

Analysing national climate change-related documents: Spatial and temporal dimensions worldwide *

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Keywords:

climate change,
mitigation,
adaptation,
spatial distribution,
temporal distribution

The effects of climate change are wide-ranging and exacerbate existing environmental and social challenges. The Climate Change Strategies of the World's Countries geodatabase, developed for the present study, comprises national-level data on the climate change-related documents of 199 countries worldwide, which were grouped into types according to their fields of application. Furthermore, four categories were created based on these types. Spatial and temporal analyses of the distribution of documents were conducted to examine their specifics. A total of 300 documents were identified, comprising complex- (50%), adaptation- (32%), and mitigation-type (18%) documents. Although first mitigation- and adaptation-type documents appeared as early as the 1990s, a significant increase in their number occurred only in the early 2000s; first complex-type documents were created around the same time. Complex-type documents were found to occur more frequently; however, the spatial distribution of categories across continents reflected varying perspectives.

Introduction

Climate change has emerged as one of the greatest problems of the 21st century. According to numerous publications and the latest report of the Intergovernmental Panel on Climate Change (IPCC), significant anthropogenic greenhouse gas emissions (primarily CO₂) are responsible for global warming (Shine et al. 2005, Eby et al. 2009, Allen et al. 2009, Zickfeld et al. 2012, IPCC 2014, Alcaraz et al. 2019). The IPCC (2014) emphasises that the effects of climate change are wide-ranging and intensify pre-existing environmental and social problems. The effects differ across

* The study examines the territorial distribution in 2018.

geographies and levels of development (Akerlof et al. 2013, Arnell et al. 2019, Benzie et al. 2019), and countries are subject to varying degrees of vulnerability (Hamilton–Keim 2009, Wang et al. 2016). Numerous reports suggest that the least-developed countries (Gebreyes et al. 2017, Gwimbi 2017, Said et al. 2019, Jiao et al. 2020) and the Small Islands Developing States (Ourbak–Magnan 2018, Thomas–Benjamin 2018, Monioudi et al. 2018) are most affected by the adverse effects of climate change, such as a rise in the sea level and average temperature, drought, and water scarcity. These countries have a higher probability of experiencing climate change-induced economic losses compared with developed countries (Oztig 2017).

There are two separate approaches to tackling climate change: mitigation and adaptation, which differ spatially and temporally (Baum–Easterling 2010, Locatelli et al. 2016). The widespread use of geodatabases facilitates spatial and temporal data visualisation in spatial research (Zichar–Tóth 2011, Balla et al. 2020, Kincses–Tóth 2020, Péntzes 2020, Elekes–Szilágyi 2021, Papp et al. 2021, Sruthi Krishnan–Mohammed Firoz 2021, Uzzoli et al. 2021). Mitigation is often accomplished at the international or national levels, and its benefits are global. In contrast, adaptation measures are primarily local or regional, providing benefits at both the local and national levels. Both top-down and bottom-up measures are possible within the spatial approach (Biesbroek et al. 2009, Martens et al. 2009, van Vuuren et al. 2011, Moser 2012, Locatelli et al. 2016). Climate modelling forecasts advise the immediate execution of mitigation measures (Kovács 2015) that may be short-, medium-, and long-term but are necessary for achieving long-term goals. Adaptive measures can provide short-term solutions for society. However, the accomplishment of certain measures requires time and provides long-term benefits (e.g. energy saving projects). Adaptation strategies are mostly reactive, whereas mitigation strategies are proactive and aim at avoiding long-term negative climatic impact (Biesbroek et al. 2009, Martens et al. 2009, van Vuuren et al. 2011, Moser 2012, Locatelli et al. 2016).

Climate change-related documents at the national level can target either mitigation or adaptation measures; they may also be complex plans targeting both simultaneously (Göpfert et al. 2019). It is essential to implement and periodically revise national climate change documents for effective mitigation (Koch 2010, Zhao 2015) and adaptation (Ford–Berrang-Ford 2016). Successful climate policy-making is a delicate combination of mutually complementary mitigation and adaptation efforts to address climate change (Biesbroek et al. 2009, Laukkonen et al. 2009).

Compliance with the landmark Paris Agreement – a legally binding global agreement that came into force on November 4, 2016 – can only be achieved through more ambitious efforts (Doelle 2016, Johansson et al. 2015, Holman et al. 2019, Jonas–Żebrowski 2019). The convention does not outline specific values or recommend strategies to achieve the results (Groot–Swart 2018), instead emphasising the participating countries' voluntary commitments (Cléménçon 2016, Höhne et al. 2017, Oztig 2017, Jernnäs–Linnér 2019). Its successful implementation requires the

further reduction of national-level greenhouse gas (GHG) emissions by the signatories (Pauw et al. 2018, Ogunbode et al. 2019) and more numerous climate change adaptations (Lesnikowski et al. 2017, Ray et al. 2017). However, there are significant differences between countries' GHG emissions, their objectives, and the measures intended to reduce such emissions. In terms of total GHG emissions (kt CO₂ equivalent), the three largest emitters in 2012 were China (12,454,711), the United States of America (US; 6,343,841), and India (3,002,895), according to World Bank data [1], although the Kyoto Protocol has not been ratified by either country [2]; in 2019, the US also announced its withdrawal from the Paris Agreement effective 2020 onwards [3]. Nevertheless, there has been a positive trend in the efforts of China and India towards addressing climate change, as indicated by their respective national climate change strategies (Oberheitmann 2010, Johansson et al. 2015, Jørgensen et al. 2015, Liu et al. 2020, Long et al. 2020, Mi et al. 2017). In the US, there are no documents at the national level; however, several subnational governments have set ambitious climate change policy targets (Hogan 2008, Lutsey–Sperling 2008, Schreurs 2008, Fisher 2013). The European Union (EU), as a collective unit, was the third-largest emitter in the world in 2012 [1]. The EU plays a key role in shaping the world's climate policy (Jagers et al. 2020, Hoerber et al. 2021a, 2021b), and its mitigation objectives are the most ambitious globally ([4], Oberthür–Groen 2017, Stoczkiewicz 2018).

In this context, this study aims to emphasise the importance of the fight against climate change at the national level, in addition to the global level. We also provide an overview of the specifics of existing national climate change documents. This study analysed the climate change-related documents of various countries and typified them according to their field of application (adaptation, mitigation, or complex). Furthermore, the spatial distributions of documents in various countries were evaluated by continent, followed by an examination of the temporal patterns of the documents and their specific characteristics. Notwithstanding similar studies related to climate change and environmental protection that have previously been published (e.g. UNFCCC National Inventory Submissions [5], WWF's Living Planet Report [6]), the classification of climate documents at the national level and the evaluation of the spatial and temporal differences within them is a novel contribution of this study.

Materials and methods

Data collection and description of geodatabases

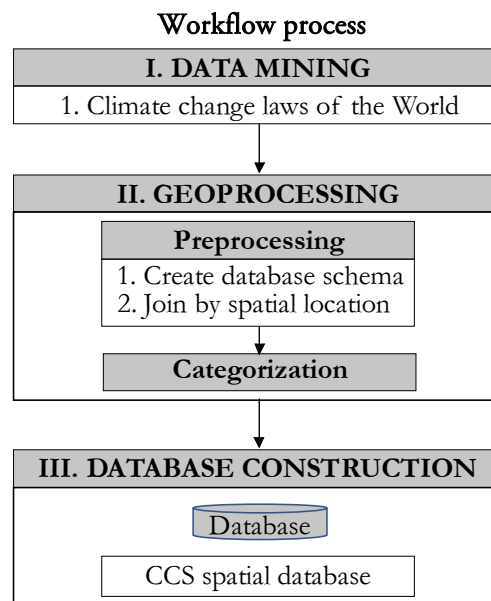
A geodatabase was specifically developed for this study. First, climate change-related documents were selected by country from the Climate Change Laws of the World [7] database. Data from February 2019 for 199 countries were downloaded and analysed. Second, the documents were grouped according to their field of application as follows: adaptation; mitigation; or complex (both adaptation and mitigation aims appear in one document). Each document was assigned to a kind; 12 potential kinds

were identified: accord; act; decree; framework; law; plan; policy; programme; resolution; roadmap; rule; and strategy. Documents classified into the same group were ordered according to the date of their creation as first, second, or third documents. After grouping, the types associated with the countries were listed and organised into categories: adaptation (only); mitigation (only); complex (either a single document or two separate documents); and N/A (where no documents were found). If a country had adaptation, mitigation, and complex document types or adaptation and mitigation document types, it was classified within the complex category, which represented the highest level. The resulting geodatabase was named Climate Change Strategies of the World's Countries (CCS), ([8], Kiss et al. 2020).

Geoprocessing and statistical analyses

The implementation of geoprocessing involved three steps (Figure 1). Data were collected from the Climate Change Laws of the World, the United Nations Treaty Collection, the World Bank, and the World Factbook web platform (Kiss et al. 2020).

Figure 1



A geodatabase containing a vector file (.shp) of country boundaries was downloaded from Eurostat. Based on the aforementioned classification, arrays were created comprising four classes of climate change documents by country. During geoprocessing, related attribute data from the Eurostat database were connected to the established CCS database by spatial location. Next, for geoinformatics processing, thematic maps were created using ArcMap 10.4.1. Statistical analyses were performed using SPSS22 and MS Excel 2016.

Results and discussion

The spatial dimension of climate change documents

In the first phase of the study, the spatial distributions of climate change documents by type and kind within the continents were analysed. The following document types were identified: first mitigation, second mitigation, third mitigation, first adaptation, second adaptation, first complex, second complex, and third complex.

- Africa

Data from 55 African countries were studied (see Figure A1 in the Appendix). Figure A1/I–VII shows the spatial distribution of the document types and kinds. 22 adaptation- (Figure A1/III–IV) and 38 complex-type (Figure A1/V–VII) documents were identified, whereas no mitigation-type document was found. 30.9% of the countries possessed first adaptation-type documents, whereas second adaptation-type documents were found in 9.1% of the countries. First, second, and third complex-type documents occurred in 49.1, 16.4, and 3.6% of the countries, respectively. 7 of the 12 possible document kinds were found in Africa. Four document kinds were classifiable as adaptation-type documents: decree, plan, programme, and strategy. Programmes were the most frequent (10 documents), with a share of 45.5%. Decrees were the least frequent (two documents), with a share of 9.1%. Six kinds of complex-type documents were identified: law, plan, strategy, policy (which occurs most frequently; 16 documents, i.e. a share of 42.1%), programme, and resolution. The last two were the least frequent (one document each with a share of 2.6%).

- Asia

Data from 44 Asian countries were studied (see Figure A2 in the Appendix). The spatial distributions of document types and their kinds are shown in Figure A2/I–VII. Asia exhibited great diversity, comprising first, second, and third documents. 12 mitigation- (Figure A2/I–II), 18 adaptation- (Figure A2/III–IV), and 33 complex-type (Figure A2/V–VII) documents were identified. First and second mitigation-type documents were found in 18.2 and 9.1% of the countries, respectively. First and second adaptation-type documents were found in 31.8 and 9.1% of the countries, respectively. First and second complex-type documents were found in 50 and 15.9% of the countries, respectively. Third complex-type documents were found in 9.1% of the countries. 10 of the 12 possible document kinds were found for Asia, the highest among the continents. Of the 10 occurring kinds, 6 were observed within mitigation-type documents: decree, law, plan, roadmap, rule, and strategy. Plans occurred the most frequently (five documents, 41.7%); decrees, roadmaps, and rules occurred least frequently, with one document each (a share of 8.3%). Seven kinds of adaptation-type documents were found. Acts, frameworks, and laws occurred least frequently, with only one document each (a share of 5.6%). The

most frequent kind within this type comprised plans, with seven documents (a share of 38.9%), followed by policies, programmes, and strategies. Six kinds of complex-type documents were found: framework, law, plan, policy, programme, and strategy. Plans were the most frequent, with 14 identified documents (a share of 42.4%). Only one document was identified as a framework (a share of 3%).

- Australia and Oceania

Data from 16 countries in Australia and Oceania were studied (see Figure A3 in the Appendix). The spatial distribution and kinds of documents are shown in Figure A3/I–V. 4 mitigation- (Figure A3/I), 14 adaptation- (Figure A3/II), and 19 complex-type (Figure A3/III–V) documents were identified. Although second adaptation-type documents were found in two countries (Marshall Islands and Vanuatu), these have not been illustrated on the map owing to the large geographical distance between them (see Appendix for detailed data on the countries). Mitigation-type documents were found in only 25% of the studied countries. First and second adaptation-type documents were found in 75 and 12.5% of the countries, respectively. First (87.5%), second (25%), and third (6.3%) complex-type documents were found as well. 6 of the 12 possible document kinds were found within the continent, of which 3 were identified as mitigation-type documents: law (two, 50%), act (one, 25%), and strategy (one, 25%). Among adaptation-type documents, five kinds were identified: law, plan, policy, programme, and strategy. Plans comprised 50% of such documents (seven in number). Law and strategy documents ranked the lowest, with one document each (7.1%). Four kinds of complex-type documents were identified: law, plan, policy, and strategy. Of these, 78.9% (15) were policy documents, whereas plan and strategy types had merely one document each (5.3%).

- Europe

Data from 49 European countries were studied (see Figure A4 in the Appendix). The spatial distribution and kinds of document are presented in Figure A4/I–VI. 37 mitigation- (Figure A4/I–II), 29 adaptation- (Figure A4/III–IV), and 20 complex-type (Figure A4/V–VI) documents were identified. First and second mitigation-type documents were found in 51 and 22.4 % of the countries, respectively.

Third mitigation-type documents were found only in Europe – in Norway – and were of the strategy kind. This single document has not been presented on the map (see Appendix for detailed data). First and second adaptation-type documents were found in 44.9% and 14.3% of the countries, respectively. First and second complex-type documents were found in 32.7% and 8.2% of the countries, respectively. 9 of the 12 possible document kinds were identified for Europe, of which 8 were mitigation-type documents: act, decree, law, plan, policy, programme, resolution, and strategy. Law and plan documents had the largest frequencies, comprising nine (24.3%) and eight (21.6%) documents, respectively. The least occurring kinds were

acts, decrees, and resolutions, comprising one document each (2.7%). Of the nine occurring kinds, six were adaptation-type documents: decree, framework, plan, policy, programme, and strategy. The most frequent kind were strategy documents (14 identified documents, 48.3%), whereas decree documents were the least frequent (1 identified document, 3.4%). Furthermore, six of the nine occurring kinds were complex-type documents: law, plan, policy, programme, resolution, and strategy, with laws being the most frequent kind (eight documents, 40%) and policies and programmes being the least frequent kinds (one document each, 5%).

- North and Central America

Data from 23 countries in North and Central America were studied (see Figure A5 in the Appendix). Their spatial distribution and document kinds are presented in Figure A5/I–VI. The results for the region identified 1 mitigation- (Figure A5/I), 10 adaptation- (Figure A5/II–III), and 22 complex-type (Figure A5/IV–VI) documents. The share of mitigation-type documents was 4.3%. First and second adaptation-type documents were found in 34.8 and 8.7% of the studied countries, respectively. First, second, and third complex-type documents were found in 60.9, 26.1, and 8.7% of the countries, respectively. Of the 12 possible kinds, 6 were found in North and Central America. The mitigation-type document was a strategy document; four kinds of adaptation-type documents were found: plan, policy, programme, and strategy. Policy (four documents) and programme (one document) kinds were found in 40 and 10% of the countries, respectively. Five kinds of complex-type documents were identified: decree (two documents, least frequent, 9.1%), law, plan, strategy, and policy (six documents, most frequent, 27.3%).

- South America

Data from 12 South American countries were studied (see Figure A6 in the Appendix). The spatial distribution and document kinds are presented in Figure A6/I–VII. 4 adaptation- (Figure A6/III–IV) and 18 complex-type (Figure A6/V–VII) documents were identified. Mitigation-type documents were not available. Adaptation-type documents were found in 33.3% of the countries. 75, 58.3, and 16.7% of the countries possessed first, second, and third complex-type documents, respectively. 6 of the 12 document kinds were found in South America. Three kinds of adaptation-type documents were found: plan (two documents, 50%) and decree and policy (one document each, 25% each). Six kinds of complex-type documents were found: accord, decree, law, plan, policy, and strategy. Law and strategy documents were the most frequent with four identified documents each (22.2% each), whereas only one accord document was identified (5.6%).

Temporal dimensions of climate change documents

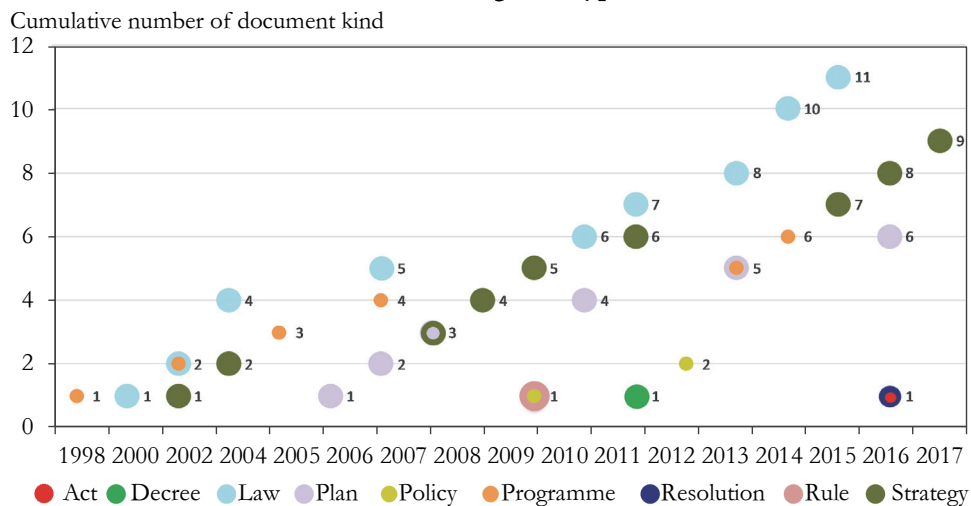
- Mitigation

The second part of the study involved the temporal analysis of the cumulative number of document types. The distribution of first mitigation-type documents is shown in Figure 2 a). 38 documents were identified worldwide, comprising 9 of the 12 possible kinds. The earliest mitigation-type document – of the programme kind – which dates back to 1995, was found in Greece, followed by a Japanese law from 1998. Law documents occurred the most frequently throughout the 22-year interval (28.9%), followed by strategy documents (23.7%). The highest number of issued documents (four) was observed in 2016, an increase of 10.5% compared with the previous year. The distribution of second mitigation-type documents is presented in Figure 2 b). The study identified a total of 15 documents comprising seven kinds. The earliest document, from 2003, was found in Greece and was of the programme kind. Plan documents occurred the most frequently (46.7%) over the 14-year interval. The greatest increase in the number of documents occurred between 2014 and 2016 (26.7%). The highest number of issued documents (four) was observed for 2016. A third mitigation-type document was identified for Norway, dated 2017.

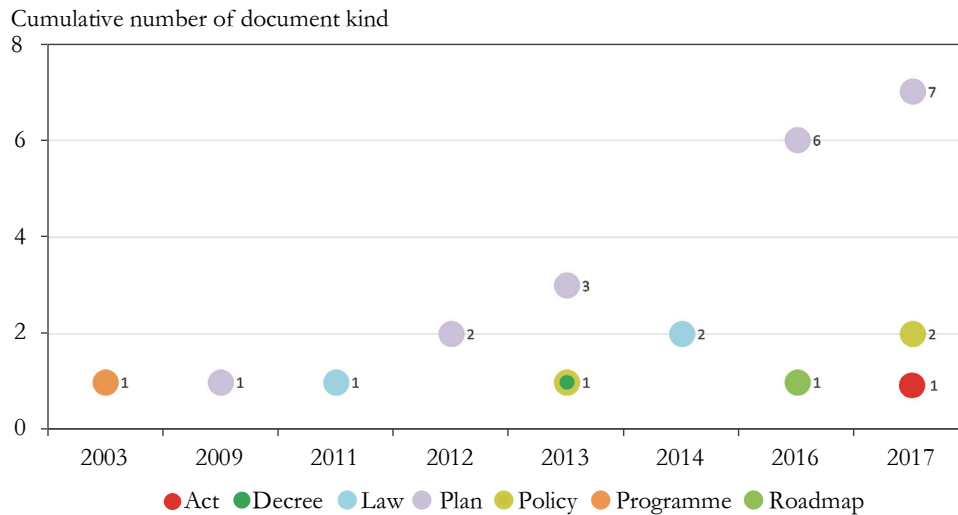
Figure 2

First and second mitigation-type document kinds and their cumulative numbers along a temporal scale

a) First mitigation-type



b) Second mitigation-type



• Adaptation

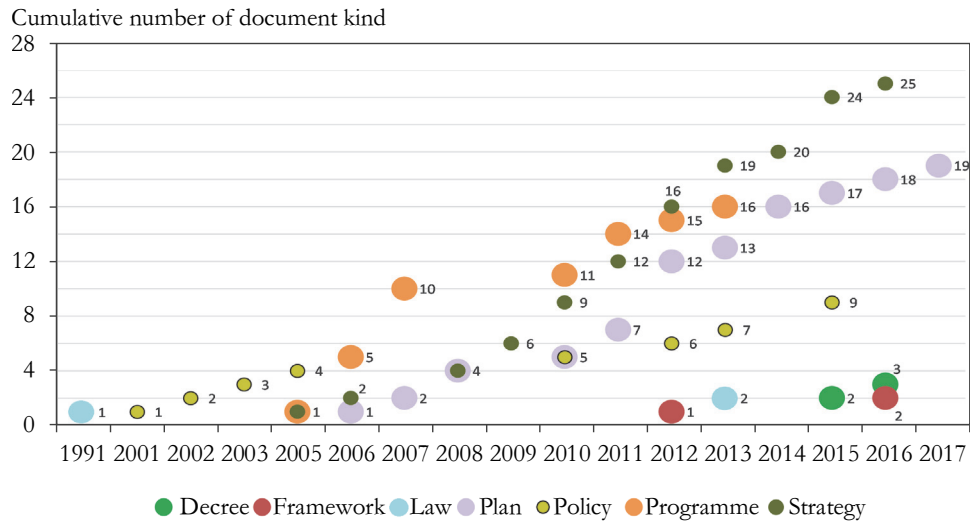
The distribution of first adaptation-type documents is shown in Figure 3 a). A total of 76 documents were identified worldwide across 7 kinds. The earliest document was a New Zealand law dated 1991. No such document was created in the subsequent decade until a policy was issued in Guyana in 2001. Strategy documents occurred the most throughout the 26-year interval (32.9%), followed by plan (25%), and programme (21.1%) documents. The greatest number of issued documents (12) was observed in 2012, representing an increase of 15.8% compared with the previous year.

Figure 3 b) illustrates the distribution of second adaptation-type documents. 20 documents across 7 kinds were found, beginning in 2010 with a plan document in South Korea and two programme documents in Ethiopia and Rwanda, respectively. Plan documents occurred the most frequently throughout the eight-year interval (45%). The greatest increase in the number of issued documents was observed in 2018 (with four issued documents), an increase of 20% compared with 2016.

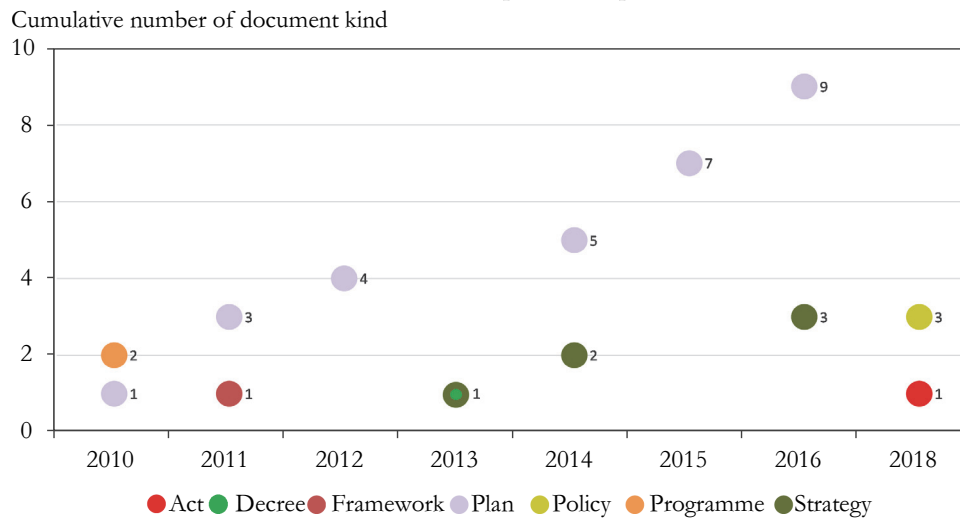
Figure 3

First and second adaptation-type document kinds and their cumulative numbers along a temporal scale

a) First adaptation-type



b) Second adaptation-type



- Complex

The distribution of first complex-type documents is shown in Figure 4 a). A total of 102 documents across 8 kinds were identified. The earliest document was a programme issued by France in 2000, followed by a decree issued by Paraguay in 2001. The most frequent kind over the 18-year interval were policy documents (37.3%), followed by strategy documents (21.6%). The most documents were issued in 2012 (19), representing an increase of 18.6% compared with the previous year.

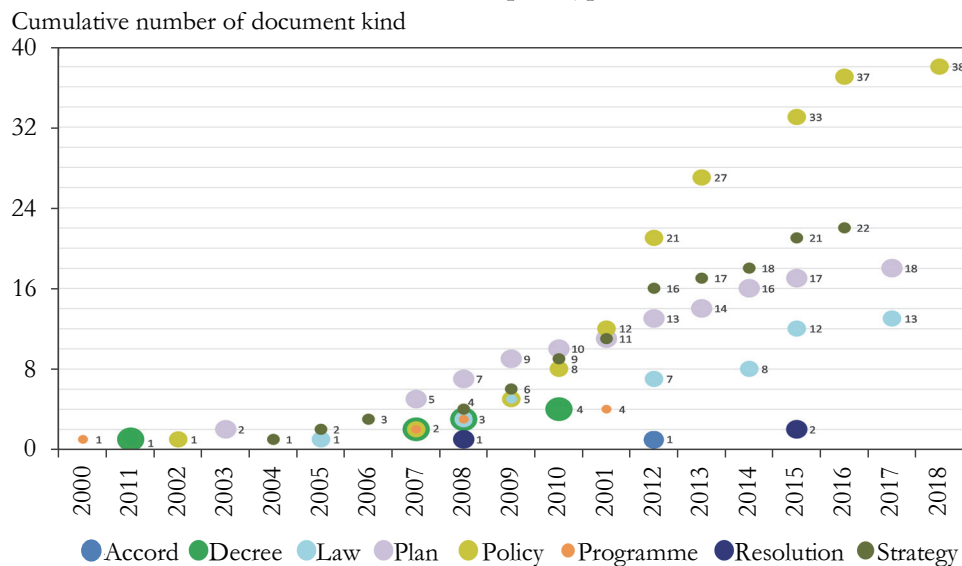
The distribution of second complex-type documents is shown in Figure 4 b). The earliest document, a strategy, was developed by Peru in 2003. Following this, a plan and a policy were created in Chile and China, respectively, in 2008. Plans were the most frequent document kind over the 15-year interval (29.7%), followed by policies (24.3%). The most documents were issued in 2013 (9), representing an increase of 24.3%.

The distribution of third complex-type documents is presented in Figure 4 c). 11 documents were identified and classified into four kinds. The earliest documents, from 2011, were a plan in the Philippines and a policy in South Africa. Plans were the most frequent document kind over the seven-year interval (45.5%). The increase was 18.2% for all years except 2016, with two documents in each year.

Figure 4

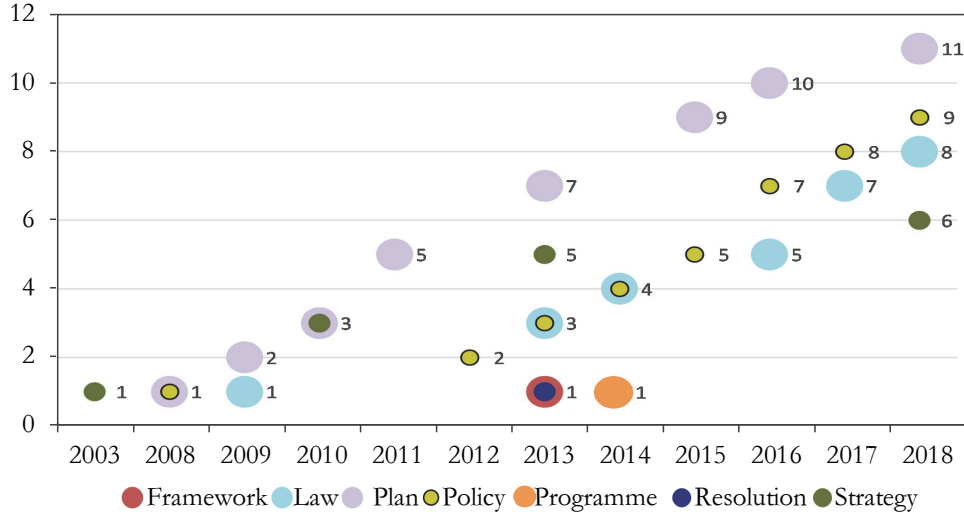
First, second and third complex-type document kinds and their cumulative numbers along a temporal scale

a) First complex-type



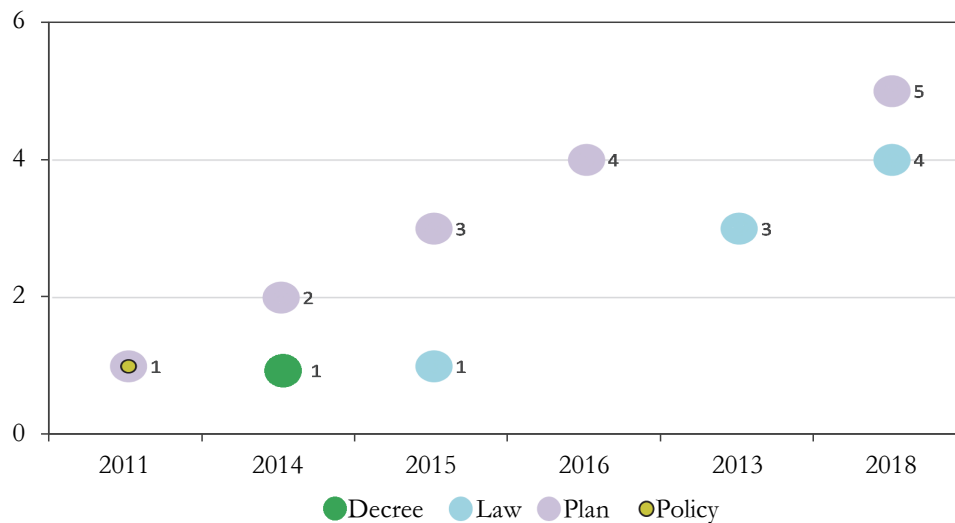
b) Second complex-type

Cumulative number of document kind



c) Third complex-type

Cumulative number of document kind



The results of categorisation: the spatial distribution of climate change document categories worldwide

Following the typification of documents, four categories were identified. The distribution of categories worldwide is shown in Figure 5. The most frequent category was the complex type, with 116 countries (58.29%). This was followed by the N/A

category (where no document was found), with 62 countries (31.16%). The adaptation (only) category included 13 countries (6.53%). The least frequent category was mitigation (only), comprising eight countries (4.02%; Figure 6).

Figure 5

Spatial distribution of the CCS categories worldwide by category

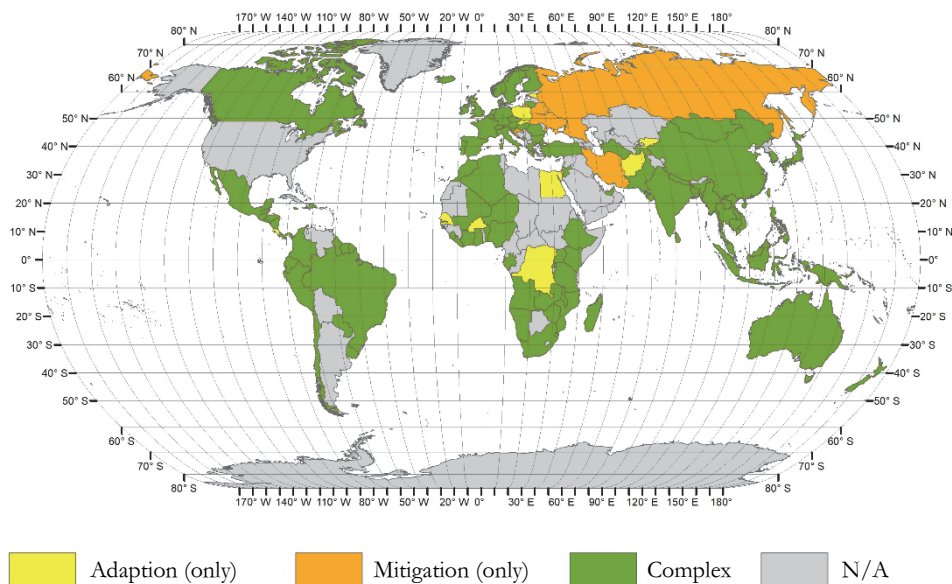


Figure 7 shows the distribution of categories by continent. Of the four possible categories, four occurred in Asia and Europe, three in Africa and North and Central America, and two in Australia, Oceania, and South America. The share of the N/A category was the highest in Africa (43.64%), comprising 24 countries, followed by Asia (36.36%), with 16 countries. The shares of Europe, North and Central America, and South America were 26.53% (13 countries), 26.09% (6 countries), and 25% (3 countries), respectively. No N/A category was found in Australia and Oceania, that is, every country possessed at least one kind of document. The share of the complex-type category was the highest in Australia and Oceania (93.75%, across 15 countries), followed by South America (75%, across 9 countries). The shares were 60.87, 55.10, 54.55, and 49.09% in North and Central America (14 countries), Europe (27 countries), Asia (24 countries), and Africa (27 countries), respectively. The share of the adaptation (only) category was the highest in North and Central America (13.04%, three countries). The mitigation (only) category occurred only in Europe and Asia, with shares of 12.24 and 4.55% (six and two countries), respectively.

Figure 6

Proportion of the CCS categories

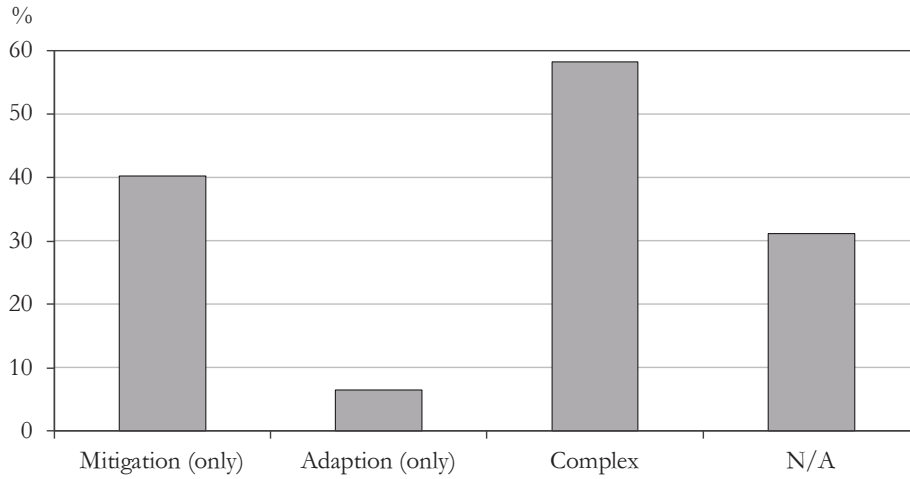
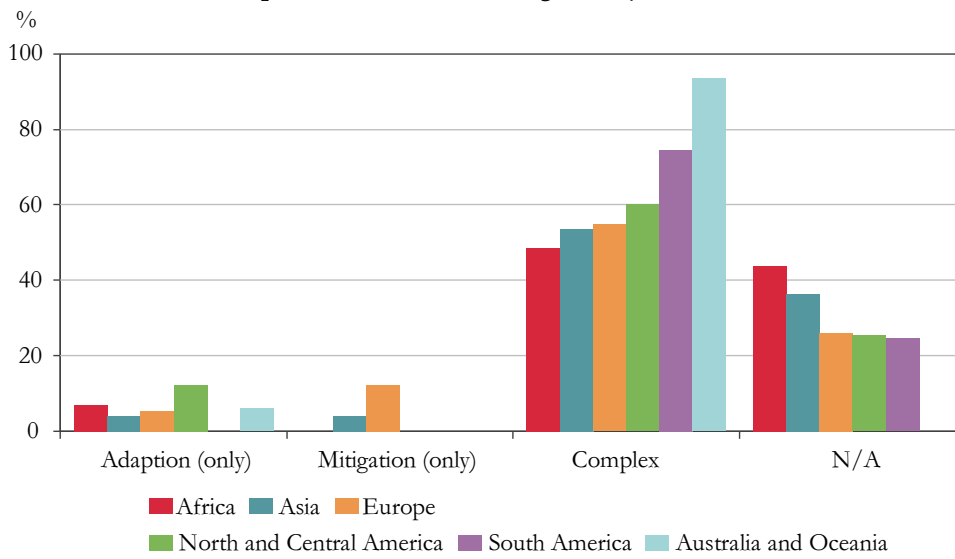


Figure 7

Proportion of the CCS categories by continent



Conclusions

A total of 300 documents related to climate change were identified in this study, of which 50% (150), 32% (96), and 18% (54) were complex-type, adaptation-type, and mitigation-type documents, respectively. Considering their temporal distribution, the first mitigation- and adaptation-type documents were issued in the 1990s; however, their number grew substantially only since the early 2000s, which was when the first complex-type documents were issued as well. The most frequent category of the four was the complex type, with 116 countries yielding a share of 58.29%, followed by the N/A category, in which 62 countries represented a share of 31.16%. The adaptation (only) category included 13 countries with a share of 6.53%. The least frequent category was mitigation (only), comprising eight countries (4.02%). The spatial distribution and diversity of the categories implies the existence of different patterns across continents. Although complex-type documents were found across all continents, the N/A category did not occur in Australia and Oceania, the adaptation (only) category was not found in South America, and the mitigation (only) category was detected primarily in Europe and Asia. Based on evidence from the pioneering Climate Change Strategies of the World's Countries geodatabase, it appears that numerous countries have already made strides in terms of mitigation and adaptation by issuing the relevant documents. Notably, despite the severity of the global climate change problem, many countries still lack appropriate measures to successfully tackle it. According to prognoses, the effects of climate change are likely to become increasingly severe in the future; therefore, a potential increase in the number of documents – especially in countries where they are not currently available – presents avenues for further research in this regard.

Appendix

Figure A1

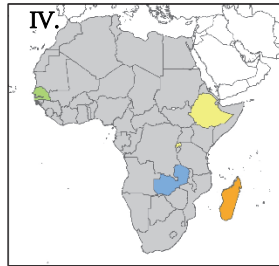
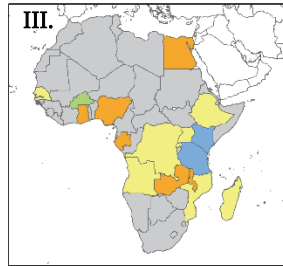
Spatial distribution of climate change documents within Africa by kind

First mitigation document Second mitigation document



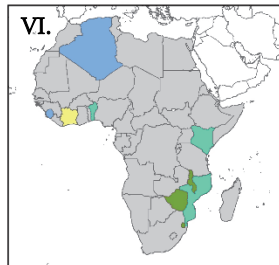
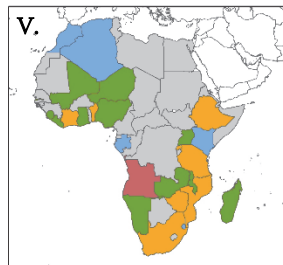
First adaptation document

Second adaptation document



First complex document

Second complex document



Third complex document



Kind of document

- Accord
- Act
- Decree
- Framework
- Law
- Plan
- Policy
- Programme
- Resolution
- Strategy
- N/A

Figure A2

Spatial distribution of climate change documents within Asia by kind

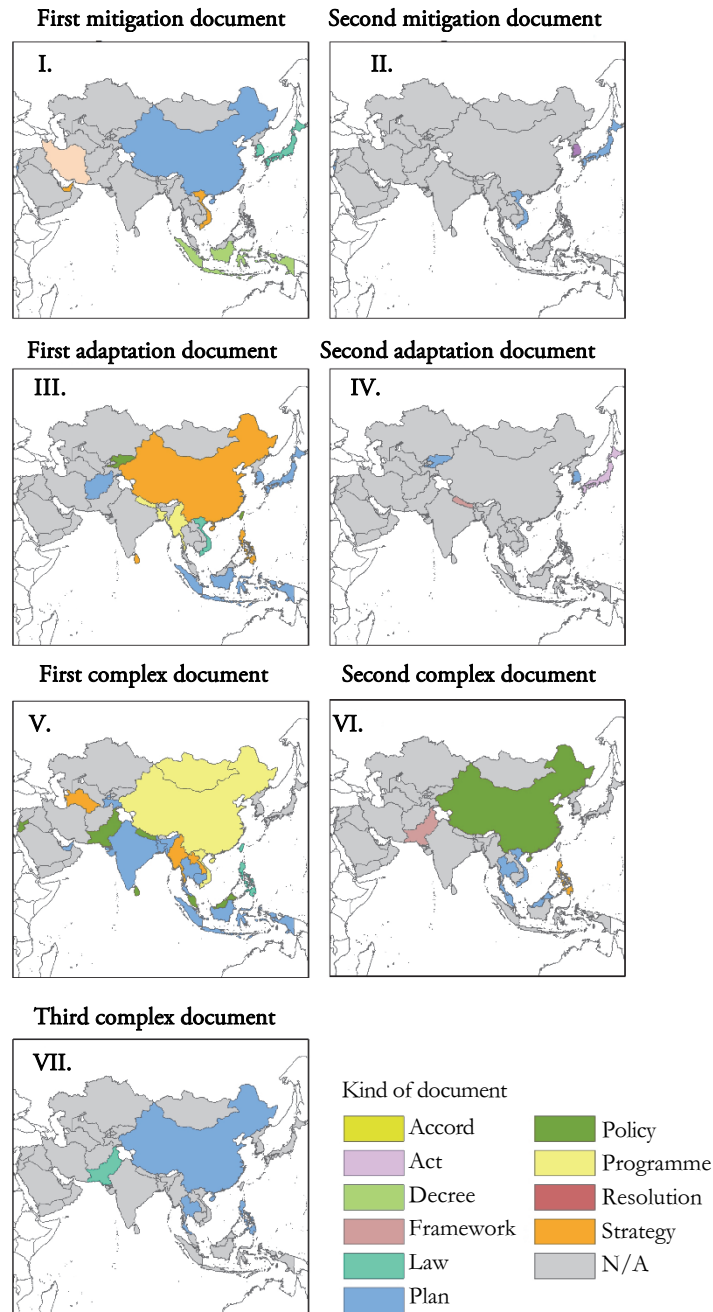


Figure A3

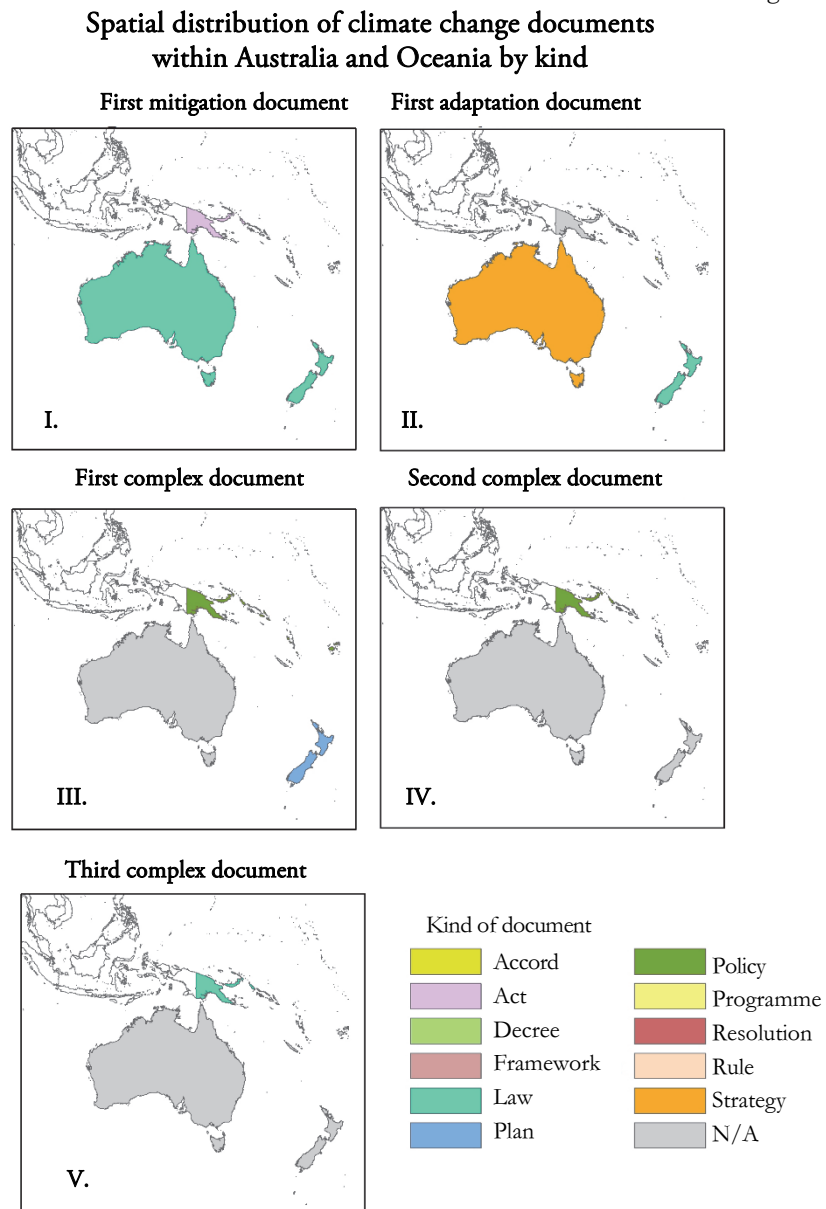


Figure A4

Spatial distribution of climate change documents within Europe by kind

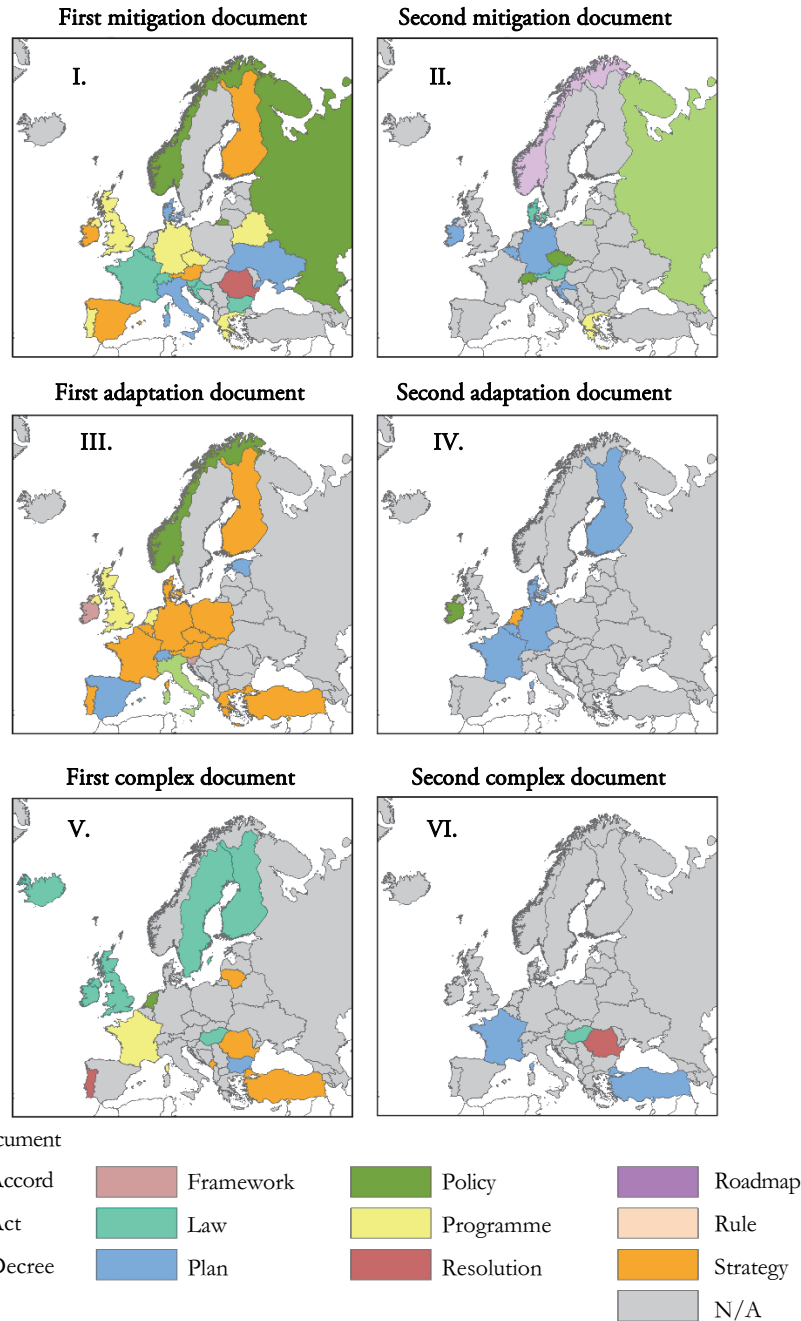
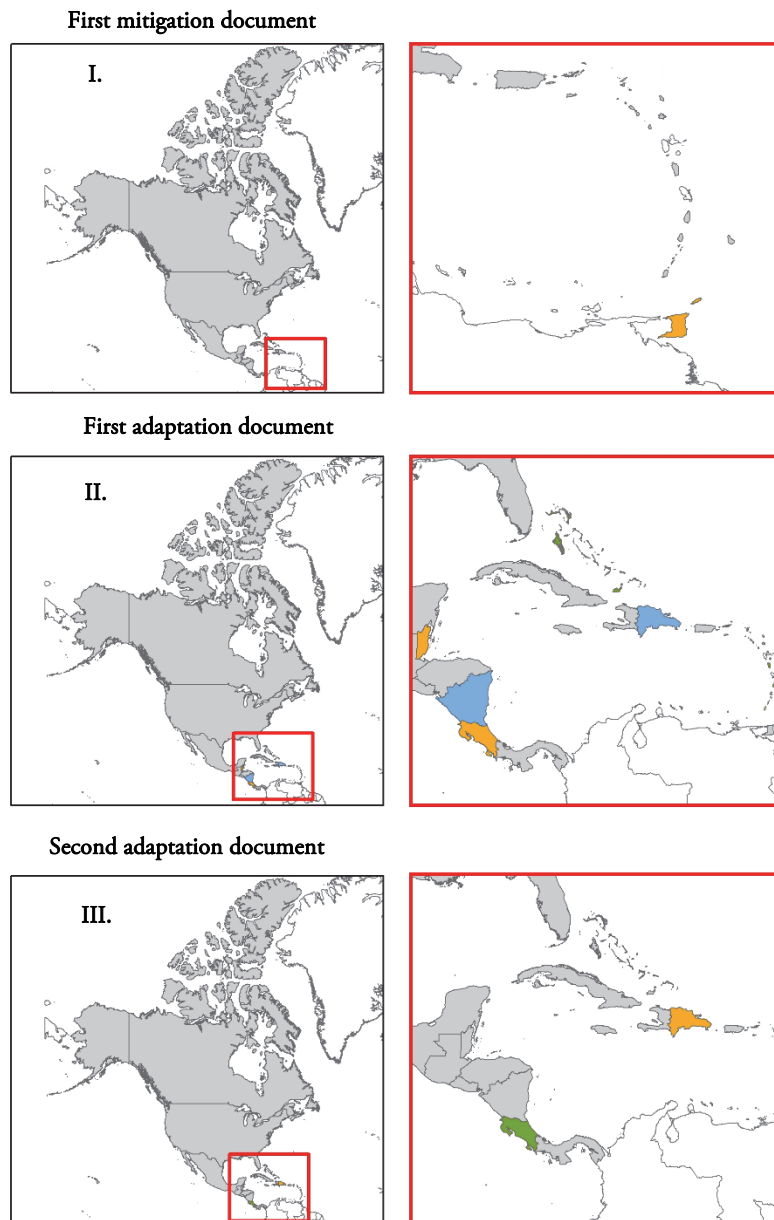


Figure A5

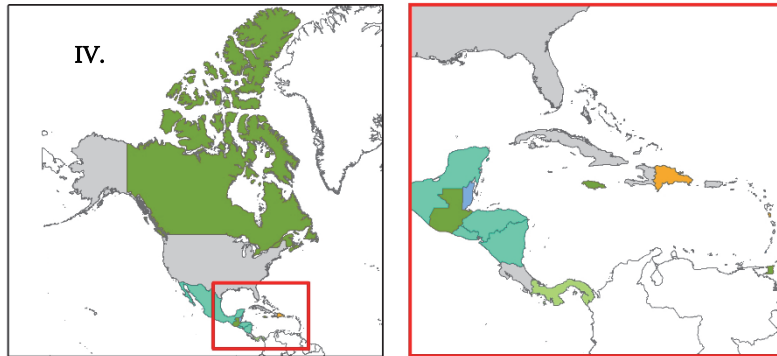
Spatial distribution of climate change documents within North and Central America by kind



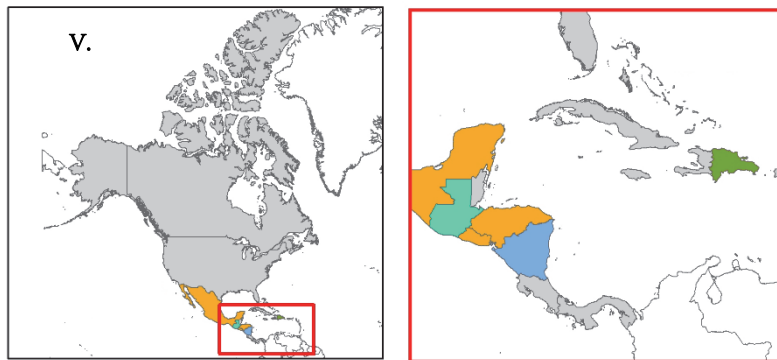
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First complex document



Second complex document



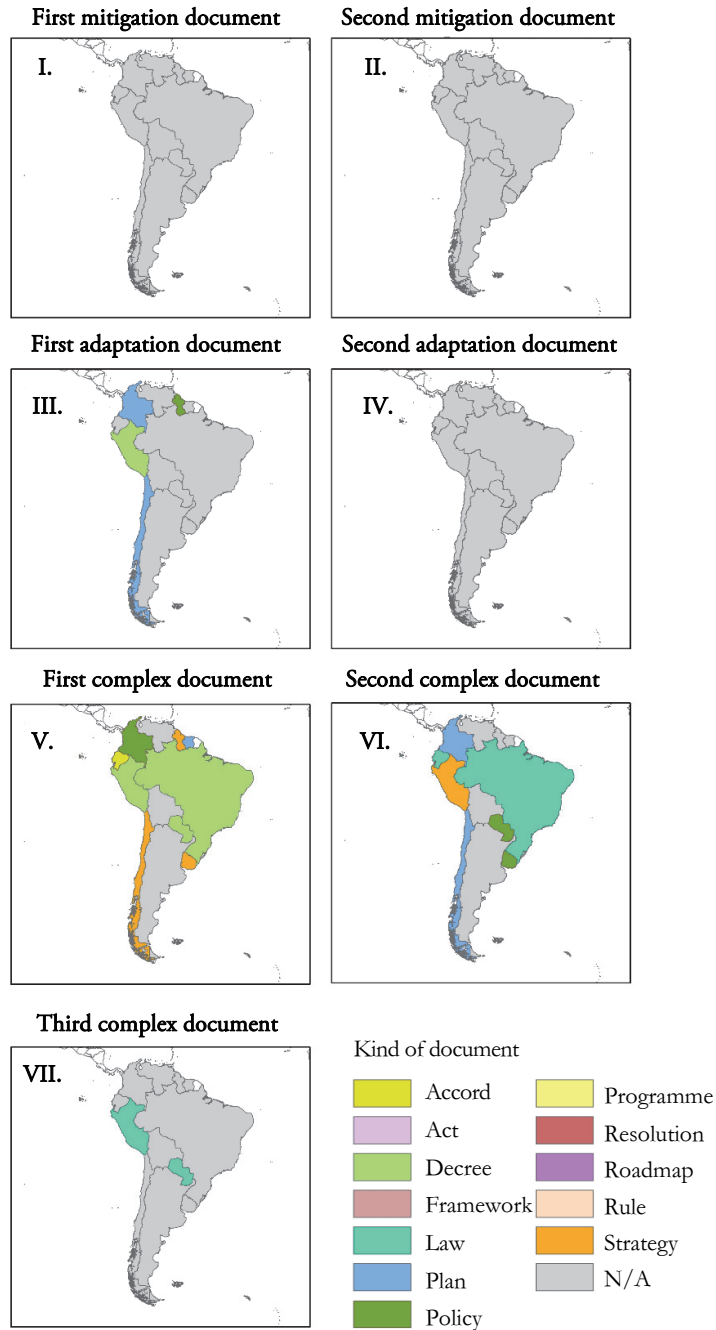
Third complex document



Kind of document



Figure A6
 Spatial distribution of climate change documents within South America by kind



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