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A cross-scale worldwide analysis of coastal adaptation planning

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Abstract

The Paris Agreement requires measurement of the progress made on adaptation. Tracking the progress made by governments through analysis of policies provides insight into the goals and means to achieve adaptation targets. Here we show the current state of the art in public adaptation planning affecting 136 of the largest coastal port urban agglomerations, covering 68 countries. We identify 226 adaptation policies: 88 at national level, 57 at regional/state level and 81 at city/metropolitan level. This set of adaptation policies can be considered the latest, most up-to-date database of governmental and public-led adaptations. Our analyses show that (1) in one half of cases, there is no evidence of policy implementation, (2) in almost 85% of cases, planned adaptation actions are not driven by present or future climatic impacts or risks, and (3) formal adaptation planning is relatively recent and is concentrated in more developed areas and countries.

Keywords: adaptation measurement, adaptation metrics, Paris Agreement, adaptation tracking, adaptation policy and planning, public policy

1. Introduction

Tracking adaptation is needed to identify who is adapting to what, when, where and why; to understand the efficiency of assigned resources and to adjust adaptation planning given that information (Lesnikowski *et al* 2017, Tompkins *et al* 2018, Magnan 2016, Magnan and Ribera 2016, Ford *et al* 2015). Adaptation tracking and measurement faces numerous challenges. Limitations include the ambiguity of the concept of adaptation per se (what can be considered adaptation?) and the lack of comparable, aggregable metrics (Ford and Berrang-Ford 2015, Magnan 2016, Tompkins *et al* 2018). These factors contribute to the messiness of adaptation tracking-related research (Ford *et al* 2015) which is currently characterised by non-robust methodologies and insufficient comparable data sources, leading to a lack of consistent guidance (Tompkins *et al* 2018, Ford *et al* 2015, Berrang-Ford *et al* 2019, Ford and Berrang-Ford 2015, Biesbroek *et al* 2018). This makes it difficult to: (i) develop robust approaches to measure the progress and effectiveness of implemented interventions; (ii) define adequate adaptation monitoring, evaluation and reporting (MER) systems; (iii) identify regions of high and low adaptation activity; and, (iv) simulate planned actions providing credible scenarios of successful adaptation.

Prior to tracking adaptation progress, a reference baseline is needed to stocktake what is actually occurring on the ground (Tompkins et al 2018) so that future efforts of tracking can be adequately sized and compared. Documenting adaptation to create this reference baseline faces the same problems as previously noted (Tompkins et al 2018): lack of methods, lack of reliable and comparable data sources, and lack of an agreed definition of adaptation. Research to date has often delivered selective analysis of adaptation initiatives focusing on certain policy scales, types of adaptations, or world regions. For example, research has focused on city level plans, globally (see Araos *et al* 2016) or regionally (see Reckien *et al* 2018 for Europe). Local scale policy instruments in some developed countries have been assessed (Lesnikowski *et al* 2019). National

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Communications to the United Nations have been analysed to understand national adaptation progress (Lesnikowski *et al* 2016). More recently, Le (2019) has studied coastal adaptation planning in global south coastal cities using a selection of local adaptation planning documents and reports. Only a few studies (Tompkins *et al* 2010 in the UK) have delivered more comprehensive analyses covering various scales, types of sources and adaptation promoters (including public and private actors).

We add to this literature by offering a global cross-scale analysis of adaptation policy with the aim of progressing towards a reference baseline for the Global Stocktake. We document government-led (top-down) adaptation initiatives (as described in Berrang-Ford *et al* 2019) across national, regional and local administrative scales relative to the 136 largest coastal port cities worldwide. The study focuses on actual public policy on climate change adaptation – i.e. intentional policy (Dupuis and Biesbroek 2013). We do not consider public policies that, although incentivise adaptation, are not motivated by climate change. Adaptation policy is presumed to be formally documented through risk and vulnerability assessments, future climate change scenarios and adaptation options assessments. The final objective of our work is to provide a state-of-the-art assessment of government goals and actions in relation to adaptation under these premises, so that evidence on the alignment of current action to future risks can be made in these coastal regions. We discuss the results highlighting similarities and divergences among policy scales and world regions.

2. Data and methods

From November 2018 until April 2019, we collected and analysed 226 national, regional and local adaptation-related policies affecting the 136 largest coastal port cities worldwide - a set of cities of more than 1 million inhabitants for which coastal-related risks have been widely studied (Abadie *et al* 2017, Hallegatte *et al* 2013, Hanson *et al* 2011). These coastal cities concentrate around 700 million inhabitants[1] (approximately 10% of the world population); the 68 countries where they are located contain over 6 billion people (almost 82% of the world population). Most of the sampled large cities (54 out of 136) and their respective countries (22 out of 68) are located in Asia (see Table 1). Europe, Latin America and Africa are fairly equally represented in terms of cities and countries. The nineteen (19) cities of North America (2 countries) contrast with the 6 cities sampled in Oceania (2 countries).

For the search, selection and characterisation of adaptation-related policy documents, we follow the *four-step stocktaking approach* by Tompkins et al.(2018). The approach allows room for comparability, interpretability and usability of the results for multiple purposes, identifying 4 required steps (a) obtaining consensus on the objectives of adaptation; (b) agreeing on the sources of evidence; (c) agreeing the search method; and (d) categorizing the adaptations. Based on this approach, and acknowledging other literature on the topic (Biesbroek *et al* 2018, Ford *et al* 2015, Berrang-Ford *et al* 2015, 2019), we have developed a documenting protocol, consisting of 3 sub-protocols: (i) search, (ii) selection and (iii) characterisation. The three protocols used in our study are linked through a circular iterative step-by-step process, as illustrated in Figure 1. These protocols help to define: (a) data sources and collection process establishing search criteria and search levels, (b) the adaptation landscape: how adaptation looks in the study, what outputs, sectors and scales are taken into account, and (c) how adaptations are categorised, what aspects and criteria are tracked and analysed. Using this approach, we aim to enhance replicability and comparability of the results, thereby increasing transparency of the process required for adaptation stocktaking (Tompkins *et al* 2018). The understanding of the benefits and limitations of the documentation protocol is critical for the interpretability of the results.

The documenting protocol used here allows us to include policies that are labelled as adaptation or contain adaptation-related information. This is translated into a collection of policy documents that are both adaptation-focused, as well as integrate adaptation-related objectives and actions that demonstrate the intention to reduce climatic risks. Sectoral policies (e.g. flood, biodiversity) are not included unless they specifically contain actions

[1] 697,933,903 inhabitants, according to United Nations World Population Prospects 2018 and the 2008 population census of North Korea for the city of Nampho.

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to reduce coastal climatic risks. Documents are collected at all policy scales affecting the sampled 136 large cities: local (city and metropolitan), regional/state and national. We use an Internet search engine (Google) and a second step where we verify findings with local experts or public officials. All documents found, regardless of the language[2], have been analysed using translation services. These adaptation initiatives take the form of documents (strategies, programmes and plans, not laws or regulations) existing in public sites (either official governmental sites or public databases) or provided by public officials during the verification stage. Collected policies date from 2006 until early 2019. These policies are the latest information available on governmental plans to adapt at each administrative scale. Detailed information on each of the protocols, including the metadata and search method for each of the aspects characterised, is to be found in the Supplementary Information (SI) attached to this article. The original cities data set file (136DB) and collected data (CharacterisationDB and AdaptationDB) are also provided as SI spreadsheet files.

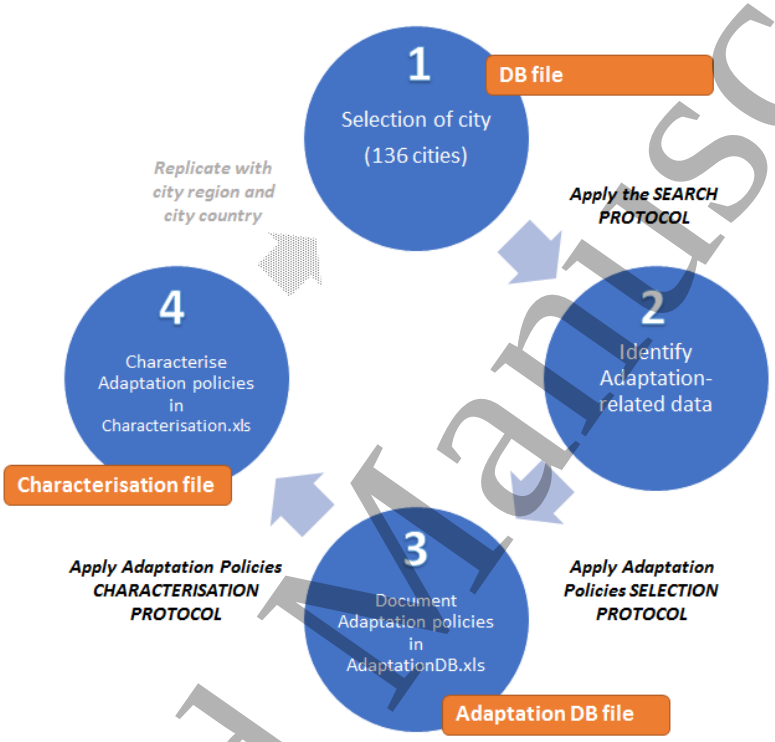

Figure 1 Documenting protocol iterative step-by-step process. The search protocol; the selection protocol; and the characterisation protocol are linked through this process.

3. Results

3.1. Distribution and types of policies across world regions and scales[3].

Overall, adaptation policy is distributed reasonably evenly across national (38.9% of all policies found), regional/state (25.2%) and city/metropolitan (35.8%) scales. The data show that adaptation planning in Asia,

[2] Documents analysed covered languages such as English, Spanish, Portuguese, French, Finnish, German, Dutch, Chinese, Greek, Japanese, Korean, Indonesian, Arabic, Swedish, Danish, Italian, Russian, Hebrew, Thai and Vietnamese.

[3] We classified policies in 5 scales: national, state, regional, metropolitan and city scales. National are country specific policies. State policies are developed in smaller divisions of federal countries. Regional policies correspond to provinces

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Africa and Latin America is mostly dominated by national and local (city/metropolitan) plans (with exceptions such as Japan and South Africa that have regional policies). However, polices on the same scale may have different implications for adaptation and risk reduction depending on the context. For example, the City of London covers only one-mile square and is home to 7,400 inhabitants (plus 482,340 commuters)[4] while Panamá City (of 38.5 miles square) plans to reduce the risk exposure for around 430,000 residents[5].

Although the figures are influenced by the number of countries per region, most adaptation policies can be found in Asia followed by Europe and North America (Table 1). Eleven (11) countries out of 68 have no national adaptation policy in place, most of them in Asia. State level policies are developed in federal countries such as the United States (US), India and Brazil. Almost all studied coastal cities in the US and all in India are covered by a state plan, while in Brazil, only 2 out of 10 are located in a state with a strategy to adapt. Globally, there is a lack of regional[6] planning in developing countries (only 4 out of 37 regional policies affect developing regions, namely, Colombia, Peru, Ecuador and Philippines).

Table 1 Number of countries and cities with no planning per world region. The total number of countries and cities analysed is also indicated together with the total number of adaptation policies found per world region.

World regions	Total countries analysed	Total cities analysed	Total number adaptation policies (% of total adaptation policies found)	Number of countries with no planning* (% of total countries in world region)	Number of cities with no planning** (% of total cities in world region)
Africa	16	19	26 (11.5 %)	1 (6.2 %)	16 (84.2 %)
Asia	22	54	55 (24.3 %)	5 (22.7 %)	39 (72.2 %)
Europe	14	17	50 (22.1 %)	2 (14.3 %)	5 (29.4 %)
Latin America	12	21	32 (14.1 %))	2 (16.7 %)	13 (61.9 %)
North America	2	19	43 (19.0 %)	1 (50.0 %)	5 (26.3 %)
Oceania	2	6	20 (8.8 %)	0 (0.0 %)	1 (16.7 %)
TOTAL	**68**	**136**	**226 (100%)**	**11 (8.1 %)**	**79 (58.1 %)**

* At national level

** At local level (city and/or metropolitan policies)

At the local scale, there is a significant gap in adaptation policy in certain regions of the world. In Africa, the vast majority of cities do not have local government-led adaptation policy, followed by Asia and Latin America (Table 1 and Fig. 2). The percentage of cities without adaptation plans increases in these continents when the most developed countries are removed from consideration, i.e. South Africa, Brazil, South Korea or Japan. Following this pattern, in other more developed world regions, the share of cities without local planning is significantly lower (below 30%). Globally, on average, 58% of cities (79 cities home to 372 million people) do not have any local adaptation planning in place.

and land areas under the responsibility of a regional administrative body. A metropolitan policy may cover various municipalities including the city proper. City level policies refer to the administrative boundaries (city proper) of the local administration. Example: Country: Spain, Region: Catalonia, Metropolitan area: Área Metropolitana de Barcelona, City: Barcelona. In some cases, these 5 scales are further grouped in three scales for simplification: national, regional (state + regional) and local (city + metropolitan).

[4] "City of London Resident Estimates and Projections" Department of the Built Environment, City of London. June 2018;

[5] "Superficie, población y densidad de población en la República según provincia, comarca, distrito y corregimiento: Censos de 1990 a 2010". Instituto Nacional de Estadística y Censo (INEC), Contraloría General de la República de Panamá. May 2010

[6] Regional policies may be developed by one or more governmental agencies and may affect areas not limited to administrative boundaries. Examples are: Region Hovedstads (in Denmark), Fukuoka Prefecture (Japan) and Durban Bay Estuary (South Africa).

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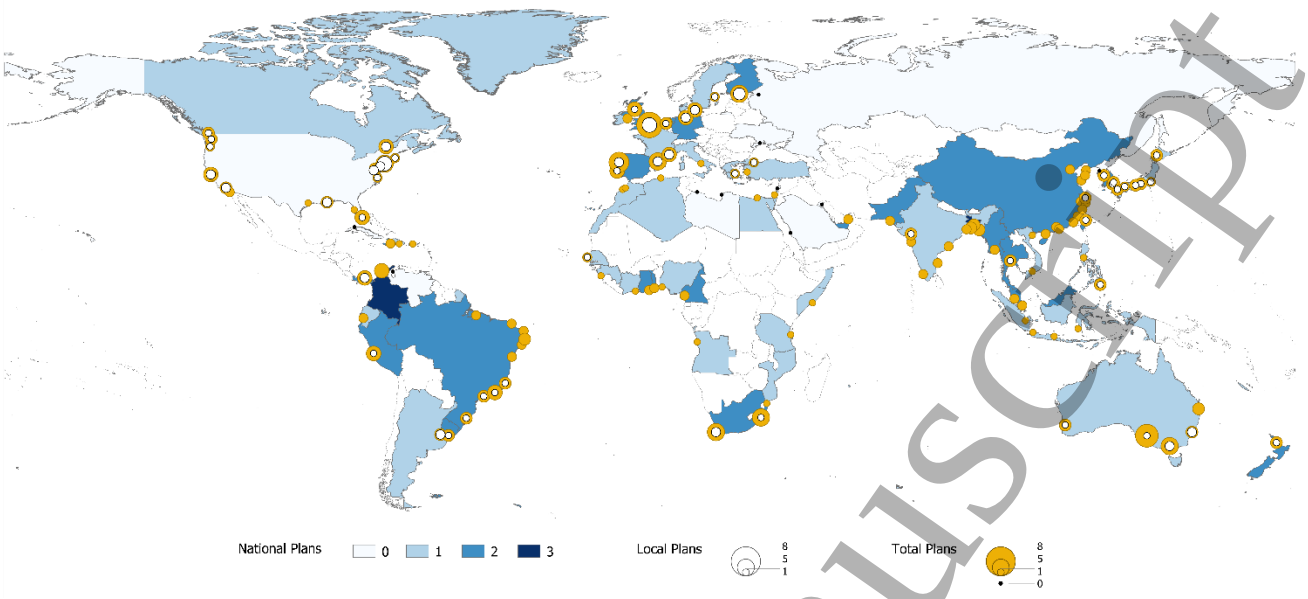

Figure 2 Number of adaptation policies at national, regional and local levels per city. Orange bubbles indicate the total number of plans; white bubbles indicate the total number of local (city and metropolitan) plans. Sampled countries are shaded gradually indicating the number of national policies. Most adaptation policies are delivered in richer areas both in developed or developing world regions.

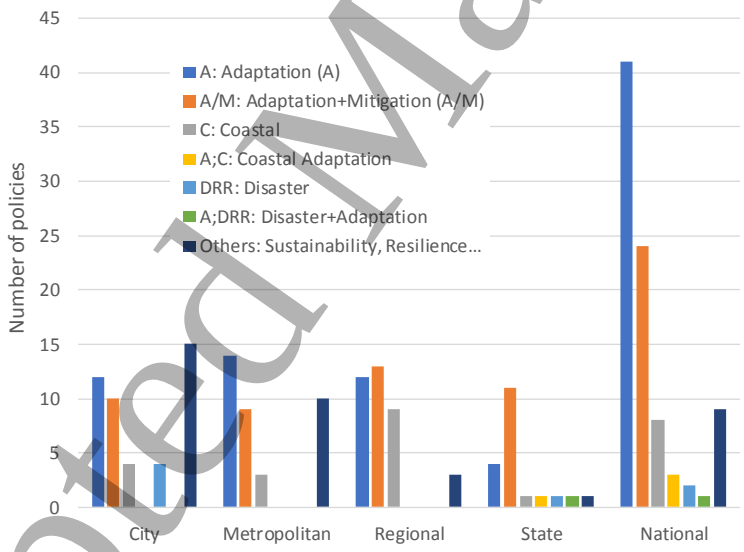

Figure 3 Types of policies and scale. Distribution across policy scales of the seven types of adaptation-related policies identified in the sample. Most policies are adaptation (A) or climate change (A/M) focused.

Seven main types of adaptation-related policies have been identified (see Fig. 3): climate adaptation policies (A), climate change policies including both mitigation and adaptation objectives (A/M), coastal management policies (C), coastal adaptation policies (A;C), disaster risk reduction policies (DRR) and disaster and adaptation policies (A;DRR). The rest are sustainability, resilience and master plans which are grouped as 'Others'. Across scales, the most frequently used way to plan for adaptation is through A and A/M plans (66.4% of the cases). The national scale is dominated by A and A/M policies. 'Others' are most frequent at city and metropolitan level (65.8% of the total 'Others' are local). A;C, A;DRR and DRR policies are not numerous and limited to higher scales, with the exception of a few DRR policies (so called, hazard mitigation plans) at local level in the US.

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3.2. Commitment, concreteness, and implementation.

The date of publication can reveal the growth in prevalence of policies. Existing adaptation policies mostly date after 2014, with 68.6 % of the policies found (Fig. 4), suggesting an emerging trend in adaptation policymaking. From 2014 onwards, the number of policies which revise or follow-up on a preceding adaptation policy slightly increases (an average of 44.2 % yearly are revisions in contrast to 33% in the previous period), identifying a small increase in adaptation maturity.

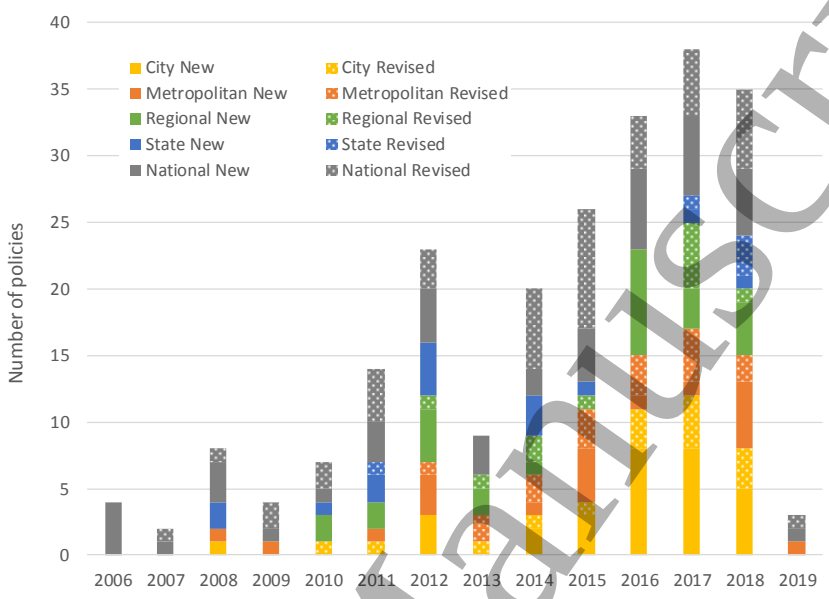

Figure 4 Publication year of adaptation policies. Data shows the publication year of new and revised policies per policy scale (city; metropolitan; regional; state; national). (Note: end of collection date: April 2019)

Through policy approval, the government officially acknowledges responsibility for implementation and budget allocation. Evidence of governmental approval of adaptation policies was only found for 92 policies (i.e. 40.7% of the total). Around 10% of adaptation policies were approved between 1 and 3 years after publication.

Policies can be either strategic (40.3%) in nature with broadly defined objectives and proposed lines of action or more tangible (59.7%) if they define concrete measures and interventions. Local and regional/state adaptation-related policies tend to be more concrete (67.0% of the cases), whilst half (51.1%) of national policies are more strategic. The majority of the policies (81%) define adaptation measures[7], as defined by Lesnikowski et al. (2011, 2013), as both *groundwork* (measures to increase the level of knowledge) and *actions* (measures to initiate changes in policies, programmes, or the built environment). Distinctively, North America has the highest number of policies exclusively defining *groundwork*-type measures (23.3%) or *action*-type measures (20.9%), those often being state policies.

The number of measures contained per policy may be used to evaluate the progress in adaptation (Araos *et al* 2016) and prioritisation needs (Olazabal *et al* 2019). However, a large number of measures does not necessarily lead to policy concreteness. State policies, for example, are usually concrete and contain on average more measures per policy (102.2 mpp). Contrastingly, national policies are more strategic but they contain on average

[7] None of the policies included *recognition* (Lesnikowski *et al* 2013, 2011) as our documenting protocol required the inclusion of adaptation measures, which are lacking in 'recognition' type policies (those recognising the importance of adaptation, only).

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more adaptation measures (76.5 mpp) than city (48.8) or metropolitan (31.2) policies. Coastal adaptation measures are more prevalent in regional (15.5 mpp)[8] and state (29.4) policies. Remarkably, 24% of regional policies are coastal, but only 5% of state policies are (see Fig. 2).

Nevertheless, not all adaptation policies are implemented. According to policy lifetimes, 79.6% of the adaptation policies are in the process of being implemented, and 7.1% have already been implemented, with only 13.3% not being implemented (as they are too recently developed). In contrast, actual evidence[9] of implementation was found in only half of these cases (54.1%).

3.3. Topics, budget, monitoring and participation: what is the big picture?

There has been limited work to date to identify the sectoral focus of adaptation measures across regions or policy scales. Globally, the most frequent focus of adaptation measures is on governance, coast and water, DRR, ecosystems and urbanization (urban) (between 70 and 80% of the policies cover these topics, Table 2). Governance, health, ecosystems, energy and agriculture and food are more frequently addressed in national policies. Metropolitan plans focus more on waste and city plans focus the least on ecosystems[10]. There are significant regional variations in the focus of policies, possibly reflecting different adaptation needs or progress in each world region. Policies in Asia, Africa and Latin America cover more governance issues, relative to, for example North America or Oceania. Africa addresses the finance sector and waste more than other regions. Notably, North American policies have the least focus on ecosystems and health, in contrast to Asia. Transport is most covered in Oceania while disaster risk management is in Asia.

[8] We consider the Thames River Basin District Flood Risk Management Plan 2015-2021 (United Kingdom) as an outlier as it contains 1371 adaptation measures. Taking this plan into consideration, the regional policies contain 52.2 coastal mpp.

[9] We consulted online government pages and progress reports.

[10] Adaptation measures classified under 'Ecosystems' may include ecosystem-based adaptations and also adaptation measures addressed for restoration of current degraded ecosystems.

Table 2 Coverage of topics per world region and policy scale.

	Transport	Disaster Risk management	Health	Tourism	Finance	Business	Ecosystem	Coast and Water	Energy	Waste	Agriculture and Food	Urban	Governance
Policy scale													
City	46.7%	82.2%	57.8%	13.3%	31.1%	35.6%	60.0%	77.8%	44.4%	8.9%	35.6%	71.1%	80.0%
Metropolitan	47.2%	75.0%	61.1%	19.4%	8.3%	36.1%	75.0%	75.0%	33.3%	25.0%	41.7%	80.6%	75.0%
National	45.5%	77.3%	71.6%	36.4%	33.0%	43.2%	86.4%	78.4%	52.3%	11.4%	70.5%	75.0%	90.9%
Regional	51.4%	56.8%	54.1%	27.0%	13.5%	40.5%	67.6%	81.1%	32.4%	5.4%	48.6%	64.9%	62.2%
State	45.0%	80.0%	65.0%	20.0%	15.0%	20.0%	70.0%	80.0%	40.0%	15.0%	60.0%	60.0%	60.0%
World region													
Africa	61.5%	65.4%	69.2%	53.8%	65.4%	65.4%	96.2%	92.3%	50.0%	46.2%	69.2%	69.2%	92.3%
Asia	27.3%	96.4%	89.1%	32.7%	1.8%	30.9%	100.0%	85.5%	49.1%	10.9%	80.0%	96.4%	98.2%
Europe	48.0%	76.0%	48.0%	26.0%	26.0%	34.0%	62.0%	78.0%	50.0%	8.0%	42.0%	56.0%	72.0%
Latin America	43.8%	68.8%	65.6%	15.6%	31.3%	37.5%	84.4%	65.6%	40.6%	15.6%	62.5%	78.1%	96.9%
North America	41.9%	72.1%	34.9%	4.7%	20.9%	20.9%	30.2%	74.4%	23.3%	2.3%	20.9%	48.8%	55.8%
Oceania	95.0%	40.0%	85.0%	35.0%	20.0%	70.0%	90.0%	70.0%	50.0%	0.0%	55.0%	90.0%	45.0%
Total	**46.9%**	**74.8%**	**63.7%**	**26.1%**	**23.9%**	**38.1%**	**74.8%**	**78.3%**	**43.4%**	**12.4%**	**54.4%**	**72.1%**	**78.8%**

Monitoring, evaluation and reporting (MER) systems are important to understand adaptation policy implementation and delivery. Promisingly, MERs are proposed in 88.9% of the policies. Evidence of effective budgeting for adaptation is less clear, with almost three quarters of identified policies failing to include a budget for full or partial plan implementation. Interestingly, we found no significant differences in the extent of participation in policy development across policy scales (an average of 80%, except state policies with 95%). The use of participatory methods in policy definition ranges from Latin American and North America (around 90%) to Africa (73.1%). Overall, 19.5% of the adaptation policies have not used participatory methods, although around two thirds of these propose them for future policy developments or project definition.

3.4. Uncertainty, risk and vulnerability.

Globally, 98.2% of the adaptation policy documents mention 'risk', however, only 64.7% acknowledge the uncertainty inherent in climate change. In 79.6% of the cases, the word 'disaster' is mentioned and acknowledged as a potential outcome of not adapting. This understanding of disaster does not percolate through policies. For example, disaster is only mentioned in 48.0% of examined coastal management plans (C) in contrast to 100% of examined coastal adaptation plans (A;C).

A comprehensive vulnerability assessment can help to evaluate risks and identify current or future adaptation needs. In 57.5% of the cases (Table 3), there is a vulnerability analysis[11] of population and/or built and natural assets. Most national documents (65.9%) assess vulnerabilities to climate change compared to only 40.5% of regional plans. Coastal (C), and sustainability, resilience and master plans ('Others') use vulnerability assessments relatively less often. The vast majority of policies labelled as 'adaptation' (A; A/M; A;C; and A;DRR) include vulnerability assessments.

Unexpectedly, risk assessments[12] in adaptation policies are not standard, lacking in 46.0% of the policies (Table 3). European policies have the highest rate (70.0%) and North American and African the lowest (around 40%). Risk assessments are also infrequent in 'Other' policies and regional policies. Risk assessments can be

[11] As understood in the latest reports of the Intergovernmental Panel on Climate Change, IPCC (2014).

[12] As understood in IPCC (2014).

qualitative and/or quantitative (IPCC 2014) and may be based on future, present or past vulnerabilities (Conway *et al* 2019). Most policies that include a risk assessment have also used climate scenarios (88.5%), suggesting the consideration of future risks. One fifth of policies including risk assessments do not document any assessment of vulnerability – this tends to be the case where a qualitative risk assessment is developed. For example, the Metropolitan Adaptation Plan of Porto (Portugal) develops diagnoses based on qualitative evaluations of risk using scientific literature and population surveys.

Table 3 Consideration of current exposure and future risks and definition of adaptation actions.

	Vulnerability assessment (% Yes)*	Risk assessment (% Yes)*	Aligment of actions with scenarios and risks (% Yes)*	Socio-economic projections (% Yes)*	Climate scenarios (%Yes)*	*IPCC scenarios (% directly)***	*IPCC scenarios (% indirectly)***
Type of policy							
A	74.7%	65.1%	19.3%	14.5%	90.4%	*66.7%*	*17.3%*
A/M	58.2%	47.8%	11.9%	19.4%	79.1%	*52.9%*	*11.8%*
A;C	100.0%	75.0%	50.0%	25.0%	75.0%	*66.7%*	*33.3%*
A;DRR	100.0%	100.0%	50.0%	50.0%	100.0%	*50.0%*	*50.0%*
C	28.0%	52.0%	16.0%	12.0%	64.0%	*25.0%*	*50.0%*
DRR	57.1%	71.4%	42.9%	28.6%	71.4%	*0.0%*	*60.0%*
Others	31.6%	34.2%	2.6%	36.8%	44.7%	*41.2%*	*5.9%*
Policy scale							
City	53.3%	53.3%	26.7%	31.1%	77.8%	*42.9%*	*22.9%*
Metropolitan	58.3%	75.0%	16.7%	22.2%	69.4%	*56.0%*	*12.0%*
National	65.9%	51.1%	5.7%	14.8%	75.0%	*59.4%*	*17.2%*
Regional	40.5%	35.1%	8.1%	10.8%	73.0%	*44.4%*	*25.9%*
State	60.0%	65.0%	45.0%	35.0%	90.0%	*66.7%*	*22.2%*
World region							
Africa	69.2%	38.5%	0.0%	23.1%	61.5%	*50.0%*	*0.0%*
Asia	54.5%	50.9%	9.1%	14.5%	74.5%	*79.5%*	*0.0%*
Europe	60.0%	70.0%	18.0%	8.0%	86.0%	*39.5%*	*37.2%*
Latin America	68.8%	62.5%	0.0%	25.0%	65.6%	*66.7%*	*14.3%*
North America	46.5%	41.9%	39.5%	39.5%	88.4%	*36.8%*	*31.6%*
Oceania	50.0%	55.0%	20.0%	15.0%	60.0%	*58.3%*	*16.7%*
Total	**57.5%**	**54.0%**	**15.5%**	**20.4%**	**75.7%**	***53.8%***	***19.5%***

Most beneficial for adaptation planning — Least beneficial for adaptation planning

* of the total number of policies analysed

** of the total number of policies using climate scenarios

Where risk assessments were undertaken, only 23.8% of the policies aligned the proposed actions to identified risks (15.5% of the total number of policies analysed, Table 3). Coastal and DRR adaptation policies (A;C, A;DRR and DRR) are most likely to propose actions aligned to climatic risks or scenarios (50.0, 50.0 and 42.9%, respectively). By far, North American state policies are the ones that most frequently propose adaptation actions addressing specific risks and/or climatic scenarios.

3.5. Climate scenarios and projections

Adaptation policies rarely (20.4%) use future socio-economic projections for their assessments (Table 3), and these are mostly limited to population projections only. Using socio-economic projections is more widespread in North America (39.5% of policies) than in Europe (8.0%). Remarkably, only 12.0% of coastal plans and 10.8%

of regional plans take into account future socio-economic data. Disaster-related (A;DRR 50% and DRR 28.6%) and policies classified as 'others' (36.8%) include socio-economic projections more often.

Far more policies consider climate change scenarios[13] (Table 3). North American and European policies are most likely to take future climate change into account. Regionally, the lowest incidence of using climate change scenarios is in Oceania (60%), while, per plan type, 'others' use them the least (47.2%). Among policies using climate scenarios, 53.8% directly and 19.5% indirectly use IPCC scenarios (Table 3); the rest develop their own scenarios or do not specify the source of data. Most policies in Asia make direct use of IPCC scenarios (none, indirectly) in contrast to North American or European policies (36.8% and 39.5%, respectively). Notably, the greatest indirect use of IPCC scenarios is in North American and European[14] policies. North America and Africa are also the world regions where there is a greater use of independent scenarios.

4. Policy and research implications

Our results, for the first time, provide a global cross-scale baseline assessment of where government-led policy is happening, and where it is not, in coastal regions. Our focus is on cross-scale policies affecting coastal port cities over 1 million inhabitants. This however should not deviate our focus from other areas where action needs to be urgently addressed. That might be the case of small and medium coastal cities and towns that are currently affected by sea-level rise and which conditions will severely worsen in the future (for example in Small Island Developing States) (Kulp and Strauss 2019). We have drawn a limit to adaptation action by considering only policies intentionally designed to adapt to climate change. Although this helps to gather knowledge specific to how climate information is used, it may also provide a narrowed lens regarding the number of initiatives in place particularly for developed regions where there might be a significant diversity of policy instruments in use for adaptation (Lesnikowski *et al* 2019). Likewise, other non-governmental institutions and actors undertake adaptation, and we acknowledge the importance of multilevel governance (including informal processes and networks) in delivering adaptation, especially in developing regions (Béné *et al* 2018, Mimura *et al* 2014).

Despite the high number of adaptation policies found, these are unevenly distributed spatially. In particular, national policy is not trickling down to regions or cities in the developing world, highlighting a general absence of local government-led action in areas with lower adaptation capacity, higher vulnerability and exposure to climatic impacts. There is also little evidence that: they fully consider climate risks and future uncertainties, have a clear pathway to implementation, and cover all sectors adequately. We do not speculate why this is, but the evidence base allows us to ask appropriate questions in a context of monitoring and adaptation tracking, especially considering the high divergences across policy scales and world regions.

Our findings also point to the relatively recent development and implementation of climate change adaptation policies, which indicates that experience in understanding the effects of planned actions is yet to develop. Adding to this, there is a clear discrepancy between stated and evidenced levels of implementation of adaptation policy. This emerging landscape of policy documents leaves little space for the definition of adequate metrics that could inform policymaking about the potential effectiveness of current adaptations. We find little evidence of the use of socio-economic projections or of the alignment of planned actions with identified risks or climate scenarios. This poses serious concerns about our skill at translating risk knowledge into practical action and raises important questions regarding the effectiveness of planned actions.

Beyond the above, further research is needed to understand other important policy implications of our findings. For example, how and where is the level of definition and concreteness of policies and measures relevant? How effectively are MER systems and participatory processes deployed? How does the use of climate and socio-economic projections affect policy development, design and implementation? Responding to these questions may further help policy makers in defining more effective adaptation strategies.

Through the Paris Agreement, there is a unique opportunity for the scientific and policy community to make advances in climate adaptation policy. Building a methodologically transparent large database of policy

[13] As understood in IPCC (2014).

[14] Many UK policy documents, for example, rely on the UK Climate Projections 2009 which consider IPCC scenarios.

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documents, we intend to contribute to the construction of a reference baseline across policy scales for the Global Stocktake. As shown, these data can help to identify research needs, clarify adaptation policy trends, highlight achievement of adaptation targets, or be used as policy guidance. More work is needed to draw out appropriate metrics that could be employed to assess the effectiveness of adaptation policy. In this sense, more research focused on actual evidence of implementation of adaptation actions is required, as is the need to repeat this baseline assessment of government-led adaptation for non-coastal areas. Once this is in place, we envisage that adaptation tracking can progress more quickly.

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6. Authors' contributions

M.O. led and coordinated the project. M.O. and E.T. conceived the conceptual approach for the experiment. M.O., M.R.G. and K.V. designed the protocol-based methodology and performed the pilot testing. M.O., M.R.G., K.V. and R.S. collected the data. MO performed the analyses. M.O. developed Figures 1, 2 and 4 and Tables 1, 2 and 3. MRG and MO developed Figure 3. All authors jointly discussed the results, conclusions and the supplementary material and edited the manuscript.

7. Data availability statement

Any data that support the findings of this study are included within the article.

8. Additional information

Supplementary Information (SI), including all data that supports the findings of this study, is available in the online version of the paper. Correspondence should be addressed to MO (marta.olazabal@bc3research.org).

9. Competing financial interests

The authors declare no competing financial interests.

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