Cities 109 (2021) 103018

Contents lists available at ScienceDirect

Cities

journal homepage: www.elsevier.com/locate/cities

How well do climate adaptation policies align with risk-based approaches? An assessment framework for cities

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ARTICLE INFO

Keywords:
Climate change adaptation
Climate risk
Local adaptation planning
Adaptation policy
Disaster risk reduction
Climate policy

ABSTRACT

Many cities around the world are undertaking adaptation planning processes in contexts of considerable uncertainty due to climate risks. However, new evidence suggests that current adaptation policies are failing to fully incorporate risk-related information and knowledge. Understanding how policies account for current and future risks becomes crucial to assess whether they will effectively contribute to reduce vulnerability and increase resilience. Exploiting the synergies between the well-established discipline of disaster risk reduction and climate adaptation may be an interesting option. In this paper we develop an Adaptation-Risk Policy Alignment (ARPA) framework to assess whether (and how) climate change adaptation policies integrate risk knowledge and information. ARPA displays a set of risk-based metrics that we test in four early adapters cities: Copenhagen, Durban, Quito and Vancouver. These cities are considered pioneer cities in the design and implementation of adaptation plans and have the potential to show the full applicability of ARPA. The framework is easy to apply and allows to systematically assess whether and how policies appropriately account for major risks and properly integrate risk management into the policy-making process. We propose that the framework can be used for self-evaluation and learning as well as in large-scale adaptation tracking exercises.

1. Introduction

There is a general agreement that coping with climate change requires the combination of mitigation and adaptation strategies, as well as accounting for uncertainty and risk (IPCC, 2014). While substantial progress has been made in terms of defining mitigation goals, until the Paris Agreement there was no formal agreement concerning to the need to establish a global goal on adaptation (Magnan & Ribera, 2016). However, establishing a global objective faces, at least, three important challenges: i) determining the global adaptation goal in itself, ii) dealing with political barriers and iii) establishing tracking and measuring criteria and methods.

Adaptation faces numerous challenges and demands the development of specific frameworks, methods and tools (Ford et al., 2015; Magnan & Ribera, 2016; Olazabal, Galarraga, Ford, Sainz de Murieta, & Lesnikowski, 2019). The vagueness and different understandings of the concept of adaptation itself and the need to consider adaptation to climate change across temporal and spatial scales requires acknowledging different values and perceptions at different scales and working on agreed definitions (Hinkel, 2011). Likewise, comparable indicators and baselines, common guidelines and systematic approaches to data collection are required (Araos et al., 2016; Ford et al., 2015; Revi et al., 2014). One could also highlight additional problems linked to the nature of climate change impacts and adaptation (Craft & Fisher, 2016): (i) the long-term time horizons, (ii) the uncertainty surrounding climate projections as well as the timing, frequency and intensity of the impacts, (iii) the changing baselines in time and (iv) the cross-sectorial nature of adaptation. Given the difficulties in evaluating outcomes of adaptation (Hallegatte & Engle, 2019), a significant part of current methodological approaches to monitor adaptation focus on tracking policy outputs in the form of policy documents (e.g. Lesnikowski, Ford, Biesbroek, Berrang-Ford, & Heymann, 2016; Olazabal, Ruiz de Gopegui, Tompkins, Venner, & Smith, 2019; Reckien et al., 2018a) or by assessing policy processes (Olazabal, Galarraga, et al., 2019). However, in order to track real progress, the changes in the outcome (e.g. vulnerability or risk reduction) as a result of adaptation efforts (e.g. policy outputs) need to be accounted for (Berrang-Ford et al., 2019). Considering risks, rather than limiting the assessments to vulnerability, has the advantage of

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https://doi.org/10.1016/j.cities.2020.103018
Received 31 July 2019; Received in revised form 25 February 2020; Accepted 7 October 2020
Available online 29 November 2020

including in policy-making the magnitude and frequency of impacts and accounting for major uncertainties inherent to climate change (IPCC, 2014). However, new evidence suggests that in around 85% of the cases, adaptation policies are not defined as a direct response to the risks identified or the climate scenarios developed, showing that appropriately translating risk knowledge into policy action remains a challenge (Olazabal, Ruiz de Gopegui, et al., 2019). Methodologically, this means that focusing on policy outputs might overestimate adaptation progress and further research is needed to understand if and how risk knowledge is being considered and integrated into current adaptation policymaking.

The aim of this study is to assess the extent to which climate adaptation policies are aligned with climate risk knowledge and risk-based approaches. The concept of alignment has been often used in different situations to describe if two or more things are positioned in a straight line or run in parallel (CED, 2017). This concept has often been used in multi-level governance studies (Smith, 2004), environmental integration research (Betsill & Bulkeley, 2004; Happaerts, 2012; Oberthür & Gehring, 2006), climate policy (Andonova, Betsill, & Bulkeley, 2009) and even in the business sector to assess the alignment between the projects developed and the corporate strategy, identified a key to success (Goicoechea, 2017; Kerzner, 2000). In the climate change context, Hsu, Weinfurter, and Xu (2017) developed a framework to identify the linkages and coordination of regional (sub-national) climate policies. They identify two types of alignment dimensions: vertical, defined as "the linking and coordination of policies between different levels of government, with the aim of achieving policy coherence", and horizontal, which refers to the "linkages between actors as characterised in the [transnational climate governance] TCG literature" (Hsu et al., 2017: 422). We can find many examples in the climate governance literature that assess vertical alignment (e.g. multilevel governance studies, such as Bauer & Steurer, 2014; Fuhr, Hickmann, & Kern, 2018; Happaerts, 2015) and horizontal policy linkages (in the field of transnational climate governance as Bertoldi, Kona, Rivas, & Dallemand, 2018; Gordon & Johnson, 2018; Michaelowa & Michaelowa, 2017). In our context and as defined by Hsu et al. (2017), linkages between local climate adaptation and risk management policies exist and can be understood as a form of horizontal alignment (not transnational, but across policy domains).

In this paper, we go beyond the state of the art and develop a conceptual and operational framework to assess how well adaptation policies align with climate risk-based approaches and integrate risk knowledge and information. We name this as the Adaptation-Risk Policy Alignment (ARPA) framework. The assessment focus of ARPA is on policies at one unique scale and is particularly looking to risk and uncertainty approaches in climate policies; it is, in this sense, a contribution adding to Hsu et al. (2017).

To this end, we review current approaches to climate change adaptation policy evaluation (Section 2) and the use of knowledge developed in the well-established discipline of disaster risk reduction (DRR) (Section 3). Extracting main components of current DRR frameworks, we develop an alignment framework (Section 4) that is tested in four early adapter cities from different geographical areas and with contrasting socioeconomic backgrounds, for which substantial information on their plans is available. These are Copenhagen (Denmark), Durban (South Africa), Quito (Ecuador) and Vancouver (Canada). We discuss the potential use of this approach in the context of adaptation tracking and the future avenues of this area of research (Section 5) and present some final conclusions in Section 6.

2. Approaches to assess climate adaptation policies

In the last few years, there has been an increasing demand to assess the progress of adaptation policies at different scales and with different objectives. At global and national levels, institutional changes that mainstream climate adaptation into existing policies and administrative structures have been used to track adaptation (Berrang-Ford et al., 2014; Lesnikowski et al., 2016). Other approaches include several frameworks that have been developed to monitor and evaluate adaptation in the context of international climate funding, via donor agencies such as the Green Climate Fund or the Adaptation Fund (see, for example, Craft & Fisher, 2016; Lamhauge, Lanzi, & Agrawala, 2012; Brooks & Rowley, 2015; CPI, 2019). Other assessments have explored adaptation progress at the regional (Chan, Falkner, Goldberg, & van Asselt, 2016; Galarraga, Sainz de Murieta, & França, 2017) and local levels (Araos et al., 2016; Olazabal et al., 2014; Reckien et al., 2018a; Woodruff & Stults, 2016), or across scales (Olazabal, Ruiz de Gopegui, et al., 2019). Sectorial approaches have also been developed, as it is the case of Austin et al. (2016), that examined the advances of adaptation policies in the health sector in several OECD countries, or Kamperman and Biesbroek (2017), that looked at the evolution of adaptation measures in the Dutch water sector. However, in most cases, the aim of the evaluation was limited to the accounting of outputs and description of processes, while smaller attention was paid to the impacts of the initiatives themselves. The literature on adaptation tracking (or evaluation) has focused on the adaptation process itself or adaptation outputs, as these are "concrete, tangible products or services resulting from the use of inputs toward a particular (set of) objective(s)" (Spearman & McGray, 2011: 66). Output-based methods represent an important contribution to adaptation tracking as credible approaches that include sound scientific, technical, ethical, political and economic considerations are more likely to achieve the intended outcomes (Chan et al., 2016; Olazabal, Galarraga, et al., 2019). However, they are also indirect as they do not provide information on the effectiveness of adaptation policies and how much these are contributing to reducing climate change impacts.

As a result, there is an increasing interest in measuring the outcomes, i.e. the effectiveness of adaptation in terms of risk reduction or increased resilience (Hallegatte & Engle, 2019). However, if adaptation tracking faces important conceptual, methodological and empirical challenges (Ford et al., 2015), measuring the effectiveness or outcomes of adaptation poses an even more difficult encounter. Adaptation policy outcomes are difficult to assess due to the long-time horizons of the potential impacts (Ford, Berrang-Ford, Lesnikowski, Barrera, & Heymann, 2013), the lack of a clear baseline for comparison and the recent implementation of many of these policies, which makes calculating their effectiveness rather difficult, and in some cases even impossible (Chan et al., 2016). Additionally, establishing the causal relationship between an adaptation policy or measure and the desired outcome is not always straightforward, as other policies and factors might also be involved and usually are (Ford et al., 2015). Attribution is problematic in the case of climate adaptation also due to the specific challenges it faces, e.g. uncertainty in the timing and intensity of the impacts, long timescales and its cross-sectorial nature (Klostermann et al., 2018). Furthermore, in many cases the necessary data to assess if actions have been fully effective only becomes available after an extreme climatic event occurs.

In this sense, Monitoring, Evaluation and Reporting (MER) processes turn into an important asset in adaptation policies, plans and projects. MER systems help to "assess progress and outcomes according to a set of goals" defined for the adaptation policy, plan or project (Olazabal, Galarraga, Ford, Lesnikowski, & Sainz de Murieta, 2017: 5). MER systems are indispensable to follow-up the implementation processes, ensure that the objectives will be met and enable for adjustments and flexibility (Klostermann et al., 2018). An absence of these mechanisms was evidenced in local adaptation plans (Araos et al., 2016), but new research has found that MER processes are included or proposed to be developed in more than 90% of the adaptation policies globally (Olazabal, Ruiz de Gopegui, et al., 2019). How they are used and if they include sufficient information to support adaptation decision-making, is yet to be explored.

Ford et al. (2015) or Preston, Westaway, and Yuen (2011), for example, have argued in favour of indirect measures, to avoid the obstacles posed by outcome-based approaches. But tracking and evaluating adaptation outputs is no guarantee that climate risks are being reduced and that societies are growing more resilient. On the contrary, time and resources might be wasted in policies and measures that do not necessarily reduce vulnerability, leading to maladaptation (Barnett & O'Neill, 2010; Juhola, Glaas, Linnér, & Neset, 2016; Leiter & Pringle, 2018), referring to an "action taken ostensibly to avoid or reduce vulnerability to climate change that impacts adversely on or increases the vulnerability of other systems, sectors or social groups" (Barnett & O'Neill, 2010:211).[1] In this context and given the difficulties to address adaptation evaluation through an outcome-based approach, the need to find assessment approaches that guarantee risk consideration might prove to be a relevant alternative.

3. A risk lens in adaptation policy

3.1. Review of current risk approaches

In its 5th Assessment Report (AR5), the IPCC introduced a risk-based framework to assess adaptation, which focuses on three elements: hazard, vulnerability and exposure, defining risk as to the combination of all three of them (IPCC, 2014). In this context, there is an increasing interest in using risk-based approaches, including appropriate methods and metrics, to support adaptation decision-making. A risk-based approach can also help linking adaptation planning and climate risk reduction by guaranteeing that both policies are coherent, coordinated and, ultimately, aligned (Dow et al., 2013). We can thus define alignment as the extent to which linkages between climate adaptation and risk management policies exist, ensuring the coherence of both policies. This alignment presents several advantages: firstly, risk management is a well-established discipline, familiar not only to decision-makers but also to many stakeholders, financial entities and private companies, and it has been previously applied to deal with current natural hazards in many different contexts and scales (Rosenzweig et al., 2011; Yohe & Leichenko, 2010). Secondly, risk-based methodologies enable dealing with uncertainty and defining robust measures that perform well under a wide variety of scenarios, which is very relevant to build flexibility in a dynamic climate-change setting (Chambwera et al., 2014). Thirdly, these approaches can support an effective public expenditure not only in the light of high probability extremes but also considering low-probability, high-damage events that may have catastrophic results (Abadie et al., 2017; Yohe & Leichenko, 2010). In addition, one could argue that these approaches may also be used to stress-testing both adaptation actions and plans (Galarraga, Sainz de Murieta, Markandya, & Abadie, 2018). Finally, applying risk-based approaches to climate change adaptation has been suggested to be relevant to account for different perceptions of risk and corresponding social preferences, including identifying risk thresholds, prioritising interventions, discussing available strategies to manage and cope with risk and estimate the costs or trade-offs of the different options (Dow et al., 2013).

Risk-based approaches to develop and inform public climate change adaptation policies have been already used at the local level. Good examples are the Thames Estuary 2100 (TE2100) project, that developed a long-term plan to manage flood risk in the Thames Estuary for the following 100 years (Lowe, Reeder, Horsburgh, & Bell, 2008; Ranger, Reeder, & Lowe, 2013), and the adaptation plan developed by the city of New York (Yohe & Leichenko, 2010). However, risk-based approaches to inform the accomplishment of adaptation outcomes remain a challenge and few examples exist. For example, Aerts et al. (2014) develop a comprehensive methodology to determine the effectiveness of several adaptation strategies that aim at reducing vulnerability or reducing coastal flood-risk in New York City. The assessment uses a probabilistic risk assessment of the impacts of hurricanes and storm surges to estimate the vulnerability of exposed areas at high resolution, including a cost-benefit analysis of each measure under different scenarios. Probabilistic approaches have also been used to estimate the risk posed by future sea-level rise and extreme events in 120 coastal megacities (Abadie et al., 2017). The authors suggest that this kind of risk-based approaches could be used to co-define acceptable levels of risk in cities, involving stakeholders and with the final aim of supporting effective adaptation planning.

Despite the synergies that could arise from aligning DRR and climate adaptation for sustainable development, Birkmann and von Teichman (2010) identified a number of differences that have hindered integration in practice. The first barrier refers to different time and spatial scales. The authors argue that climate change has been mainly assessed from a global perspective, compared to a more local approach to disaster risk management (DRM). The authors refer to the lack of local climate data that could contribute to easier integration of DRM and adaptation policies. However, the literature framing adaptation as a local issue has bloomed in the last decade, and so has its practice, with cities worldwide planning for adaptation. Thus, the spatial scale should not be an insurmountable barrier, despite the need for local climate data. As for temporal scales, climate change and, consequently, adaptation policies have long-term perspectives. While disaster risk management in principle aims at achieving sustainable development and strategies should have a long-term focus, in practice, many of the efforts concentrate on short term post-disaster reconstruction. The second barrier is what Birkmann and von Teichman (2010) call "knowledge mismatches", referring to the lack of common definitions, indicators and norms, which has already been mention as a challenge to adaptation. The third barrier relates to different governance traditions. In practice, DRR is often managed by development, interior or even defence departments. Climate adaptation, in turn, most usually lies with the environment and natural resources departments or agencies.

In summary, risk-based approaches to determine the effectiveness of adaptation have a large potential to support adaptation decision-making in different ways, but they often require a large amount of data, resources and multi-disciplinary expertise that is not always available (Connelly, Carter, Handley, & Hincks, 2018; Yohe & Leichenko, 2010). Other approaches that consider climate hazard and impact indicators can result very valuable to inform local policymakers about the effectiveness of planned or ongoing adaptation initiatives and to check whether these are well aligned to climate risks (Jacob, Blake, Horton, Bader, & O'Grady, 2010). We thus aim at finding a good compromise between ideal measurement and the practicality and "readiness to be used" of the framework.

3.2. Main components across DRR frameworks

The Sendai Framework 2015–2030 is a voluntary non-binding agreement that aims at achieving "the substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries" (UNISDR, 2015a: 5). To respond to the global challenge of reducing disaster risk, the Sendai Framework defined four priorities for action:

(i) **Understanding risk**, which refers to the knowledge of risks in terms of likelihood, frequency and expected future evolution.
(ii) Strengthening **governance for risk management**, about institutional coordination, mainstreaming adaptation across policies and, in general, the adequate governance structure to deal with climate risks.
(iii) Acting to **reduce disaster risk and build resilience**, which addresses the existing adaptive capacity, policies to increase resilience and reduce vulnerability and exposure.

[1] Barnett and O'Neill (2010) identify 5 types of maladaptation as actions that (i) result in increasing emissions, (ii) have higher economic, environmental or social costs than other alternatives, (iii) reduce incentives to adapt, (iv) are not flexible nor reversible and (v) affect most those at greater risk.

(iv) Improving **disaster preparedness and recovery** processes. Disasters will occur despite strong mitigation efforts, so this priority deals with the preparedness and post-disaster recovery processes, including financial protection.

To reduce bias and increase the coherence and applicability of our proposal, we have also analysed the core elements of three other disaster risk management, adaptation and risk-tracking frameworks. These are (i) the Hyogo Framework for Action, which preceds the Sendai agreement; (ii) the Tracking Adaptation and Measuring Development (TAMD) framework, designed for assessing the efficiency and adequacy of adaptation measures, and mainly oriented to developing contexts (Craft & Fisher, 2016). This framework is relevant to this study as it is one of the few examples that look at adaptation-outcomes. And finally, (iii) the index of Governance and Public Policy for Disaster Risk Management (iGOPP), developed by the Inter-American Development Bank (IDB) to evaluate a country's progress toward the adoption of DRM processes. The critical elements of the different frameworks are presented in Table 1, showing their similarity to and synergies with the Sendai action priorities.

Despite the different structure or classification used in each case, we found that all key elements in the different frameworks address the four main Sendai priorities of action. For example, *the understanding of risk* is a key element in all four frameworks. While in the Sendai Framework, it constitutes the first priority for action, under the Hyogo Framework, it is included in the second priority of action aimed at identifying, assessing and monitoring risks, which implicitly refers to understanding risk. The TAMD Framework identified the need to incorporate uncertainty and use appropriate methodologies to assess risk, and the iGOPP index includes a section on risk identification and knowledge. This correlation between the different frameworks, observable in Table 1, is the reason why we chose to define the core components of our proposed risk-based approach following the four priorities of action of the Sendai Framework.

4. Methodological proposal and testing conditions

4.1. The ARPA framework

Based on the four major components of the risk-based approach identified in Section 2 and following the relevant literature that has developed risk or adaptation-progress indicators, including the reports by UNISDR (2017a, 2017b) to promote resilient cities, we propose the Adaptation-Risk Policy Alignment (ARPA) framework. For this purpose, we have identified 23 easy-to-apply metrics across components, which can be used within a risk-based framework. Table 2 below outlines the metrics proposed grouped in four main components: (i) understanding risks, (ii) risk governance, (iii) disaster risk reduction and resilience and (iv) disaster preparedness, response and recovery. Since we are assessing the alignment of adaptation policies and climate risks as a means to build resilience, it is important to note that only risk indicators relevant to climate change adaptation have been considered in this framework. Also, for the sake of simplicity, the indicators are defined as binary, i.e. if adaptation policies and measures account for the risk indicators defined in Table 2, the metric is given a value of 1. If no evidence is found, the value is 0. We acknowledge that scoring is not without problems, but it has been successfully used for adaptation tracking purposes before as it allows for some degree of comparability across planning processes, time and case studies (Araos et al., 2016; Heidrich, Dawson, Reckien, & Walsh, 2013; IDB, 2015; Kamperman & Biesbroek, 2017; Lesnikowski et al., 2016; Morgan, Nalau, & Mackey, 2019; Olazabal, Galarraga, et al., 2019; Preston et al., 2011).

Due to the particularities of the areas to be assessed in terms of their geographic or socio-economic characteristics, their adaptation preparedness stage or their acceptable risk level and to allow comparability, we opt not to weight the different components. The relative importance of the components is likely to be case-specific and differ from place to place. For the same reason, we do not produce a global score; instead, we test the alignment per component, intending to provide support to identify those areas that need more attention. The alignment framework can be used as ex-ante guidance or/and ex-post evaluation of adaptation policies to improve the integration and coherence of these policies and climate risks. That is, as a policy planning tool and/or a policy fine-tuning instrument.

Also note that due to the uncertainty related to climate hazards, their impacts and the long-time frames of adaptation strategies in many cases, this framework should not be considered a static recipe for measuring the alignment of adaptation policies to climate risks. Instead, the framework should be flexible, as the monitoring and evaluation processes themselves should also feed, at regular intervals, the existing policies and monitoring tools (Yohe & Leichenko, 2010).

Table 1
Comparison between the Sendai Framework for disaster risk reduction and other tracking frameworks (Craft & Fisher, 2016; IDB, 2015; UNISDR, 2015a, 2008), including the risk-based approach developed in this study.

Risk-based approach	Sendai Framework 2015–2030	Hyogo Framework 2005–2015	TAMD Framework	Inter-American Development Bank (IDB)
Core components	Priorities for action	Priorities for action	Dimensions of climate risk	iGOPP index
1. Understanding risk	Priority 1. Understanding disaster risk	Priority 2. Identify, assess and monitor disaster risks and enhance early warning.	Planning under uncertainty using appropriate methodologies	2. Risk identification and knowledge
2. Risk governance	Priority 2. Strengthening disaster risk governance to manage disaster risk	Priority 1. Ensure that disaster risk reduction is a national and a local priority with a strong institutional basis for implementation.	Climate integration into planning Institutional coordination for integration Participation of relevant stakeholders in national planning	1. General framework of Governance for disaster risk management
3. Disaster risk reduction and resilience	Priority 3. Investing in disaster risk reduction for resilience	Priority 3. Use knowledge, innovation and education to build a culture of safety and resilience at all levels. Priority 4. Reduce the underlying risk factors.	Institutional knowledge and capacity	3. Risk reduction
4. Preparedness, response and recovery	Priority 4. Enhancing disaster preparedness for effective response and to "Build Back Better" in recovery, rehabilitation and reconstruction	Priority 5. Strengthen disaster preparedness for effective response at all levels.	Awareness among stakeholders	4. Disaster preparedness 5. Post-disaster recovery planning 6. Financial protection

Table 2
Indicators that can measure the alignment of adaptation policies to climate risks, per component.

Component	Indicator	Indicator type	Source
1. Understanding risks	1.1 Current and future climate hazards are identified	Output	Brooks, Anderson, Ayers, Burton, and Tellam (2011) Lamhauge et al. (2012) Mechler (2016) Rosenzweig et al. (2011) UNISDR (2017a, 2017b, 2008) Woodruff and Stults (2016)
	1.2 Hazard probability is estimated	Outcome	
	1.3 Low-probability, high-damage events are considered	Output	
	1.4 Population at risk is identified	Outcome	
	1.5 Assets and critical infrastructure at risk are identified	Outcome	
	1.6 Risk-damage assessments are calculated	Outcome	
	1.7 Information on hazards and risks is regularly updated	Output	
2. Risk governance	2.1 Integration of risk-related measures in regulatory documents other than the adaptation plan	Output	Olazabal, Galarraga, et al. (2019) Brooks et al. (2011) van Asselt and Renn (2011) Woodruff and Stults (2016) UNISDR (2017a, 2017b, 2008)
	2.2 Institutional coordination for risk-management has been organised	Output	
	2.3 There is evidence of the participation of experts, stakeholders and the civil society on risk-related aspects	Output	
	2.4 Monitoring, evaluation and learning processes are defined	Output	
3. Disaster risk reduction and resilience	3.1 Population at risk after implementing adaptation is estimated	Outcome	Brooks et al. (2011) Solecki et al. (2015) UNISDR (2017a, 2017b, 2015b, 2008) Woodruff and Stults (2016) World Bank (2011)
	3.2 Assets at risk after implementing adaptation is estimated	Outcome	
	3.3 Direct economic loss resulting from climate risks are estimated	Outcome	
	3.4 Potential economic benefits of adaptation are calculated	Outcome	
	3.5 New developments in areas at risk are limited or additional measures planned	Output	
	3.6 Adaptation measures devoted to increase resilience and/or reduce risks are defined	Output	
	3.7 Flexibility has been incorporated into planning (e.g. no- or low-regret adaptation options are planned, adaptation pathways defined…)	Output	
4. Disaster preparedness, response and recovery	4.1 Disaster preparedness		UNISDR (2008) IDB (2015) UNISDR (2017a, 2017b, 2015b) Solecki et al. (2015)
	4.1.1 Early warning systems in place	Output	
	4.1.2 Risk monitoring and forecasting systems in place	Output	
	4.1.3 Preparedness and response plans exist	Output	
	4.2. Financial protection		
	4.2.1 Financial mechanisms for disaster recovery, including contingency funds, exist	Output	
	4.2.2 Insurance protection exists in the city, across sectors, business and individuals?	Output	

4.2. City cases and testing approach

In order to test the ARPA framework, as pilot case or plausibility probe before large scale testing (George & Bennett, 2005; Hsu et al., 2017), we selected four cities: Copenhagen (Denmark), Durban (South Africa), Vancouver (Canada) and Quito (Ecuador), that have three main common characteristics that make them be worth experimental cases. First, all four cities have made significant progress on adaptation and are recognised as early adapters (Araos et al., 2016; Carmin, Roberts, & Anguelovski, 2011; European Commission, 2013): as such, they have implemented local adaptation plans as early as 2006. Copenhagen is a signatory of the Covenant of Mayors; Durban, Vancouver and Quito are members of the 100 Resilient Cities initiative by the Rockefeller Foundation and they all belong to the C40 Group. Due to this long experience in adaptation planning, each of the metrics proposed in our framework, even the most ambitious ones, can be tested and contrasted. Second, these cities represent very different socio-economic contexts: Durban and Quito are located in developing countries while Copenhagen and Vancouver are located in rich industrialised countries. Studies addressing urban climate adaptation are more frequent in developed contexts (van der Heijden, 2019), but considering that disaster preparedness and capacity building are weaker in developing countries, the alignment of adaptation efforts with disaster risk is especially relevant, so it was important to test the ARPA approach in different settings. Third, the selected cities represent a range of different climate challenges. While extreme rainfall is one of the main priorities in Copenhagen and coastal flooding is a major concern to Vancouver, water availability, together with extreme events and food production are the main expected impacts in Durban. In addition to water scarcity, Quito faces other non-climate-change related risks due to its abrupt volcanic geography. Table 3 presents some of the main characteristics of these four cities.

5. Results and discussion

5.1. Pilot testing the ARPA framework

Ongoing adaptation initiatives in each of these cities were identified, following a similar search protocol such as the ones used in Reckien et al. (2014), Araos et al. (2016) and Olazabal, Galarraga, et al. (2019). We searched for relevant information in each city's official website to identify government documents reporting planned adaptation policies that aimed at reducing climate risks and vulnerability. We focused on planned municipal action and reviewed those documents that were publicly available. The type and number of documents examined are case-specific, but we reviewed the adaptation plans and other subsidiary documents in all cities (Table 3). For example, in Copenhagen, we analysed its *Climate Adaptation Plan* (2011) and the two *Climate Change Adaptation and Investment Statement* reports published in 2015. We also reviewed the *Green paper on the insurance of natural and man-made disasters* (2013). In the case of Durban, the city has a local *Disaster Management Plan* (2016), that we examined additionally to the current

Table 3
Characteristics of the selected case studies.

Characteristics	Copenhagen	Durban	Quito	Vancouver
Country	Denmark	South Africa	Ecuador	Canada
Country per capita GDP (2018)[a]	61,350	6374	6345	46,233
Country GINI Index[b]	28.2 (2015)	63 (2014)	44.7 (2017)	34 (2013)
Population (thousands, 2015)[c]	1721	3063	1734	2437
Main climate impacts	• Extreme rainfall • Sea-level rise • Heatwaves	• Water availability • Extreme events • Biodiversity loss • Agriculture and food production • Health	• Water availability • Health • Agriculture • Ecosystems • Risks (e.g. fires, floods)	• Extreme rainfall • Sea-level rise • Extreme events • Heatwaves
Networks				
C40	✓	✓	✓	✓
100 Resilient Cities		✓	✓	✓
Covenant of Mayors	✓			
Main adaptation plan or strategy identified	Copenhagen Climate Adaptation Plan (2011)	Durban Climate Change Strategy (2015)	Quito Climate Action Plan 2015–2025	Vancouver Climate Change Adaptation Strategy (2012)
Number of adaptation documents revised	4	10	5	4

[a] Source: World Bank Data.
[b] Source: World Bank Data. The Gini index is used to measure income inequality.
[c] Source: UN World Urbanization Prospects: The 2018 Revision. Population refers to urban agglomerations.

Durban Climate Change Strategy (2015) and related reports and documents, such as the previous adaptation strategy from 2006, an ulterior local Climate Protection Programme Climate (2011) and several other reports addressing climate change in specific sectors (e.g. water and health). The full list of revised documents is included in the Supplementary material (Table SM1).

Once the relevant adaptation planning documents were collected, each document was critically analysed to identify the evidence that responds to the indicators listed in Table 2, assess how these adaptation policies account for climate risks and obtain a score for each of the four major alignment components. The higher the score, the stronger the goals of adaptation are linked and coherent with risk reduction approaches. The list of 23 indicators has been evaluated in every city, as explained in Section 4.1. The value of each component is obtained by summing up the scores of the indicators grouped in the component. The score per city and component is presented in Fig. 1 below. Further details are provided in the Supplementary material (Tables SM2–5).

In component 1, on **understanding risks**, we find that all cities identify current and future hazards. The probability of occurrence is considered except in Quito, where only national-level projections are available. However, the Ecuadorian city does consider worst-case scenarios, unlike Durban. In terms of exposure, the population at risk is identified, with more or less level of detail, in all cities but Durban, even though this city did include a general estimation of the population at risk in previous documents (e.g. Naidu, Hounsome, & Iyer, 2006). Assets at risk, at least for some hazards such as sea-level rise, are also considered by all cities, except Quito. Potential damages are estimated in Vancouver and Copenhagen. Vancouver is the only city that commits to annual and five-year reviews of its adaptation strategy, including the update of climate hazards and related impacts. Durban does consider regular reviews of the strategy, even though it does not mention hazard nor impact data. Vancouver presents the best performance in all four components, followed by Copenhagen. According to these results, both cities present a strong alignment of planned adaptation measures and the understanding of climate risks (see light green shaded accumulation in Fig. 1).

All cities show a strong alignment concerning the second component, **risk governance** (see blue shaded accumulation in Fig. 1). This component is assessed through four indicators, the first looking at how risk is integrated into related local regulatory frameworks. Copenhagen's plan, for example, includes a specific section on local regulations that need to be updated in the light of flood risk. In Durban, the implementation of the strategy foresees those policy documents in which adaptation needs to be mainstreamed and Vancouver's strategy stresses the need for integration. Quito defined a strategic objective for the integration and mainstreaming of adaptation policies into other areas. The second indicator evaluates if institutional coordination for risk management has been organised and we find that in all cities different municipal departments have been involved in the development

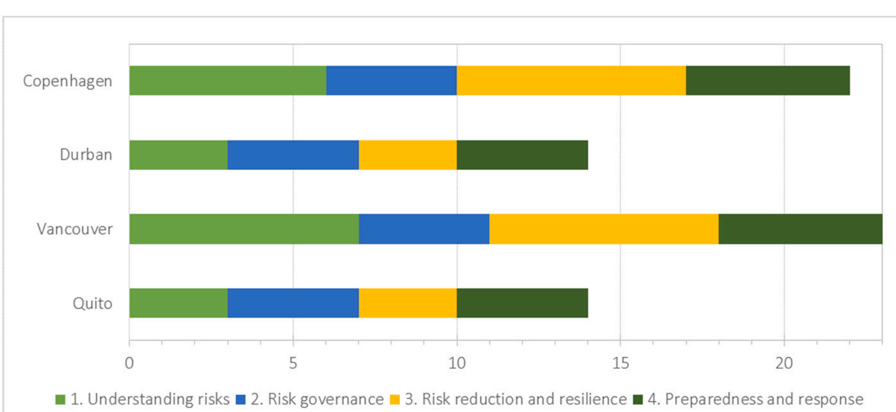

Fig. 1. Scores obtained for each component and case study. (For interpretation of the references to colour in this figure, the reader is referred to the web version of this article.)

of the strategy. In some cases, there has also been vertical integration at national (e.g. Copenhagen) or provincial level (Durban or Vancouver). In Durban, the Environment and Climate Change department was also part of the Disaster Management Advisory Forum (DMAF), created under the umbrella of the municipal Disaster Management Plan. As for stakeholder engagement (third indicator), it is mentioned in all four adaptation plans. In Copenhagen, participatory processes are included in the strategy, and particularly in the annual project implementation reports. In Vancouver, stakeholder engagement is also included in several sectorial assessments related to the adaptation strategy, such as in the coastal risk report. Durban provides detailed information about participatory processes and Quito has a specific report explaining the participatory process followed to develop the initial assessment. The last indicator refers to the existence of monitoring, evaluation and learning (MER) processes. All cities foresee a regular revision of the plan (e.g. Copenhagen) or include a MER system (Quito). In Vancouver, its strategy incorporates an implementation plan, a schedule for evaluation and a list of potential adaptation indicators. Durban's climate change strategy outlines a MER system, that needed further development, but no evidence of this has been found. However, we observe a lack of follow-up processes within the adaptation plans. Global evidence shows that despite the progress in incorporating monitoring systems in local adaptation plans, it is yet uncommon to find reporting of such processes (Olazabal, Ruiz de Gopegui, et al., 2019

In addition, while most of the strategies and plans acknowledge the importance of monitoring and evaluation processes (in the case of Vancouver, a set of potential adaptation indicators has even been proposed), no public evidence has been found of these evaluation processes in any of the cities analysed.

Component 3 addresses **resilience and disaster risk reduction** measures (yellow shaded area in Fig. 1). Outcome indicators 3.1 to 3.4 aim at assessing whether the risk reduction potential of adaptation measures included in the plan has been considered. In other words, if the benefits of adaptation measured in terms of the impacts that can be avoided have been accounted for. Copenhagen and Vancouver show a high alignment: in both cities reduced asset and population exposure is estimated for certain risks, as well as the potential economic losses due to climate risks and the benefits of the proposed adaptation measures. No evidence of this is found for Durban nor Quito. Nonetheless, all cities propose additional measures to protect new and existing developments. For example, Durban and Quito foresee relocation strategies in areas at risk, while Vancouver established a building bylaw to raise constructions levels in risk-prone areas. Copenhagen's adaptation plan projects raising building elevations and updating existing planning documents and regulations to ensure adaptation is mainstreamed in future developments. The last indicator of component three refers to flexibility, a key principle to deal with uncertainty (Sainz de Murieta, Galarraga, & Markandya, 2014) and urban resilience (Ahern, 2011; Olazabal, 2017). In all cities, we find evidence of flexible measures (e.g. planning of no- or low-regret adaptation options), even if the term is only mentioned as such in the case of Quito. Vancouver and Copenhagen have flexibility as a guiding principle in the light of uncertainty, and Durban explicitly acknowledges the need for flexible approaches to respond to changing risks.

Component 4, **on preparedness and response**, scores well across cities showing a strong alignment with the concept of risk (dark green area in Fig. 1). All cities have forecast and early warning, monitoring and forecasting systems planned or underway, and that is also the case of emergency response plans. Regarding financial mechanisms for disaster recovery, Copenhagen and Vancouver mention the existence of compensatory schemes and Quito has a disaster risk and emergency fund set up in 2008, that is provisioned from the municipal budget. No evidence of such mechanisms was found in Durban. As for insurance, this is mentioned in Copenhagen as a key area to be addressed. In view of increasing insurance costs due to climate risks, Vancouver foresees working with the sector to develop adequate risk reduction products. The role of insurance and/or other risk-pooling schemes has been acknowledged to be decisive (Hochrainer-Stigler & Mechler, 2011; Surminski, 2014). In the case of Durban, the country has one of the highest insurance penetration rates, and this potentially represents a strength to develop new insurance products to share the losses in the light of more frequent climate extremes. However, this area should be further explored in Quito. Ecuador's capital city has one of the lowest penetration rates in Latin America. Mainstreaming insurance provision, together with other social protection measures, could be an effective risk management measure (Siegel & Fuente, 2010). Insurance might also prove to be useful to avoid risk-induced poverty traps. In these contexts, local governments could play a key role in making sure the insurance designed reaches the most vulnerable (Dercon, Bold, & Calvo, 2008).

In summary, Copenhagen and Vancouver have adaptation strategies highly aligned with a climate risk-based perspective. Durban and Quito show a lower alignment and perform in quite a similar way. The highest alignment is obtained with regards to risk governance. Both cities have made significant efforts to promote the integration of climate change adaptation into other sectoral policies and governance scales. In the case of Quito, the city implemented several individual disaster risk management plans during the late 1990s, but these were not able to respond to the serious governance and sustainability challenges of the city. As a result of this experience, a more integrated policy approach that linked adaptation to disaster risk management, sustainability and other social challenges (poverty, increasing populations, budgetary constraints) was considered key to achieve a more effective reduction in vulnerability (Obermaier, 2013). A similar experience was lived in Durban, where the very early Headline Adaptation Strategy published in 2006 was not effective to mainstream adaptation into other sectoral policies and municipal departments. The next planning process had two main lines of action: the first, putting the main city sectors at the centre of the adaptation strategy, by developing sectorial plans; the second, promoting the participation of local communities through specific community-based adaptation programs (Anguelovski, Chu, & Carmin, 2014). This stronger focus on governance in Durban and Quito, together with broader development challenges, seems a likely explanation for obtaining a higher result in component 2, 'risk governance', compared to the first one, on 'understanding risks'. Finally, the regular integration of updated climate and risk projections is a weak area in all four cases. In a context of great uncertainty about future impacts, learning and evaluation processes are critical to allow for flexibility and adjust plans or projects in the light of new information (Haasnoot, Kwakkel, Walker, & Ter Maat, 2013; Kingsborough, Borgomeo, & Hall, 2016).

5.2. Usefulness and applicability of the ARPA framework

One of the main strengths of the ARPA framework is that it is relatively easy to apply in most city planning processes to assess the alignment or coherence between adaptation and risk reduction efforts. The framework does not require a sophisticated data gathering process but instead, it is based on a systematic revision of regular public information practices. The fact that it may be applied in both the policy design and implementation phase as well as the policy revision or fine-tuning cycles is also a considerable advantage compared to other frameworks. For these reasons, the ARPA framework could prove to be very useful in adaptation tracking exercises but also supporting decision-making on adaptation at the local scale.

Note, however, that ARPA also presents some limitations to be highlighted. First, in this paper, we do not assess the policy process itself. This work was previously advanced in Olazabal, Galarraga, et al. (2019) that developed a conceptual framework (Adaptation Policy Credibility – APC – assessment framework) and an operational index to evaluate how successful local adaptation plans might be, according to several indicators that measure legitimacy, policy, economic and technical credibility of local adaptation policies. The APC tool only includes risk and uncertainty consideration in 2 out of 53 metrics, which provide a limited understanding of how risk knowledge is integrated into adaptation planning processes. For this reason, APC and ARPA can be complementary offering a more complete picture of the effort made by cities in adaptation to climate change. Second, we only rely on the publicly available information without undertaking any in-depth interview with city managers or stakeholders that could validate or extend the assessment. One could argue, however, that a systematic review process can be advantageous to allow for comparison (Olazabal, Galarraga, et al., 2019) and that, for the sake of transparency, all relevant information should be publicly available in open and accessible information channels. This framework has been developed to be pragmatic and easy to be used in public policy planning and for most cities, and as such has left aside indicators that cannot be easily collected through secondary sources and interpreted. Third, the binary scoring approach implies trade-offs with having a more nuanced assessment. We assigned a score of 1 when we found any evidence responding to each indicator. However, this does not mean that evidence exists for all risks or sectors, nor that actual implementation has taken place.

The pilot testing offers some insights worth highlighting. For instance, cities show the highest score for 'governance', followed by 'disaster preparedness' while 'understanding risk' and 'disaster risk reduction and resilience' present the lower scores, especially in Durban and Quito. Both components include outcome indicators, whose quantitative assessment may need regionalised climate data and projections. However, risk assessments can also be qualitative (Conway et al., 2019; IPCC, 2014) and this kind of approach could prove to be useful in certain cities to overcome insufficient data or lack of modelling capabilities.

6. Conclusions

Adaptation to climate change is still relatively new in the field of public (and private) planning practise and is in the middle of a learning-by-doing process. The large uncertainty, the lack of clear baselines for comparison and the long-term nature of climate impacts make the planning process more challenging and require finding ways to integrate risks and uncertainties in a practical manner. Recent research shows that appropriately translating risk knowledge into policy action remains a challenge (Olazabal, Ruiz de Gopegui, et al., 2019), but it does not explain the degree to which climate adaptation policies are aligning with risk-based approaches. This would allow to identify areas for improvement and to undertake an adequate design, implementation and fine-tuning of adaptation policies.

The ARPA framework is, to our knowledge, the first attempt to measure the alignment of both the adaptation strategy/plan/policy and the way climate risks, from a disaster reduction lens, are integrated into the planning processes. The framework could be much more complex, but at the cost of making it unrealistic to be implemented in real policy planning processes. To illustrate its applicability and usefulness, the ARPA framework has been pilot-tested in 4 cities worldwide, all of them considered front-runners in climate adaptation planning. Our results suggest that the ARPA framework could be useful to inform adaptation tracking assessments, as well as supporting adaptation policies by guiding a risk-based planning process. Despite its potential, the pilot testing exercise has shown that assessing the progress of these early adapter cities planning is still difficult through secondary sources. Most of the key risk issues in ARPA are promisingly incorporated in the planning processes, but the gap between planning and actual implementation still remains.

Finally, when there is a strong alignment between adaptation plans and climate risks according to ARPA, in other words when adaptation policies adequately integrate risk knowledge and information according to ARPA, it is possible to evaluate the potential effectiveness of adaptation policies in terms of risk reduction. This kind of information could be aggregated and upscaled to contribute to measuring the global progress of adaptation.

CRediT authorship contribution statement

ESM led and coordinated the study. ESM, IG and MO designed the conceptual approach. ESM designed the methodology and performed the analyses. All authors jointly discussed the results, conclusions and the supplementary material and edited the manuscript.

Declaration of competing interest

The authors declare that there is no conflict of interest.

Acknowledgements

This research is funded by the Basque Government through the BERC 2018-2021 program and by the Spanish State Research Agency through María de Maeztu excellence accreditation 2018-2022 (Ref. MDM-2017-0714). This study also counts with the support of Fundación Biodiversidad, from the Spanish Ministry of Ecological Transition, through the project PROCESA. MO has received funding from the AXA Research Fund under Grant Agreement No. 4771 and ESM acknowledges funding from the Basque Government (Ref. POS_2018_2_0027).

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.cities.2020.103018.

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