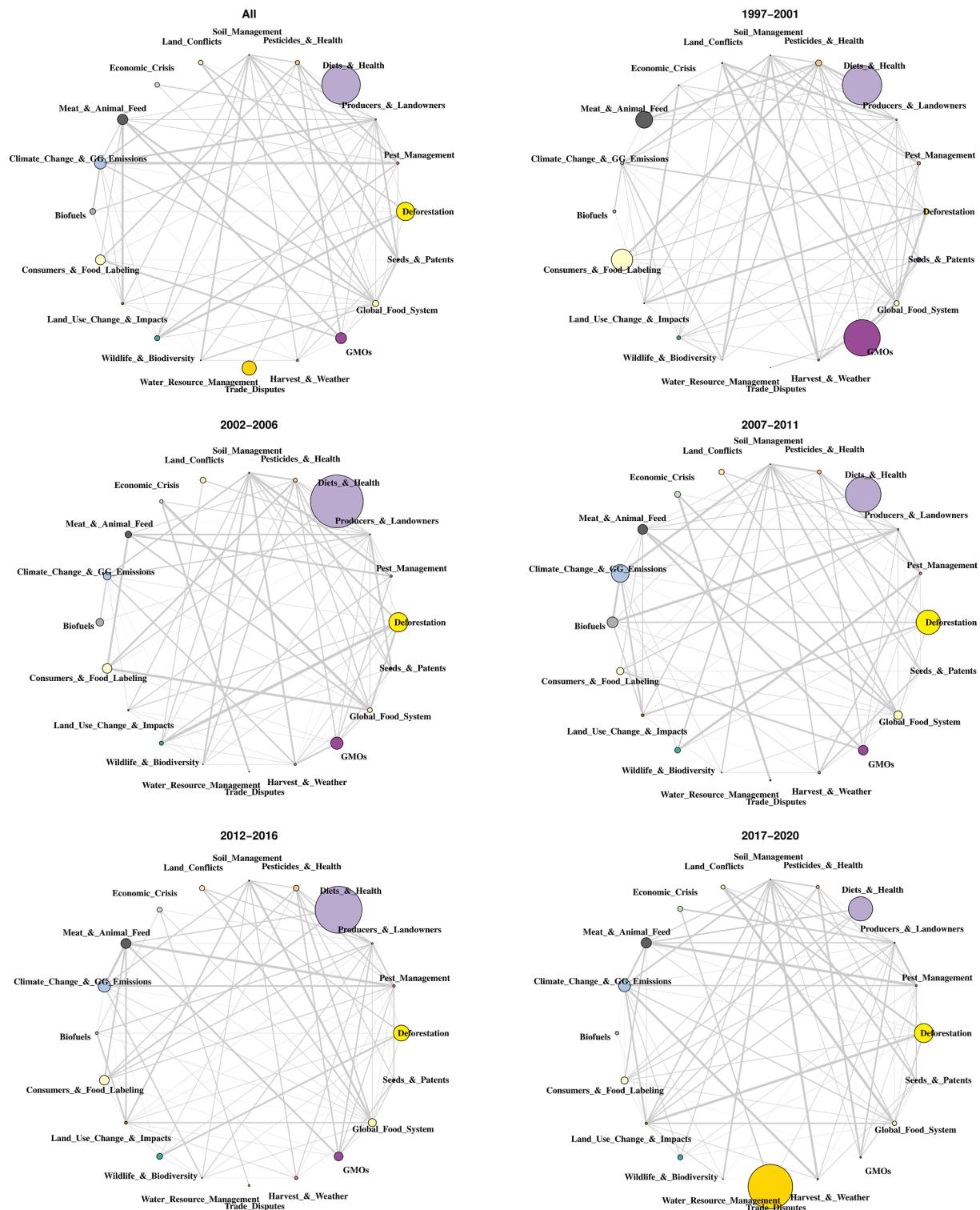
Fig. 4. Evolution of topic co-occurrence in EU print media. Circle size represents topic prevalence and line width indicates edge weight. Only edges with weights above the mean were included here.

Deforestation shows marked peaks in prevalence between 2005 and 2009, as well as again in 2019. The first peak coincides with broader public concern about high deforestation rates in the Amazon region, leading to the publication of the Greenpeace report "Eating up the Amazon" (2006) and the signing of the Amazon Soy Moratorium (2006) by different stakeholders (see also strong links to Greenpeace in Fig. 7). In 2019, broad media coverage followed the fires in the Amazon rainforest.

The topic Global Food System peaks in 2008, at the height of the 2007/2008 food crisis, when food prices skyrocketed worldwide (consider also the strong links to the entities UN and Worldbank). It further shows strong links with the topic Biofuels, which also peaks in that period. Biofuels were often seen as partly responsible for food price hikes at the time.

Lastly, the topic concerning Trade Disputes shows a dramatic peak in 2018, the year in which the Trump administration unilaterally imposed
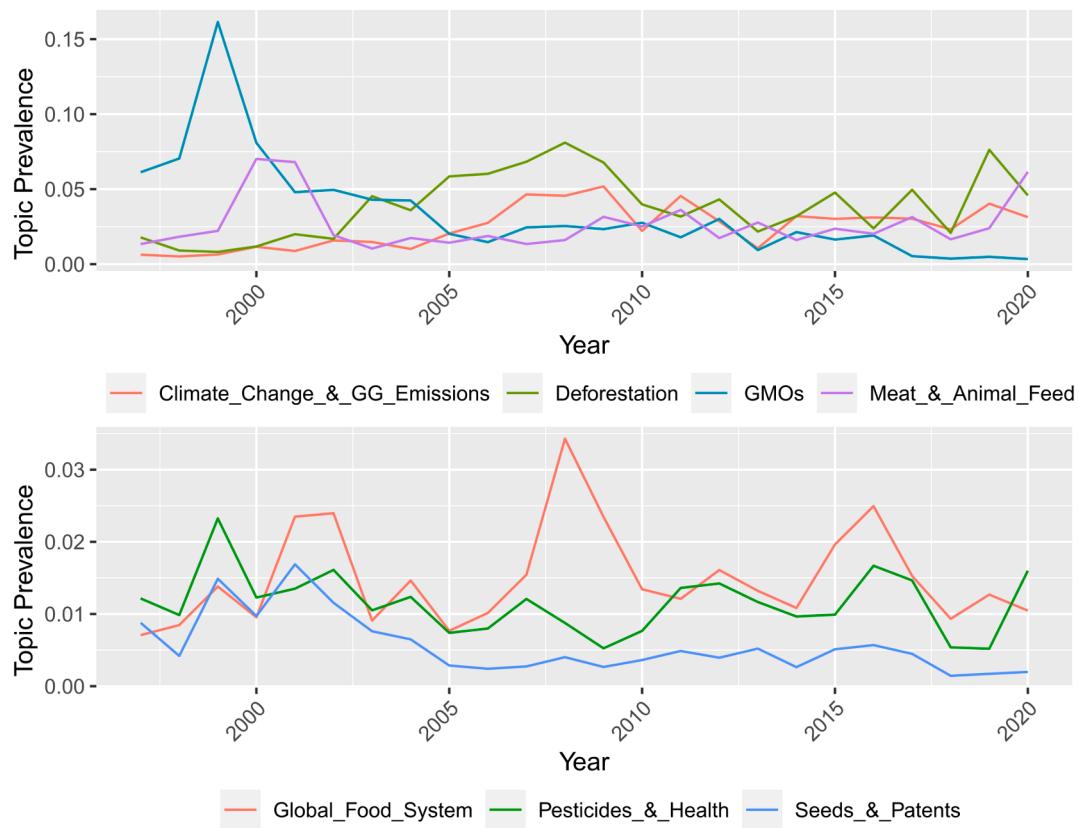
Fig. 5. Evolution of prevalence for selected topics in EU print media.

tariffs on different products from China. This was followed by similar tariffs imposed by China on US products, including soybeans (see also the strong links to entities such as the White House, the WTO and companies such as Huawei).

4.7. A closer look at media attention toward deforestation

When examining monthly prevalence values for the topic Deforestation for media outlets from the EU and Brazil, as well as transnational news agencies (see supplementary material), we observe that prior to 2003, prevalence levels are consistently higher for Brazilian news media and peaks in prevalence occur quite independently between the three sources. While prevalence remains highest for Brazilian outlets during most of the study period, the levels converge between the different sources and peaks co-occur more frequently.

The outputs from our keyness analysis show that for most years in our study period frequently used terms compared to prior years differ between outlets. However, there are several years with strikingly similar features between sources. In 2003, both Brazilian and EU media outlets appear to report on then newly elected President Lula and Minister of the Environment, Marina Silva. Both sources show peaks for the month of June, when Silva convened an important meeting on deforestation between scientists and civil society. The Brazilian outlets show another peak for the month of July, when Lula issued a presidential decree, laying out policy instruments to combat deforestation. Another common feature is the frequent mentioning of President Jair Bolsonaro in the years 2018 and 2019.

The closest resemblance, however, can be observed for the year 2006, in which key terms include the trader Cargill, the NGO Greenpeace and the fast-food chain Mc Donald's in all sources. Peaks in prevalence are identifiable for the months April, when the Greenpeace report "Eating up the Amazon" was released, and for July, when the Amazon Soy Moratorium came into force. Fig. 9 illustrates the co-occurrence networks for the selected months and the entire year 2006 for all three sources. While the Greenpeace report and the moratorium dominate the coverage in EU print media and news agencies for the entire year, in Brazilian print media this is only the case for the months of July and (to some degree) April. Another event that appears to play a major role in the coverage of news agencies that year is the blocking of Cargill's port facility in Santarem by a Greenpeace ship.

5. Discussion

Our findings provide indications regarding the evolving debates on soybean expansion and associated impacts within interlinked transnationalizing public spheres, as well as the legitimacy or lack thereof these debates confer to governance interventions at different scales.

The EU print media included in our analysis shows a clear shift from topics directly related to consumer concerns over the safety of GMOs, food labeling and other issues of direct relevance to EU citizens towards more distant or abstract phenomena, such as deforestation in producing countries and climate change. This is accompanied by mentions of a broader set of actors in the production network.

While these topics show a general upward trend, they still seem to be quite event-focused, revealing distinct peaks during times of controversial or disaster-like events. This shift in focus from biosafety of GMOs and consumer health towards deforestation and climate change can also be observed in the documents collected for the advocacy field. However, this field also emphasizes various issues that do not attain the same prominence in European print media, such as those dealing with land conflicts or seeds and intellectual property rights. Further, problems concerning the general structure of the global food system are dominant and central (highly connected to other topics) in the advocacy field, while they never play such a dominant role in the EU journalistic field.

There is a clear regional focus on the Amazon biome, particularly concerning topics related to deforestation and climate change in the
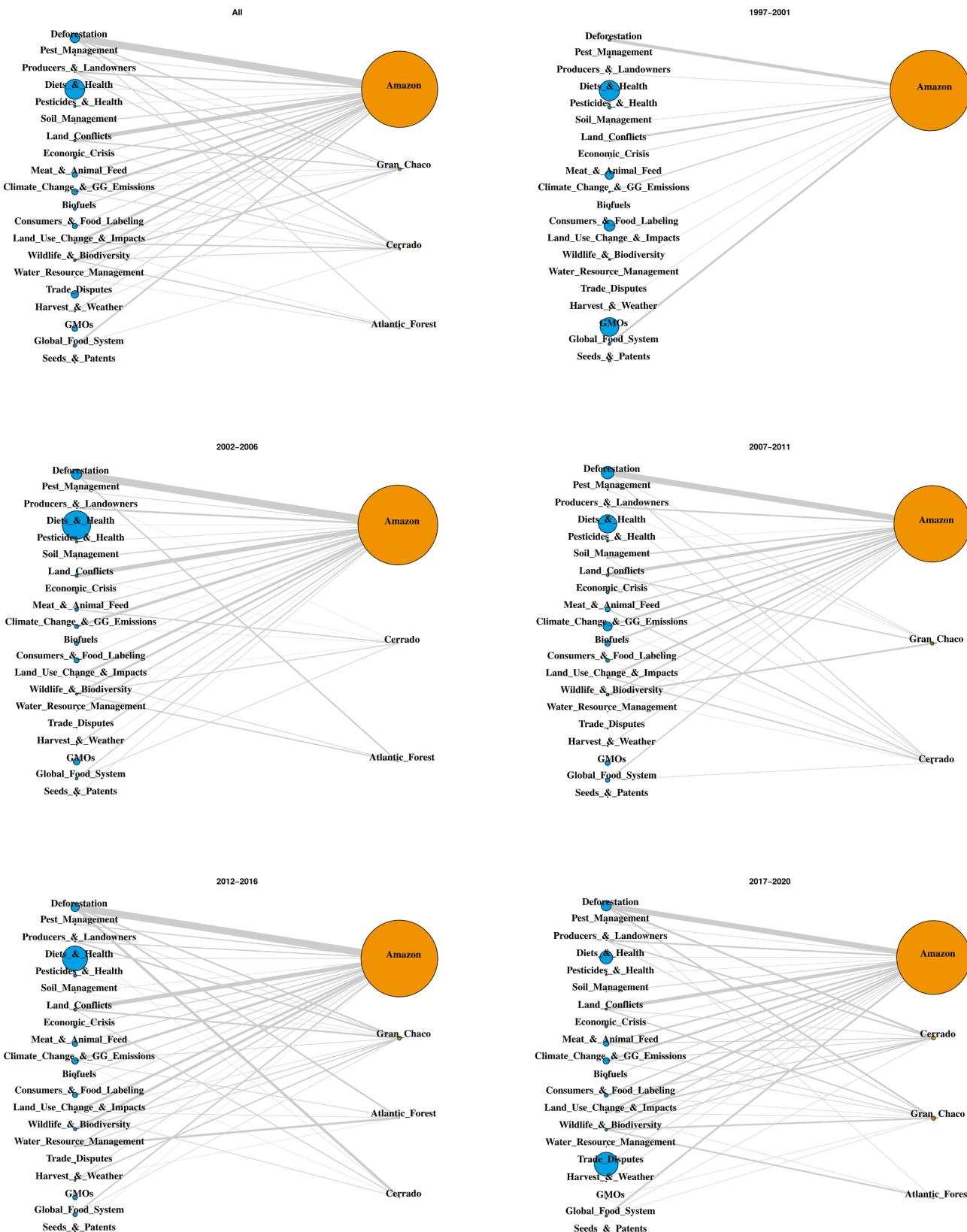
Fig. 6. Topic-biome bipartide network graphs for EU print media, illustrating the evolution of associations between topics and mentioned biomes over time. Circle sizes indicate relative topic/entity prevalence and lines indicate edge weights. Only edges with weights above the median were included.
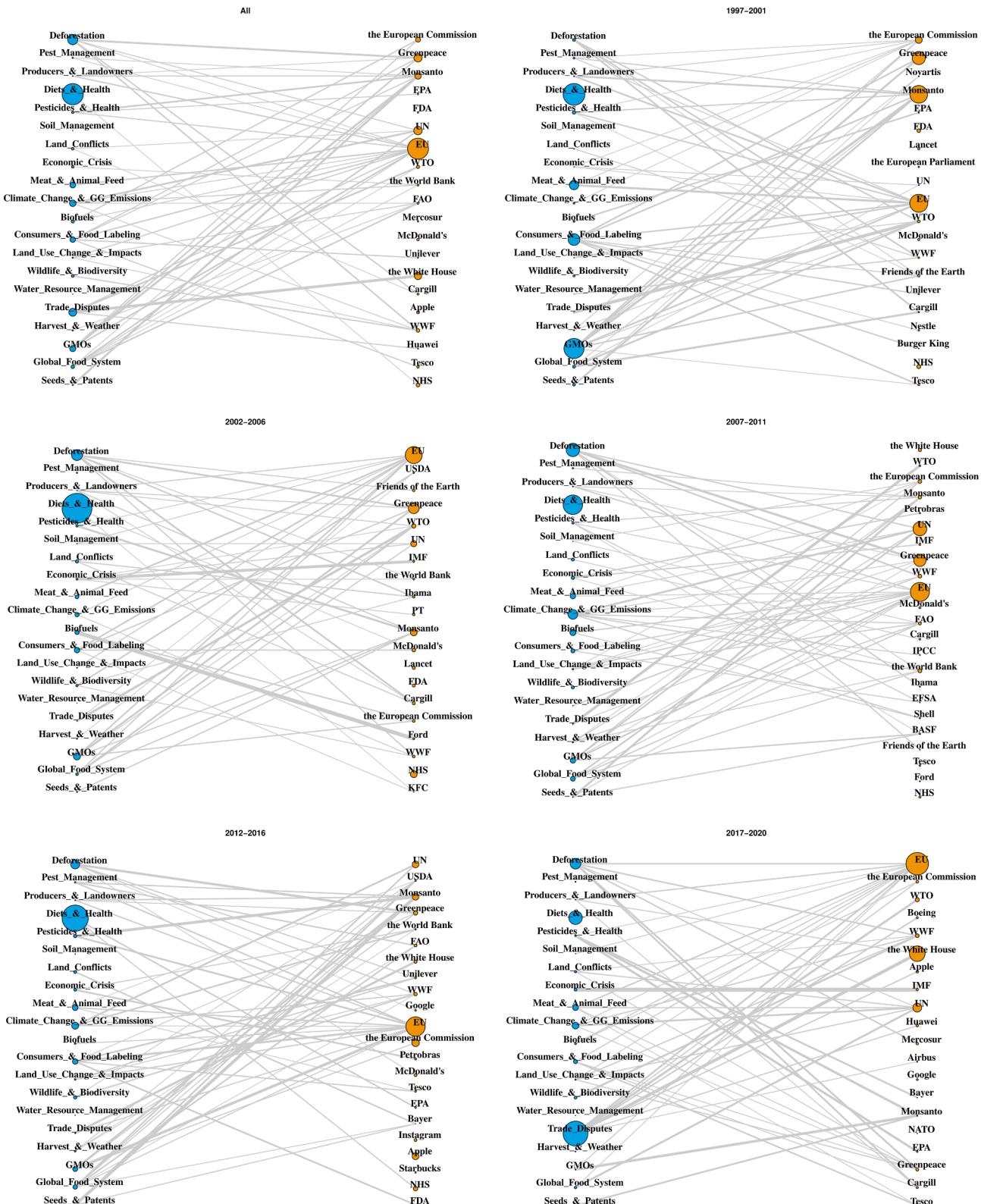
Fig. 7. Topic-organization bipartide network graphs for EU print media, illustrating the evolution of associations between topics and mentioned organizations over time. Circle sizes indicate relative topic/entity prevalence and lines indicate edge weights. Only edges with weights within the upper 12.5% quantile were included.

European journalistic field, which is more pronounced and constant than in the advocacy and academic fields. Brazilian and Argentinian print media put more emphasis on topics dealing with economic impacts and producers' concerns. Brazilian print media pay more attention to land conflicts than their European counterparts, while issues around

seeds and intellectual property are a major concern in Argentina, likely due to the yearlong legal disputes over farmers' rights to reproduce GMO seeds and the enforcement of intellectual property rights.

We further observe two simultaneous dynamics over the period 2017–2020: The Mercosur region appears among the most mentioned
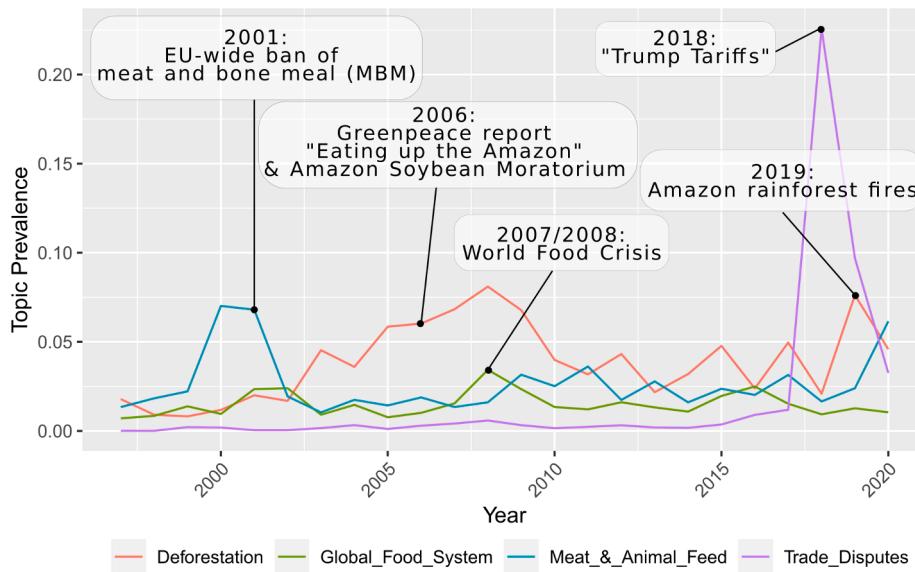
Fig. 8. Evolution of topic prevalence for selected topics in EU print media with links to key events.

entities and the association between the EU and the topic "Deforestation" becomes significant for the first time (within the highest 12.5% edge weights). This suggests increasing attention towards the responsibility of the EU as a major importer of soybeans and other FRCs with the debate around the EU-Mercosur trade agreement.

The event driven nature of environmental journalism as a form of contemporary news reporting has been pointed out before (Hansen, 2011; Pezzullo & Cox, 2018). This snapshot-like focus on certain issues (e.g. deforestation during the 2019 Amazon rainforest fires) does not provide a broader historical context for audiences (e.g. continuous loss of native vegetation in various biomes since the 1990s). Hansen (2011) also points to the "authority orientation" of news coverage, which will lead to a dominance of scientists' and politicians' key concerns (e.g., the global implications of greenhouse gas emissions from land-use change) over those of directly affected communities (e.g., land conflicts or pesticide-induced intoxication).

Our longitudinal analysis of issues related to soybean expansion confirms findings of other empirical studies. These are often grounded in theories of issue attention cycles (Downs, 1973), which aim to describe consecutive stages of attention to issues over time. Researchers have traced media coverage on specific issues, but also the evolution of coverage on entire domains (e.g., the environment) (Hansen, 2015a). In this regard, our findings related to the shifting focus over time for the EU journalistic field show close resemblance to Djerf-Pierre's (2013) study of news coverage relating to different environmental issues in Swedish television. This is particularly true for her findings concerning a focus on "the environmental impact of food production (particularly GMOs, 'mad cow disease' and the mistreatment of animals in industrialized meat production) in the late 1990s and early 2000s; and finally, the heavy focus on climate change in the late 2000s" (Djerf-Pierre, 2013, pp. 501–502). The peak in attention on climate change around 2006/2007 has also been observed elsewhere and related to the release of the documentary film *An Inconvenient Truth* (2006) and the findings of the 2007 report issued by the Intergovernmental Panel on Climate Change (IPCC) (Pezzullo & Cox, 2018).

With regards to the significance of our findings for public sphere theory, the shift from topics more relevant to individuals' personal life and in their role as consumers (GMOs, health, labeling) towards topics of environmental impacts at distant places (deforestation) or on a global scale (climate change) over the study period, may lead to the conclusion that public spheres become more porous and receptive towards issues from outside their own constituency. They appear to circulate the

concerns not only of the citizens of a given polity, but also of those affected by the production networks, whose final products are consumed by those citizens. This could introduce these issues into the centers of decision-making and thereby provide legitimacy to the governance outcomes in the sense of an all-affected or "all-subjected" principle as suggested by Fraser (2009). This could also be understood as a move towards what O'Brien et al. (2009) see as a necessary new form of social contract with a "larger conceptualization of 'we'", an expansion of moral communities, or evidence of what Eakin et al. (2014) call "feeling (empathy) at a distance".

However, while deforestation linked to soybean expansion had already been significant in the Cerrado biome throughout the 1990s (Beuchle et al., 2015), it only becomes a major concern in EU print media when the agricultural frontier moves further north and high annual deforestation rates in the Amazon biome are linked to soybean expansion in the early 2000 s. The strong focus on the Amazon biome and the relatively low prevalence of topics related to issues directly affecting local populations (e.g., land conflicts, pesticide induced health problems and disputes over farmers' rights to reproduce GMO seeds) reflects a fundamental concern with the loss of an emblematic ecosystem and the global threat of climate change rather than with the lives of people on the other side of the value chain. Therefore, in can be argued that EU print media have been more sensitive to the fate and state of ecosystems, rather than the wellbeing and struggles of people managing and living within such distant Nature.

Thus, it is unclear, whether increasing attention towards deforestation really is an outcome of increasing porosity between public spheres. EU news media appear to pay attention to major developments in Brazilian political events (e.g., the stances toward deforestation adopted by the Lula administration or later by Jair Bolsonaro). However, in our study period the journalistic field shows closest resemblance between regions when a major NGO publishes an alarming report, stages a sensational protest, and pushes for a moratorium between private stakeholders. More attention towards deforestation may therefore rather be the result of highly organized campaigning by increasingly powerful conservation NGOs, mainly based in the Global North.

It is important to note that this influence is not only limited to the level of attention an issue receives. Rather, large environmental NGOs also shape the framing of these issues and, following Dauvergne (2016), often tend to pursue an "environmentalism of the rich", emphasizing acts of eco-consumerism and corporate social responsibility. Porosity may then work in the opposite direction: governance becomes a matter
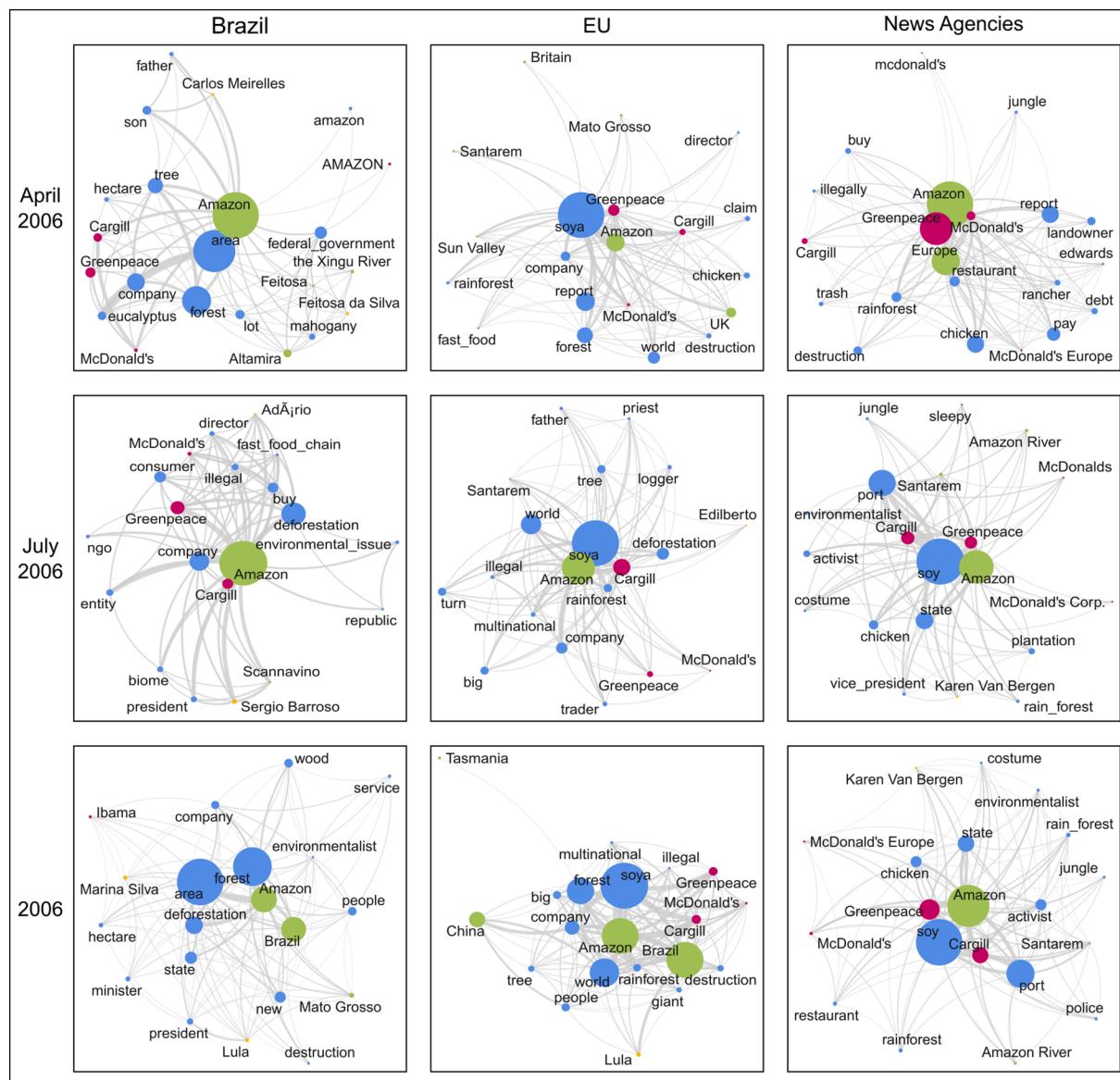
Fig. 9. Co-Occurrence networks for the topic "Deforestation" and selected regions within journalistic field. Green nodes represent countries or regions, red nodes organizations or companies and yellow nodes named individuals. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

of decisions taken by corporate actors, mediated by major NGOs and accountable mainly to final consumers, rather than an outcome of inclusive transnational public deliberation.

This casts a shadow on the promises of deliberative democracy, as the amplification of voices from professional public relations departments and the gatekeeping function of major media outlets do not allow for a level playing field between different stakeholders. Journalism's gatekeeping function may in fact prevent rather than stimulate an open public debate on fundamental asymmetries in the global food system. The increasing reliance on wire services from Western based news agencies, due to the high expense of foreign correspondents, may further aggravate this concern, as these tend to reflect the interests of the Global North (Boyd-Barrett, 2000; Hafez, 1999; Johnston & Forde, 2011; Lewis et al., 2008).

Moreover, the dominance of a single biome in media attention towards soybean expansion may help explain why there has never been a similar effort of private food law to prevent the further loss of native vegetation in the Cerrado as there has been for the Amazon. Evidence for high rates of deforestation related to soybean farming in the Cerrado

exists (Rausch et al., 2019) and recently, the carbon footprint of soybean exports from the Cerrado biome has been calculated to exceed those of other biomes in Brazil, largely due to emissions from land use change (Escobar et al., 2020). Calls by experts for a Cerrado soy moratorium (Soterroni et al., 2019) have been met with great reluctance by the industry.

The negotiations over the EU-Mercosur trade agreement appear to have temporarily pushed the question of the European Union's responsibility for environmental impacts associated with its imports into media discourse. Policy options to address this issue are currently being assessed by the European Commission (Bager et al., 2020; European Parliament, 2020) and the European Parliament has recently voted for an Amendment to the EU-Mercosur trade agreement, signaling reluctance to ratify it, mostly over environmental impacts (Boffey, 2020). However, the concerns voiced by European politicians primarily seem to echo the focus on Brazil's handling of commodity expansion in the Amazon biome, particularly after the large media attention to the 2019 Amazon rainforest fires.

It remains questionable whether the general increase of attention to

abstract or distant impacts of imported agricultural commodities, such as soybeans, will lead to a widespread fundamental debate on the implications of the current global food system for all groups affected by it. The findings of this study point instead to a pattern of recurring focus on individual issues, mainly linked to limited geographical regions and concerns. Also with regards to the political field, the outcomes of recent renegotiations on the EU's agricultural subsidies have been read by critics as mainly a continuation of the present state of large-scale, input-intensive agriculture and animal husbandry, largely dependent on the import of animal feed (Cwienk, 2020).

Further, theorists of communication studies have pointed to the individualization of media content consumption in the age of social media and even proposed the end of agenda-setting (McCombs, 2005). Bennett & Iyengar (2008) suggest that the fragmentation of audiences leads to selective consumption of information, which reinforces the individual's prior views and concerns. For our findings, this could imply that some of the less prevalent issues may only reach limited audiences, which are largely already informed about these. However, others have pointed to a more complex "inter-media agenda setting process" (Anderson, 2014). It therefore remains open how the more interactive, networked configuration between traditional media and individualized content generation will affect the construction of environmental issues in public spheres and what this means in terms of legitimacy and efficacy regarding processes of environmental governance.

6. Conclusion

In this contribution we have mobilized a text mining approach to trace the evolution of socio-ecological issues constructed around the expansion of soybean production and trade in the last two decades. Our focus has been on the journalistic field within the EU in relation to other fields and regions. Through this approach we have analyzed the functioning of contemporary, transnationalizing public spheres and their legitimacy and efficacy with regards to environmental governance.

We have shown that in the EU journalistic field, a high prevalence of issues around GMOs, health, and consumer labeling in the late 1990s has given way to more abstract and distant phenomena, such as deforestation in producing regions and climate change since the mid-2000s. This has been accompanied with a broader perspective of different stakeholders, but also with a strong regional focus on the Amazon biome. Less attention has been directed at immediate concerns for local communities, such as land conflicts or disputes over intellectual property rights, which are more prevalent in the advocacy field or the journalistic fields in Brazil and Argentina. These findings are broadly aligned with other empirical studies in the field of environmental communication.

Our findings suggest that there is some porosity between different public spheres and that reporting increasingly considers more distant and abstract impacts. However, the overarching concerns in EU news media seem to relate to the loss of emblematic ecosystems and the prospects of global warming as disaster-like events rather than to the struggles of local communities. This may help explain the relatively narrow focus on current governance mechanisms and the reluctance of corporate actors to expand these to other regions.

We also show that, even as the level of attention toward a given issue, such as deforestation, converges between different sources, the focus of reporting can still differ quite considerably. Major events and the public relations efforts of professionalized actors may temporarily align this focus. However, the themes thereby introduced can dominate reporting in Western media far beyond their immediate aftermath. The asymmetry in different stakeholders' ability to direct attention and construct dominant themes casts doubt on the promises of deliberative democracy in transnationalizing public spheres.

Even as the debate on the Mercosur trade agreement has provided a new spotlight on the European Union as an importing region of animal feed, this limited focus may lead to addressing specific regional outcomes through technical solutions and hinder a more fundamental

debate on asymmetries in the global food system. Finally, in the light of the current restructuring of networked and individualized news production and consumption, we propose to include an analysis of social networks and the sharing of and interactions with news content in future studies.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.gloenvcha.2021.102308.

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