Climate Policy

ISSN: 1469-3062 (Print) 1752-7457 (Online) Journal homepage: https://www.tandfonline.com/loi/tcpo20

Exploring links between national climate strategies and non-state and subnational climate action in nationally determined contributions (NDCs)

Angel Hsu, John Brandt, Oscar Widerberg, Sander Chan & Amy Weinfurter

To cite this article: Angel Hsu, John Brandt, Oscar Widerberg, Sander Chan & Amy Weinfurter (2020) Exploring links between national climate strategies and non-state and subnational climate action in nationally determined contributions (NDCs), Climate Policy, 20:4, 443-457, DOI: 10.1080/14693062.2019.1624252

To link to this article: https://doi.org/10.1080/14693062.2019.1624252

CLIMATE POLICY
2020, VOL. 20, NO. 4, 443–457
https://doi.org/10.1080/14693062.2019.1624252

Taylor & Francis
Taylor & Francis Group

Exploring links between national climate strategies and non-state and subnational climate action in nationally determined contributions (NDCs)

Angel Hsu [a,b], John Brandt[b], Oscar Widerberg [c], Sander Chan [d,e] and Amy Weinfurter[a,b]

[a]Environmental Studies, Yale-NUS College, Singapore; [b]Yale School of Forestry and Environmental Studies, New Haven, CT, USA; [c]Institute for Environmental Studies, Vrije Universiteit Amsterdam, Bonn, Germany; [d]German Development Institute/Deutsches Institut für Entwicklungspolitik (DIE), Bonn, Germany; [e]Copernicus Institute of Sustainable Development, Utrecht University, Utrecht, Netherlands

ABSTRACT

Non-state and sub-national actors (e.g. companies, civil society, cities and regions, collectively referred to as 'NSAs') could bridge the ambition gap left by insufficiently ambitious nationally determined contributions (NDCs) under the Paris Agreement. Increasing effective non-state and sub-national contributions could both support NDCs' implementation and spur ambitious updates to these national climate action plans. The impact of NSAs depends partly on whether and how national climate strategies recognize them. Yet, systematic knowledge about the extent to which national governments envisage a role for non-state and sub-national climate action is scarce. How do governments refer to NSAs in their NDCs; and what capacities, functions, and in which sectors do they envisage non-state contributions? We apply structural topic modelling (STM), an efficient quantitative text analysis technique seldom used in global climate governance research, to 147 NDCs to explore whether and how national governments incorporate non-state and subnational contributions into their international climate commitments. Using this method, we identify key topics for non-state and subnational engagement in NDCs, including vulnerability and adaptation, monitoring, general and sector-specific collaboration, and policy support. We find that developing countries overwhelmingly reference NSAs more frequently than developed countries. We also find predominantly negative trade-offs in how countries link to NSAs, suggesting countries tend to mention NSAs' contributions in specific roles rather than across multiple sectors. Our findings suggest there is scope for countries to broaden their linkage to NSAs in their updated NDCs to further catalyze engagement.

Key policy insights

- Linkages to NSA initiatives (including cities, regions, businesses or civil society) in NDCs under the Paris Agreement are mostly made by developing countries.
- Developing countries describe NSAs primarily in the context of vulnerability and adaptation policy implementation, while developed countries mainly describe these actors' role as collaborators across a range of functions.
- Closer coordination between NSAs and national governments, to fully leverage NSA contributions to NDCs, can be achieved by explicitly outlining NSAs' contributions in future updates of NDCs.

ARTICLE HISTORY
Received 31 October 2018
Accepted 15 May 2019

1. Introduction

The 2015 Paris Agreement ushered in a new era of climate governance, formalizing an institutional architecture based on national pledges – nationally determined contributions (NDCs) – in which governments communicate

CONTACT Angel Hsu angel.hsu@yale.edu
Supplemental data for this article can be accessed https://doi.org/10.1080/14693062.2019.1624252.
This article has been republished with minor changes. These changes do not impact the academic content of the article.

their plans to help achieve the Agreement's goals. This architecture allows for flexibility in the design and implementation of national strategies, helping the Agreement garner broad participation in the submission of 168 NDCs at the time of writing (Pauw and Klein, in preparation). Current NDCs, however, are not ambitious enough to meet the Paris Agreement's goal of holding global warming to well below 2° Celsius, resulting in an 'emissions gap' between the world's current emissions trajectory and one that leads to safer levels of global temperature rise (Rogelj et al., 2016; UNEP, 2018). Closing the gap requires governments to increase their contributions through the Agreement's mechanism to ratchet up NDC ambitions in five-year cycles, which starts in 2020 for some countries (Pauw and Klein, in preparation).

Harnessing the mitigation potential of actions by non-state and subnational actors (referred to in this paper as non-state actors or NSAs), including companies, investors, cities, regions, and civil society, may be a way to strengthen and complement NDCs to address this emissions gap (Blok, Höhne, van der Leun, & Harrison, 2012; Hsu, Moffat, Weinfurter, & Schwartz, 2015). Aligning national policies with non-state actions (Chan, Falkner, Goldberg, & van Asselt, 2016) can, *inter alia*, increase buy-in from private stakeholders, subnational authorities and civil society; leverage technical expertize and capacity; stimulate sector-specific decarbonization pathways; improve transparency; and demonstrate the feasibility of, and build political support for, increasingly ambitious national mitigation targets.

Current research on the links between international and national policies and non-state actions suffer from several knowledge gaps. Scholarly debate on the linkages between international institutions has expanded in the past ten years, generating classifications and typologies for analyzing interactions and connections between institutions (Van Asselt, 2014). This analysis, however, focuses on the interplay among international agreements and regimes (Abbott, Green, & Keohane, 2016; Betsill et al., 2015; Ivanova & Roy, 2007; Oberthür & Gehring, 2006; Stokke, 2001). Few researchers have empirically analyzed the linkages between international, transnational and local actors, although recent scholarship has emphasized potential synergies between NSAs and climate policies (see Andonova, Hale, & Roger, 2017). Yet the ways actors can steer institutional interaction towards synergistic effects remain poorly understood.

Responding to this knowledge gap, this article explores how countries refer to NSAs in their NDCs. It asks, first, which countries mention NSAs in their NDCs and then explores in what context (or in connection with what topics) NSAs are most frequently mentioned. It also asks how countries envision NSAs' roles or functions across different topics. Evaluating these linkages helps determine the extent of, and trends within, countries' NSA engagement. This research aims to act as a first step towards determining whether NSA functions – such as policy implementation, capacity building, and financing – can be linked with national governments in a way that spurs higher ambition and specific forms of collaboration between these actors.

Due to the heterogeneity in scope and content of the NDCs, a systematic analysis of NDCs is challenging (Pauw et al., 2018). We use Structural Topic Modelling (STM), which is a particularly effective method to reveal topics, trends and clusters in large amounts of text while minimizing selection biases. STM identifies general trends and linkages in an inductive manner; however, it still requires parsimonious interpretations, and should ideally be complemented with other research approaches on individual (country) cases. The paper proceeds as follows: it briefly defines the theory associated with NSA functions in global climate governance. It then describes the data and methods used to explore linkages between NDCs and NSAs, and discusses the model results. Finally, it summarizes key insights and puts forward recommendations for future research.

2. Functions of non-state and subnational climate action in global climate governance

National governments have, until recently, been the focus of global climate governance, in particular within the United Nations Framework Convention on Climate Change (UNFCCC). The UNFCCC is shifting, however, from a top-down and regulatory mode to a 'catalytic and facilitative' bottom-up process (Falkner, 2016; Hale, 2016) where cities, regions, businesses, investors, and civil society play an increasingly prominent role. The decision to adopt the Paris Agreement calls for increased action from these 'non-Party stakeholders', and for linking 'transnational initiatives directly to the development of concrete policy options for countries under the technical process of the UNFCCC' (Hale, 2016, p. 14). In December 2017 the UNFCCC initiated the Talanoa Dialogue, a

forum that allowed NSAs to directly submit contributions and viewpoints into the formal negotiation process via a public online platform that showcased and archived their submissions (UNFCCC Decision 1/CP.23, Annex II).

The Paris Agreement requires national governments to regularly update their NDCs, providing an opportunity for countries to ascertain what support and additional action can be leveraged from NSAs. For instance, 136 countries make their NDC conditional on mitigation finance, adaptation financing, technology transfer or capacity building (see Pauw et al. 2019). NSAs could, in theory, support governments in realizing the conditions set out in the NDCs (e.g. financial investment or technology transfer) and thereby raise the ambition level of countries with conditional targets, both in terms of mitigation and adaptation. Moreover, some countries could draw on sub-national policies when formulating a national strategy. For example, according to its NDC, Canada suggests building on initiatives in its provinces when developing its carbon pricing policy, demonstrating how national governments can leverage the experience of NSAs who are policy first movers. South Africa's views on NDC ambition were also shaped by direct submissions from civil society and two business associations (Cunliffe, Holz, Mbeva, Pauw, & Winkler, 2019).

NSAs, in this context, have the potential to both accelerate the implementation of, and drive greater ambition within, national climate policies (see also Widerberg, 2017). Methodologies to capture the impacts of such interaction effects, however, remain scarce (Hsu et al., 2019). A few studies suggest that national governments could increase NDC ambition, by aligning targets with ongoing NSA actions on track to deliver reductions beyond what existing policies would achieve. To support these arguments, an increasing number of studies are quantifying and aggregating the potential additional mitigation impact of NSA efforts (Hsu et al., 2019). One recent analysis of nearly 6,000 subnational governments and over 2,000 companies in 10 high-emitting regions found that these actors' emissions targets could contribute an additional 1.5–2.2 gigatons of carbon dioxide equivalent (GtCO2e) emission cuts by 2030 – roughly twice Canada's 2014 emissions – beyond the reductions expected from current national policies, if fully implemented (Yale-NCI-PBL, 2018).

NSA contributions can also inspire governments to adopt more ambitious goals. By sending a positive signal in favour of climate action, NSAs can increase policymakers' confidence to develop and adopt more ambitious goals. Civil society organizations can use political clout and public pressure to call for climate action (Jacobs, 2016), while business can provide innovation and low-carbon technological solutions. Bulkeley and Castán Broto (2013) document climate change 'experiments' in 100 urban areas, focused on infrastructure, transport and energy, that play an increasingly critical role in agenda setting and learning. Within the UNFCCC process, the 'Technical Examination Processes' on mitigation and adaptation follow a similar logic: states and NSAs share strategies that address finance, technology and capacity building, to enhance ambition '[i]rrespective of shortfalls in the ambition of current INDCs[1] and NDCs' (UNFCCC, 2016, p. 5; see also: Chan, Brandi, & Bauer, 2015). Similarly, the recent rise of NSA-led action in the United States has been seen as countering a recalcitrant federal government (Arroyo, 2018).

While these examples suggest synergistic linkages between NSAs and national governments in addressing climate change, negative interactions are also possible. For example, Oberthür and Gehring (2006) note the 'disruptive' negative interaction between the UNFCCC Kyoto Protocol, which incentivizes non-state actors to invest in fast-growing monoculture tree plantations for carbon sequestration benefits, and the Convention on Biological Diversity, which prioritizes biological diversity. In subnational climate policy, NSAs efforts to claim additional recognition or credit for climate actions can create conflict with national governments. The Brazilian state of Acre, for example, has developed programmes to link its own avoided deforestation to carbon markets in California, Rio de Janeiro and São Paulo. As Brazil defines its NDC, it may seek to subsume Acre's efforts, which would negate Acre's claim to additional credits and revenues (Hsu, Weinfurter, & Xu, 2017).

A highly fragmented governance system could increase inefficiency and transaction costs between actors, even resulting in national governments retreating from realizing their own policies (Chan, Falkner, Goldberg, & van Asselt, 2015). In the realm of sustainable development governance, governments held off on regulatory agreements while referring to 'partnerships for sustainable development' with private actors in the early 2000s (Pattberg, Biermann, Chan, & Mert, 2012). Such 'window-dressing' could undermine NSAs' potential to accelerate low-carbon pathways, and ultimately the effectiveness of the Paris Agreement. In some cases, governments could thwart non-state and subnational actions that go beyond national legislation, as illustrated by the U.S. federal government's 2018 freeze of ambitious state-level fuel economy standards, initially set by the state of California (US EPA, 2018).

More research is needed to understand linkages and interactions between NSAs and national governments. For instance, scholarship on institutional interplay points to the possibility of both negative and positive outcomes from institutional interaction (Oberthür & Gehring, 2006; Stokke, 2001; Van Asselt, 2014; Young, 1996). Biermann, Pattberg, Van Asselt, and Zelli (2009) argue that linkages could have implications for the speed of agreement; level of ambition; level of participation of different actors; and equity. Better understanding of how different jurisdictions' actions align and relate to each other to drive implementation and higher ambition could contribute to well-functioning, facilitative, and catalytic global climate governance (Hsu et al., 2017). For instance, identifying specific actors best positioned to implement mitigation initiatives would increase overall efficiency, leading to deeper emissions cuts, cross-sector learning, and systemic synergies (Broekhoff, Erickson, & Lee, 2015). Examining NSA and national linkages could also help sub-national efforts align with broad guiding strategies, such as national strategies to implement the 2030 Agenda for Sustainable Development and the Sustainable Development Goals (SDGs).

3. Data and methods

Researchers have developed methods and analytical frameworks for mapping and evaluating linkages and their effects in global climate governance (Widerberg, 2014). While acknowledging the importance of institutional linkages and their consequences, this paper focuses solely on exploring the linkages between NDCs and NSAs, without further analyzing impacts. This analysis should thus be understood as a first step towards better understanding possible implications of NDC and NSA interaction. To explore these linkages, we aim to identify the functions or topics national governments mention in the context of NSAs. Isolating the NDC text to specific passages that reference NSAs and applying text analysis techniques allows us to understand linkages, and specifically how countries view NSA contributions.

The text analysis applied in this paper is based on NDCs submitted under the Paris Agreement. Three steps were taken to create an NDC corpus for analysis. First, we compiled an English-language corpus consisting of 166 NDCs that had been submitted at the time of writing (August 2018) in Hypertext Markup Language (HTML).[2] We removed 45 countries (including the EU 28) that do not mention NSAs. These removals occurred either algorithmically, when countries' NDCs did not contain any of the keywords used to identify NSAs (listed in Table 1), or manually, for 6 countries where a close reading revealed no actual mentions of NSAs. For instance, Serbia was removed because even though the NDC included the word 'territory', one of the keywords in Table 1, in context it referred to the 'whole territory of the Republic of Serbia' rather than to NSAs. After removing these countries, the final corpus consisted of 147 NDCs (see Figure 1 for a map of countries whose NDCs refer to NSAs and Table S2, Supplementary Information, for the full list of countries excluded from the analysis).

Second, the corpus was further cleaned by removing stopwords (e.g. common words such as 'the' or 'and' that are immaterial to the analysis of textual content),[3] a few proper nouns ('European') that refer to specific countries, and words that appear often but are not tied to any specific topic (e.g. 'agreed') (see Table S1, Supplementary Information for details). In total, 45 words that were not predetermined stop words or country names were removed, according to the authors' judgment. The corpus was then reduced to passages that specifically mentioned NSAs according to a set of keywords that were used to identify these (Table 1).

Third, multi-word keywords were converted into single words by n-gram bundling, linking words together in commonly occurring phrases (e.g. the word 'sector' was commonly preceded by other modifying words critical to distinguishing the content, such as 'waste sector' and 'transport sector'). This transformation was done to conform to a 'bag of words' (BoW) approach (Zhang, Jin, & Zhou, 2010) to identify key words in textual data analysis regardless of grammar or word order (e.g. replacing the words 'capacity building' with 'capacitbuilding' and 'climate change adaptation' with 'climchangeadapt' ensures that words that are commonly grouped

Table 1. Keywords used to reduce NDC corpus to passages solely related to non-state and subnational actors. Pluralized versions of the above keywords were also included in the subsetting process.

'company', 'non-governmental', 'nongovernmental', 'subnational', 'NGO', 'non-government', 'investor', 'organization', 'city', 'university', 'corporation', 'NGOs', 'institution', 'town', 'municipality', 'metropolis', 'metropolitan', 'district', 'province', 'territory', 'county', 'college', 'private sector', 'local government', 'civil society', 'non-profit'

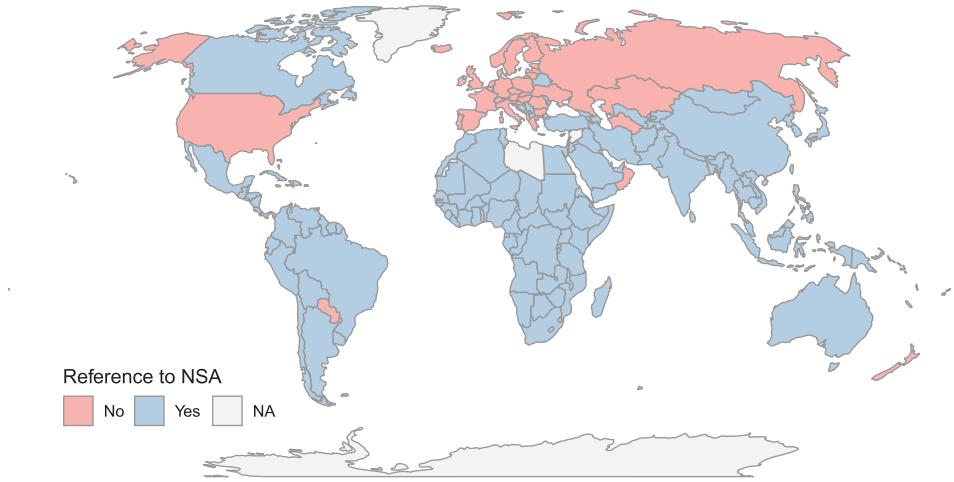

Figure 1. Global map of countries shaded according to whether their NDC refers to non-state actors in their text. In total we evaluated 147 countries' NDCs that mentioned NSAs.

together retain their contextual meaning). Special characters[4] and sentences with less than 10 characters were also removed.

Subsequently, we applied Structural Topic Modeling (STM, Roberts et al., 2014), a semi-automated quantitative text analysis technique based on unsupervised machine learning of large text data, that allows for an inductive rather than prescriptive mode of analysis (Tvinnereim, Fløttum, Gjerstad, Johannesson, & Nordø, 2017). STMs are gaining popularity among social science researchers as a method that enables them 'to discover topics from the data, rather than assume them' (Roberts et al., 2014, p. 1066). They may counter certain biases introduced through non-automated coding techniques that rely on subjective interpretations or can be influenced by selection biases (King & Lowe, 2003). STMs thus differ from supervised machine learning techniques (i.e. statistical classification methods that require user input to 'train' a model) and top-down text analysis where words and concepts of interest are defined a priori. In STMs, topics of interest are found from the 'bottom-up', using probabilities of word associations belonging to an identified topic.

STM builds on Latent Dirichlet Allocation (LDA; Blei, Ng, & Jordan, 2003), a common quantitative text analysis technique that identifies topic probabilities over a text corpus, allowing topic prevalence to be influenced by document-level covariates through a logistic-normal generalized linear regression (Roberts et al., 2014). While LDA assumes that all documents in a corpus discuss topics with the same diction, STM allows groups of documents to vary word usage within topics. We used a country's developed/developing country status as covariates to explain the prevalence of some topics over others (Mildenberger and Tingley, 2017). In the STM method case, topic prevalence refers to how much of a document is associated with a particular topic (Roberts et al., 2014).

The STM method is also suitable for dealing with documents of variable lengths. In general, developing countries' NDCs are much longer than developed countries' (Mbeva & Pauw, 2016), due to the more qualitative, policy-based commitments among developing country NDCs. For example, Pauw, Mbeva, and Dzebo (2017) found developing countries consistently discussed adaptation measures in NDCs, whereas developed countries hardly ever included these details, and instead focused on the 'headline numbers' expected for mitigation targets. Due to the wide

Table 2. Descriptive statistics for the NDCs used in the analysis.

	Word count		Vocab size	
	Raw	Cleaned	Raw	Cleaned
Min	777	30	313	25
Mean	4,563	1,104	1.292	317
Max	20,588	5,622	3,924	864

variation in NDCs' length, with the longest NDC coming from Uruguay (14,922 words) and shortest from Oman (530 words), we aggregated all NSA-relevant sentences within each NDC to provide the most coherent results, in line with Hong and Davison (2010). Table 2 includes descriptive statistics for the NDCs and the subsetted document text (containing only text snippets referring to NSAs) for passages analyzed for NSA linkages.

The number of topics was selected iteratively by maximizing exclusivity (e.g. uniqueness), semantic coherence (e.g. whether the topics contain words that are representative of a single coherent concept), 'heldout likelihood' (e.g. cross-validation), and minimizing residuals (e.g. error) while allowing for qualitative judgement in post-estimation outcomes for each potential topic (Roberts et al., 2014). This process yielded seven topics, to which we applied identification labels (Table 3), although we recognize that there is some degree of subjectivity associated with these labels. We validated the meaning of the selected topics by examining their word distributions and analyzing the most representative passages for each topic (Table 3). We also generated word clouds to illustrate differences between topics and sample words weighted by the probability that the word comes from a particular topic (Roberts et al., 2014).

4. Results

4.1. Topics identified

We identified seven topics from the subset NDC text corpus (Table 3). The STM analysis provides a measure of prevalence: the frequency with which a particular topic appears across documents. Vulnerability and adaptation (0.20 or 20% of the corpus documents), civil society collaboration (0.19), and government and policy support (0.16) were the most prevalent topics among the NDCs in our corpus, followed by energy (0.13) and monitoring and information sharing (0.12). Topics that were less prevalent among the NDCs' references to NSAs include a topic we labelled 'sector-specific collaboration', where national governments mentioned NSAs in reference to cooperation in sectors such as water, finance, and agriculture, and energy/emissions reduction (see Table 3).

The prevalence of vulnerability and adaptation is perhaps unsurprising, since most NDCs that reference NSAs are from developing countries. Eighty percent of the 45 countries that did not mention NSAs in their NDCs were developed countries. Countries that include NSAs often mention vulnerability to climate change (e.g. Cambodia), national adaptation plans (e.g. Ethiopia), and resilience (e.g. Philippines) in their NDCs. They describe NSAs as helping to provide services to climate vulnerable communities, disseminate climate adaptation and vulnerability data and information, and participate in 'climate resilience development planning' (e.g. Timor-Leste).

4.2. Distribution of topics

We found differences in how the seven topics were distributed amongst countries (Figure 2). Developed countries include industrialized countries that were members of the Organisation for Economic Cooperation and Development (OECD) in 1992 when the UNFCCC was founded, as well as economies in transition, such as South Korea, Russia and countries in Central and Eastern Europe. To provide some differentiation between the 140 NDCs from developing countries, we further designate 47 of these as least developed countries or LDCs. LDCs are defined according to three criteria: low income, weak human assets and high economic vulnerability (UNFCCC, n.d.-a). Only seven developed country and economies in transition NDCs mention NSAs: Australia, Belarus, Canada, Japan, South Korea, Monaco, and Turkey, whereas 140 developing countries reference NSAs, of which 47 are additionally classified as LDCs. In comparing the mean topic prevalences between these groups, developed countries mention monitoring more frequently (0.21 ± 0.31) than developing countries (0.14 ± 0.30). This result likely reflects developed countries' more stringent requirements to monitor, report, and verify emissions inventories under the UNFCCC and the Kyoto Protocol, which do not apply to developing countries (UNFCCC, n.d.-b). Developed countries' NDCs also discuss sector-specific collaboration (0.31 ± 0.37) and government and policy support (0.30 ± 0.36) more frequently than developing countries (0.13 ± 0.26 and 0.15 ± 0.33). Developing countries' NDCs pay greater attention to vulnerability and adaptation (0.18 ± 0.29) –

Table 3. The seven-topic model with each topic prevalence, representative word cloud, and sample texts from the NDC corpus, arranged according to the prevalence with which these topics appear in the NDC corpus.

Topic	Prevalence	Representative word cloud	Representative sentences
Vulnerability and adaptation	0.2		• 'adaptation capacity including engagement of private sector and civil society in adaptation and climate resilience' – **Kiribati** • 'at the subnational level states and municipalities have also embarked on adaptation efforts as reflected in their own climate change plans' – **Mexico**
Civil society collaboration	0.19		• 'has been prepared through an inclusive stakeholder consultation process including line ministries research institutions civil organizations provincial governments private sector and international development partners' – **Laos** • 'this will contribute to formulate policies programs plans and projects in an articulated way between the different productive sectors public and private entities non-governmental organizations and civil society in general' – **Colombia**
Government and policy support	0.16		• 'participation for the provinces through… non-governmental organizations, ngos, work associations, private, academic, and scientific sectors, and municipalities' – **Argentina** • 'The government … builds on efforts of provinces and territories, local governments, indigenous organizations, businesses, youth, academics, and NGOs' – **Canada** • 'works closely with sectorial ministries the national climate change committee sectorial [*sic*] and regional environmental offices and others non-governmental actors operating in the fight against climate change' – **Madagascar**

(*Continued*)

Table 3. Continued.

Topic	Prevalence	Representative word cloud	Representative sentences
Energy	0.13		• 'recognising and rewarding companies making efforts in the area of energy efficiency and carbon footprint as a way of promoting good behaviour' – **Zimbabwe** • 'energy service companies escos could be used to overcome financial barriers' – **Palestine**
Monitoring and information sharing	0.12		• 'experts from government ministries and departments national universities and research centers private institutions and non-governmental organizations are responsible for defining methodological approaches and implementation work to estimate ghg emissions' – **DRC**
Sector-specific collaboration	0.08		• 'creation and repowering of recycling companies with capacity to recycle wood and paper' – **Venezuela** • 'sector land use change of land use and forestry' – **Panama** • 'the private-sector intersectoral agreement was signed where the public private sector civil society and non-governmental organizations share the goal of reforestation' – **Panama** • 'new agri-food companies would partner with farmer-control farmer cooperative [*sic*]' – **Congo**

(*Continued*)

Table 3. Continued.

Topic	Prevalence	Representative word cloud	Representative sentences
Energy/emissions reduction	0.06		• 'organizations may be awarded a c-neutral certification after submitting to an emissions assessment' – **Costa Rica** • 'encouraging companies to invest in energy efficient equipment' – **Cote d'Ivoire**

with LDCs placing even more emphasis on this topic (0.28 ± 0.36) – whereas developed countries refer to this topic much less (0.7 ± 0.09). While developing countries and LDCs' mean topic prevalence numbers across topics follow similar trends, they notably diverge on monitoring (0.14 ± 0.30 for developing countries; 0.06 ± 0.18 for LDCs) in addition to the aforementioned vulnerability and adaptation topic.

4.2.1. Examining trade-offs in topics

We generated a correlation matrix plot (Figure 3) to illustrate various trade-offs in how countries may reference some NSA topics at the expense of others. Negative correlations, which mean that the topic pairs represent trade-offs (e.g. one topic is mentioned at the expense of another) are represented as negative numbers and shaded in red, with more negatively correlated topics shaded darker, and more weakly negatively correlated topics shaded more lightly. Positive correlations would suggest that a positive relationship exists between topic pairs and thus that the two topics are likely to be mentioned together in the same document, although we did not observe any positive relationships between topics in the NDCs that mention NSAs.

Figure 3 shows only negative trade-offs between topics in the NDCs. Collaboration with civil society is only mentioned at the expense of the emissions reduction topic ($R^2 = -0.24$) and the sector-specific collaboration ($R^2 = -0.23$) topics. Energy is mentioned at the expense of vulnerability and adaptation ($R^2 = -0.19$), although these negative associations are weak. For instance, Canada's NDC specifically mentions collaboration with NSAs in the realm of clean fuel standards:

> To increase the use of low-carbon fuels, the federal government, working with provincial and territorial governments, industry and other stakeholders, will develop a clean fuel standard to reduce emissions from fuels used in transportation, buildings, and industry.

There is no mention, however, of NSAs' role in vulnerability and adaptation or emissions reduction activities in Canada's NDC. The dominance of negative relationships or trade-offs between topics, however, does not eliminate the possibility of positive linkages between topics in some countries' NDCs. For instance, South Korea's NDC mentions collaboration with civil society alongside the *vulnerability and adaptation,* and *energy* topics. For instance, South Korea's NDC states:

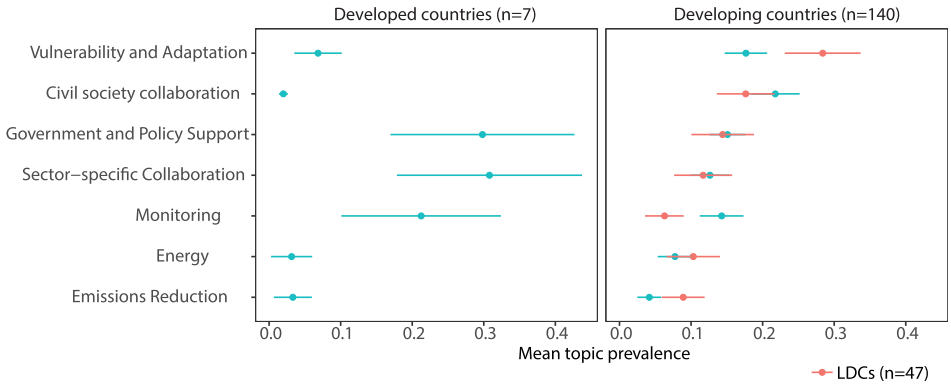

Figure 2. Mean topic prevalence for developed and developing countries' NDCs evaluated. See Table S2 for the full list of countries included in each category.

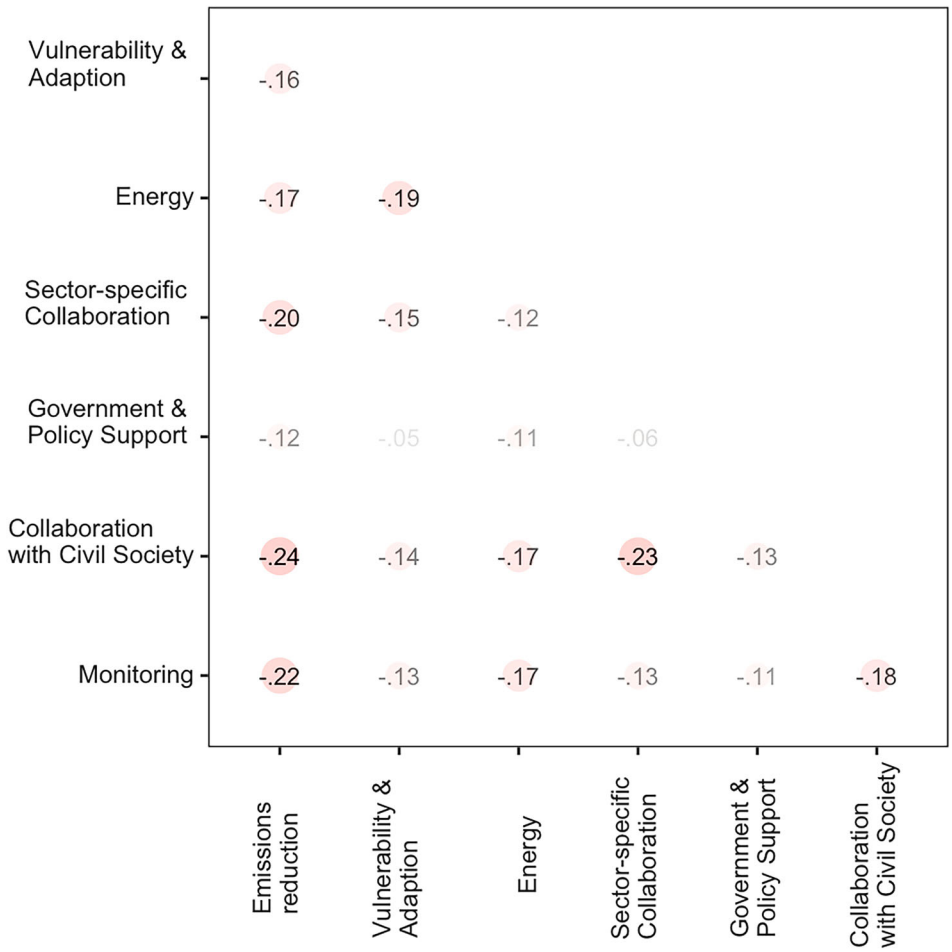

Figure 3. Correlation matrix for NSA topics in country NDCs.

> In acknowledgement of their significant roles in adaptation, subnational and local governments are mandated to develop their own action plans for climate change adaptation tailored to the local context. While implementing sectoral measures for mitigation, Korea established a domestic measurement reporting and verification system to monitor businesses with large amounts of greenhouse gas emissions in the industry, power generation, building and transport sectors.

Additionally, we observe weak trade-offs in monitoring and emissions reduction ($R^2 = -0.22$), *sector-specific collaboration* and emissions reduction ($R^2 = -0.20$).

5. Discussion

As a first step towards better understanding linkages between NDCs and NSAs, this analysis identifies discrete functions (i.e. topics) that national governments mention in the context of NSAs. The frequency with which these topics appear through the 147 NDCs evaluated vary according to levels of economic development: developed countries, developing countries, or LDCs. There is also evidence of complementarity with respect to some of these topics in developed countries' NDCs, and trade-offs between topics in developing countries and LDCs.

The results find that the majority of developed countries do not mention NSAs in their NDCs. The final corpus drawing from 147 NDCs is biased towards developing countries, which mention NSAs at a much higher frequency than developed countries. Other studies suggest most NSA climate action is recorded in developed countries, rather than in developing countries, due to greater capacity of NSAs in developed countries to participate in global climate action networks (e.g. Chan, Ellinger, & Widerberg, 2018; Hsu et al., 2018). However, our finding is perhaps unsurprising, given the variable nature of the NDCs and their focus on countries' mitigation plans (Pauw et al., 2017). There was also disagreement about the handling of NSAs in the negotiations leading up to the Paris Agreement (Chan et al., 2014). Countries including China, Brazil, India, and South Africa cautioned that NSA efforts 'must not distract' from and 'can't substitute for the core actions' of national climate efforts, particularly from developed countries (Statement on Behalf of BASIC, 2014, pp. 2–3). This tension may have resulted in some developed countries excluding any mention of NSAs in their NDCs altogether, to avoid accusations of using NSA efforts to weaken or replace their own efforts, and instead focusing on defending the fairness and ambition of their targets.

The gap between the focus and patterns of actual NSA actions, and their mention in NDCs suggests several possible explanations. Omission of NSAs in the NDCs could be a deliberate choice on the part of governments; after all, the limited NDC guidance provided to countries makes no mention of NSAs (Mbeva & Pauw, 2016). Although the Lima Call to Climate Action (UNFCCC, 2014), which set the ground rules for how countries submit their NDCs, mentions the 'meaningful and regular' engagement of 'civil society, indigenous peoples, women, youth, academic institutions, the private sector, and subnational authorities […]' (paragraph 19(iv)), it neither specifies how this should be achieved nor requires their inclusion in NDC submissions. It is not too surprising, therefore, that many NDCs, particularly those from developed countries, fail to mention these actors' role in helping to achieve mitigation, adaptation or financing goals.

Conversely, this gap could suggest greater opportunity for countries to explicitly draw upon NSAs in their NDCs. By drawing on NSA efforts in their NDCs, developed countries could send a positive signal both to NSAs and other governments to ramp up efforts and incentivise efforts by new actors. Recent studies suggest that countries can be more proactive in setting up mechanisms and platforms to harness the potential of NSAs, for instance by facilitating dialogue and knowledge exchange (see: Chan et al., 2018; Hale & Roger, 2014). Countries such as Sweden, Spain and Argentina are experimenting with strategies to support the implementation of current NSA commitments and encourage new actors to take climate action. Reinforcing and reiterating such actions in the upcoming revision of NDCs could improve the link between NSAs and national governments and inspire other governments to engage with NSAs.

We found wide variation in the breadth and depth of NSA engagement within a single topic when examining sample texts associated with each topic. While many countries mention the inclusion of stakeholder consultations with NSAs while formulating their NDC (e.g. Pauw et al., 2016), others describe efforts to build frameworks that foster continued collaboration. Costa Rica's NDC, for instance, notes the creation of a permanent forum for civil society and private sector engagement designed to 'provide continuity to subjects and

workgroups emerging from the sectoral forums in climate change' (Government of Costa Rica, 2015; p. 9). Morocco's NDC describes the creation of a national platform and competence centre 'to systematically assess, document and disseminate successful measures already in place', share examples of good practice, and document 'detailed information about methodologies, costs and results' from a variety of national, non-state and international partners (Morocco, 2015, p. 9). This range is partly due to the STM method's limitations with respect to the overall number of topics identified. Selecting more topics would have narrowed the variation of text within the topics, but would have also obscured its comparison.

The topic analysis did not reveal evidence supporting theoretical arguments that national actors consider NSAs in the context of enhancing ambition. There could be several reasons for this finding. As previously mentioned, countries were given limited guidance for NDC formulation and NSAs were not explicitly mentioned (Mbeva & Pauw, 2016). Another is methodological: for instance, it may be more challenging for quantitative text analysis methods to capture the range of semantic phrases and functions that may be thought of and classified as 'enhancing ambition'. Future research should track if and how national engagement of NSAs progresses towards enhanced ambition in terms of mitigation and adaptation. It may be particularly interesting to monitor changes in countries that do not mention NSAs in their NDCs, such as many developed countries. This type of engagement would help nations meet the Paris Agreement's ambition mechanisms, in particular, the 2020 update of NDCs and the 2023 Global Stocktake. Lastly, expanding the document corpus to include a broader range of national climate policy documents – such as Biennial Reports and Biennial Update Reports – may yield different results that could suggest countries are engaging with NSAs in the context of enhanced ambition.

Finding evidence of interactive effects among NSA and national efforts is more challenging than identifying the functions NSAs could serve. The relative lack of information on national and NSA engagement makes it necessary to rely on proxies, such as the topics and functions we trace here, that can indicate a range of different levels of interaction. It would be valuable to compare the functions that NSAs are best suited to offer with the functions featured most prominently across NDCs. Over time, strengthening data collection and reporting, policy examples, and higher ambition functions could help governments draw concretely upon NSAs to play a more active role in updating targets. Accounting for these commitments could help governments incorporate existing NSA action into their reporting systems, building partnerships to implement specific efforts.

There are methodological limitations to consider with respect to the STM method. The primary limitation is a reliance on the 'bag of words' approach, where the ordering of words within a document is discarded. This methodological choice prevents the researcher from understanding differences in how topics are discussed and whether they are viewed positively or negatively. In other words, the connotative context of the words is ignored, severely limiting attempts to understand positive or synergistic versus negative or disruptive linkages between national actors and NSAs. Neural word embeddings, such as Word2vec, have attempted to overcome this limitation by using a skip-gram approach where word order is maintained to predict the probability a given word appears in the context of other words. These methods, however, do not allow researchers to discover latent or hidden topics (Mikolov, Yih, & Zweig, 2013). The section and context within an NDC is also an important factor that would help further understanding of how countries link to NSAs, whether they are mentioned generally in an NDC's introduction or in a specific section, such as adaptation or mitigation strategy. Another limitation is that the STM method is a wholly 'unsupervised' classification technique; researchers do not provide input to 'train' the algorithm, which, as discussed above, could also be considered a strength (Denny & Spirling, 2018).

6. Conclusions and future challenges

This paper provides an empirical analysis of the linkages between NSAs and national governments in a multilevel climate governance system, using a novel method of quantitative text analysis. NDCs under the Paris Agreement provide some indication of how national governments view the roles and functions of NSAs: primarily as facilitating vulnerability and adaptation efforts, implementing climate policy and collaboration, and bolstering monitoring capacity. Reviewing these linkages, however, provides less insight as to whether they

align and produce coherence within the polycentric post-Paris governance system. This blind-spot is mainly the result of our dataset's limitations: NDCs reflect national governments' perspectives on NSA-country collaboration. Additional research that evaluates how NSAs themselves view their roles in relation to national actors may complement the analysis presented in this paper.

Through ongoing consultative policy cycles that seek to engage NSAs, such as the Talanoa Dialogue, national governments will have more opportunities to consider NSAs' potential contributions to, for example, the setting of targets or the inclusion of sectors when updating NDCs. Understanding where gaps exist and where there are missing linkages could facilitate dialogue and knowledge exchange between governments and NSAs to increase NDC ambitions and support NDC implementation.

Notes

1. Countries submitted their intended NDCs (INDCs) in the run-up to the Paris Conference. These are then confirmed by countries as they join the Paris Agreement, thereby becoming simply NDCs.
2. UNFCCC. NDC Registry (interim). (2018). Available online at: http://www4.unfccc.int/ndcregistry/Pages/All.aspx. (accessed January 31, 2018).
3. See https://www.ranks.nl/stopwords for a list of common stopwords.
4. Special characters refer to characters that are neither a letter, number, symbol, nor a punctuation mark, such as an accent mark.

Acknowledgements

We'd like to thank Willie Khoo (Yale-NUS College '17) for valuable assistance in initial research; Udit Jain (Yale College '18) and Kaiyang Xu (Yale MEM '16), for assistance in an earlier draft of this paper; and Aadit Gupta (Yale-NUS College '19), and Diego Manya (Yale MEM'18), for translation assistance. Thomas Hale, Associate Professor of Global Public Policy at Oxford University; Shikha Bhasin, Programme Lead at the Council on Energy, Environment and Water; and Harro van Asselt, Professor of Climate Law and Policy with the University of Eastern Finland Law School, and a Senior Research Fellow with the Stockholm Environment Institute, provided comments on an earlier version of this draft. We wouldd also like to thank the Galvanizing the Groundswell of Climate Action network, the International Studies Association (ISA) 2016 panel on Non-State Climate Action, and Bonn workshop participants for their valuable feedback and comments on an earlier version of this paper. Thanks also to editor Joanna Depledge, Fellow at the University of Cambridge Centre for Environment, Energy and Natural Resource Governance, guest editor Pieter Pauw, Frankfurt School of Finance and Management, and several anonymous reviewers for valuable feedback on the paper.

Disclosure statement

No potential conflict of interest was reported by the authors.

ORCID

Angel Hsu http://orcid.org/0000-0003-4913-9479
Oscar Widerberg http://orcid.org/0000-0002-8088-3709
Sander Chan http://orcid.org/0000-0001-7852-3838

References

Abbott, K. W., Green, J. F., & Keohane, R. O. (2016). Organizational ecology and institutional change in global governance. *International Organization*, *70*(2), 247–277.

Andonova, L. B., Hale, T. N., & Roger, C. B. (2017). National policy and transnational governance of climate change: Substitutes or complements? *International Studies Quarterly*, *61*(2), 253–268.

Arroyo, V. (2018). The global climate action summit: Increasing ambition during turbulent times. *Climate Policy*, *18*(9), 1087–1093. doi:10.1080/14693062.2018.1516957

Betsill, M., Dubash, N. K., Paterson, M., van Asselt, H., Vihma, A., & Winkler, H. (2015). Building productive links between the UNFCCC and the broader global climate governance landscape. *Global Environmental Politics*, *15*(2), 1–10.

Biermann, F., Pattberg, P., Van Asselt, H., & Zelli, F. (2009). The fragmentation of global governance architectures: A framework for analysis. *Global Environmental Politics*, *9*(4), 14–40.

Blei, D. M., Ng, A. Y., & Jordan, M. I. (2003). Latent dirichlet allocation. *Journal of Machine Learning Research*, *3*(Jan), 993–1022.

Blok, K., Höhne, N., van der Leun, K., & Harrison, N. (2012). Bridging the greenhouse-gas emissions gap. *Nature Climate Change*, *2*, 471–474.

Broekhoff, D., Erickson, P., & Lee, C. M. (2015). What cities do best: Piecing together an efficient global climate governance. Stockholm Environment Institute Working Paper 2015-15.

Bulkeley, H., & Castán Broto, V. (2013). Government by experiment? Global cities and the governing of climate change. *Transactions of the Institute of British Geographers*, *38*(3), 361–375.

Chan, S., Brandi, S., & Bauer, C. (2015). Aligning transnational climate action with international climate governance: The road from Paris. *Review of European Comparative International Environmental Law (RECIEL)*, *25*(2), 238–247.

Chan, M., de Souza, P., Hale, T., Lang, A., McCoy, D., St. John, S., & Weigum, N. (2014). UNFCCC parties and observers' views on sub/non-state actions and cooperative initiatives. Memo prepared for workshop on "Designing a global platform for climate actions," Oxford, July 24–25, 2014. Retrieved from https://studylib.net/doc/6817570/appendix-one–party-and-observer-statements

Chan, S., Ellinger, P., & Widerberg, O. (2018). Exploring national and regional orchestration of non-state action for a <1.5 C world. *International Environmental Agreements: Politics, Law and Economics*, *18*(1), 135–152.

Chan, S., Falkner, R., Goldberg, M., & van Asselt, H. (2015). Strengthening non-state climate action: A progress assessment of commitments launched at the 2014 UN climate summit. Centre for Climate Change Economics and Policy Working Paper London, Centre for Climate Change Economics and Policy, Grantham Research Institute on Climate Change and the Environment, German Development Institute. 242: 53.

Chan, S., Falkner, R., Goldberg, M., & van Asselt, H. (2016). Effective and geographically balanced? An output-based assessment of non-state climate actions. *Climate Policy*, *18*(1), 1–12.

Cunliffe, G., Holz, C., Mbeva, K., Pauw, P. W., & Winkler, H. (2019). *Comparative analysis of the NDCs of Canada, the European Union, Kenya and South Africa from an equity perspective*. Cape Town: Energy Research Centre, University of Cape Town.

Data Driven Yale, NewClimate Institute, PBL. (2018). Global climate action of regions, states and businesses. Retrieved from http://bit.ly/yale-nci-pbl-global-climate-action.

Denny, M. J., & Spirling, A. (2018). Text preprocessing for unsupervised learning: Why it matters, when it misleads, and what to do about it. *Political Analysis*, *26*(2), 168–189.

Falkner, R. (2016). The Paris agreement and the new logic of international climate politics. *International Affairs*, *92*(5), 1107–1125.

Government of Costa Rica Ministry of Environment and Energy. (2015). Estimated and determined contribution at the national level of Costa Rica.

Hale, T. (2016). "All hands on deck": The Paris Agreement and Nonstate climate action. *Global Environmental Politics*, *16*(3), 12–22.

Hale, T., & Roger, C. (2014). Orchestration and transnational climate governance. *The Review of International Organizations*, *9*(1), 59–82.

Hong, L., & Davison, B. D. (2010, July). Empirical study of topic modeling in twitter. In *Proceedings of the first workshop on social media analytics* (pp. 80–88). New York: ACM.

Hsu, A., Höhne, N., Kuramochi, T., Roelfsema, M., Weinfurter, A., Xie, Y., … Widerberg, O. (2019). Defining a research roadmap for quantifying Non-state and subnational climate action. *Nature Climate Change*, *9*, 1–17.

Hsu, A., Moffat, A. S., Weinfurter, A. J., & Schwartz, J. D. (2015). Towards a new climate diplomacy. *Nature Climate Change*, *5*(6), 501–503.

Hsu, A., Weinfurter, A. J., & Xu, K. (2017). Aligning subnational climate actions for the new post-Paris climate regime. *Climatic Change*, *142*(3-4), 419–432.

Hsu, A., Widerberg, O., Weinfurter, A., Chan, S., Roelfsema, M., Lütkehermöller, K., & Bakhtiari, F. (2018). Bridging the emissions gap - The role of non-state and subnational actors. In The Emissions Gap Report 2018. A UN Environment Synthesis Report. United Nations Environment Programme. Nairobi.

Ivanova, M., & Roy, J. (2007). The architecture of global environmental governance: Pros and cons of multiplicity. *Global Environmental Governance: Perspectives on the Current Debate*, 48–66.

Jacobs, M. (2016). High pressure for low emissions: How civil society created the Paris climate agreement. *Juncture*, *22*(4), 314–323.

King, G., & Lowe, W. (2003). An automated information extraction tool for international conflict data with performance as good as human coders: A rare events evaluation design. *International Organization*, *57*(3), 617–642.

Mbeva, K., & Pauw, P. (2016). Self-differentiation of countries' responsibilities: Addressing climate change through intended nationally determined contributions. German Development Institute (DIE) Discussion Paper. Retrieved from https://www.die-gdi.de/uploads/media/DP_4.2016.pdf

Mikolov, T., Yih, W. T., & Zweig, G. (2013). Linguistic regularities in continuous space word representations. In *Proceedings of the 2013 conference of the North American Chapter of the Association for Computational Linguistics: Human Language Technologies* (pp. 746–751).

Mildenberger, M., & Tingley, D. (2017). Beliefs about climate beliefs: The importance of second-order opinions for climate politics. *British Journal of Political Science*, 1–29.

Morocco. (2015). Intended nationally determined contribution (INDC) under the UNFCCC.

Oberthür, S., & Gehring, T. (2006). Institutional interaction in global environmental governance: The case of the Cartagena Protocol and the world trade organization. *Global Environmental Politics*, *6*(2), 1–31.

Pattberg, P. H., Biermann, F., Chan, S., & Mert, A. (Eds.). (2012). *Public-private partnerships for sustainable development: Emergence, influence and legitimacy*. Cheltenham: Edward Elgar Publishing.

Pauw, W. P., Cassanmagnano, D., Mbeva, K., Hein, J., Guarin, A., Brandi, C., … Muhammad, D. (2016). NDC explorer. German Development Institute / Deutsches Institut für Entwicklungspolitik (DIE), African Centre for Technology Studies (ACTS), Stockholm Environment Institute (SEI). doi:10.23661/ndc_explorer_2017_2.0.

Pauw, W. P., Castro, P., Pickering, J., & Bhasin, S. (2019). Conditional nationally determined contributions in the Paris Agreement: foothold for equity or Achilles heel? *Climate Policy*, doi:10.1080/14693062.2019.1635874

Pauw, W. P., Klein, R. J., Mbeva, K., Dzebo, A., Cassanmagnago, D., & Rudloff, A. (2018). Beyond headline mitigation numbers: We need more transparent and comparable NDCs to achieve the Paris Agreement on climate change. *Climatic Change*, *147*(1-2), 23–29.

Pauw, P., Mbeva, K., & Dzebo, A. (2017). Why data access matters: the NDC explorer reveals new insights on climate action plans. German Development Institute/Deutsches Institut für Entwicklungspolitik (DIE). Retrieved from https://www.die-gdi.de/en/the-current-column/article/why-data-access-matters-the-ndc-explorer-reveals-new-insights-on-national-climate-action-plans/

Roberts, M. E., Stewart, B. M., Tingley, D., Lucas, C., Leder-Luis, J., Gadarian, S. K., & Rand, D. G. (2014). Structural topic models for open-ended survey responses. *American Journal of Political Science*, *58*(4), 1064–1082.

Rogelj, J., Den Elzen, M., Höhne, N., Fransen, T., Fekete, H., Winkler, H., … Meinshausen, M. (2016). Paris Agreement climate proposals need a boost to keep warming well below 2°C. *Nature*, *534*(7609), 631–639.

Statement on Behalf of BASIC. (2014, June 4). Opening plenary of the Ad Hoc working group on the Durban platform for enhanced action. Retrieved from http://unfccc.int/files/documentation/submissions_from_parties/adp/application/pdf/adp2-5_statement_by_india_on_behalf_of_basic_20140604.pdf

Stokke, O. S. (2001). *The interplay of international regimes: Putting effectiveness theory to work*. (*FNI report*, 14, 2001).

Tvinnereim, E., Fløttum, K., Gjerstad, Ø, Johannesson, M. P., & Nordø, ÅD. (2017). Citizens' preferences for tackling climate change. Quantitative and qualitative analyses of their freely formulated solutions. *Global Environmental Change*, *46*, 34–41.

UNFCCC. NDC Registry (interim). (2018). Retrieved from http://www4.unfccc.int/ndcregistry/Pages/All.aspx.

United Nations Environment Programme (UNEP). (2018). The emissions gap report 2018. Retrieved from http://web.unep.org/emissionsgap/

United Nations Framework Convention on Climate Change (UNFCCC). (2014). Decision 1/CP.20 Lima call for climate action. In Report of the Conference of the Parties on its twentieth session, held in Lima from 1 to 14 December 2014. Addendum. Part two: Action taken by the Conference of the Parties at its twentieth session. Retrieved from https://unfccc.int/sites/default/files/resource/docs/2014/cop20/eng/10a01.pdf

United Nations Framework Convention on Climate Change (UNFCCC). (2016). Climate action now. Summary for Policy Makers 2016, Bonn, Germany. Retrieved from https://unfccc.int/sites/default/files/unfccc_spm_2016.pdf

United Nations Framework Convention on Climate Change (UNFCCC). (n.d.-a). Parties & Observers. Retrieved from https://unfccc.int/parties-observers

United Nations Framework Convention on Climate Change (UNFCCC). (n.d.-b). Reporting requirements. Retrieved from https://unfccc.int/process-and-meetings/transparency-and-reporting/reporting-and-review-under-the-convention/greenhouse-gas-inventories-annex-i-parties/reporting-requirements

United States Environmental Protection Agency (US EPA). (2018, 2 April). EPA administrator Pruitt: GHG emissions standards for cars and light trucks should be revised. Retrieved from: https://www.epa.gov/newsreleases/epa-administrator-pruitt-ghg-emissionsstandards-cars-and-light-trucks-should-be

Van Asselt, H. (2014). *The fragmentation of global climate governance: Consequences and management of regime interactions*. Cheltenhem: Edward Elgar Publishing.

Widerberg, O. (2014). Mapping institutions and actors in global climate governance: A network approach. *ECPR General Conference* (pp. 3–6).

Widerberg, O. (2017). The 'black box' problem of orchestration: How to evaluate the performance of the Lima-Paris action agenda. *Environmental Politics*, *26*(26), 715–737.

Young, O. R. (1996). Institutional linkages in international society: Polar perspectives. *Global Governance*, *2*, 1–24.

Zhang, Y., Jin, R., & Zhou, Z. H. (2010). Understanding bag-of-words model: A statistical framework. *International Journal of Machine Learning and Cybernetics*, *1*(1-4), 43–52.