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Adaptation planning in large cities is unlikely to be effective

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A B S T R A C T

The assessment of public adaptation policies, strategies and plans to evaluate progress, effectiveness and long-term sustainability is challenging. The potential to develop an ex-post evaluation linked to outcomes is limited given the lack of policy implementation globally and the uncertainty related to when and how impacts will happen. Ex-ante evaluations, by contrast, seem more feasible when they focus on policy processes, contents and outputs. Yet, proxies that indicate credible outcomes need to be carefully selected. In both cases, how adaptation is integrated in local planning processes, and previous experience by governments seem to be crucial. In this paper we perform an ex-ante evaluation of adaptation planning in 59 cities, identified across a set of 136 coastal cities of over 1 million inhabitants located in developed and developing world regions. We assess 3 major areas: policy and economic credibility, science and technical credibility, and legitimacy. Overall, 53 metrics are used to assess how likely local adaptation policies are to be effective, implemented and sustained in the long-term. This global assessment reveals that current adaptation planning in big global cities has a significant space for improvement and is, overall, unlikely to be effective unless greater effort is invested in financing, regulatory context, monitoring and evaluation, and legitimacy aspects. We also discuss challenges and needs, assuming this sample is representative of current progress of adaptation planning in large cities.

1. Introduction

The 2015 Paris Agreement was a milestone for adaptation policy and planning. The role of adaptation in international negotiations was reinforced by (i) normative framing of adaptation action, (ii) integrating national adaptation commitments, (iii) highlighting the multilevel nature of adaptation governance, therefore, the implication of multilevel actors, and (iv) strengthening transparent mechanisms for assessing adaptation progress (Lesnikowski et al., 2017). After Paris, there has been a growing number of scientific studies measuring adaptation progress globally. Specifically, there are numerous studies focusing on urban areas (see e.g. Aguiar et al., 2018; Araos et al., 2016; Carmin, Nadkarni, & Rhie, 2012; Dulal, 2019; Guyadeen, Thistlethwaite, & Henstra, 2019; Heidrich, Dawson, Reckien, & Walsh, 2013; Le, 2019; Olazabal, Ruiz de Gopegui, Tompkins, Venner, Smith, 2019; Reckien et al., 2014, 2018; Shi, Chu, & Debats, 2015; Woodruff & Stults, 2016). This growth in urban adaptation tracking studies coincides with a wave of *urban pragmatism* characterised by an increased international attention placed on sub-national actors for their role in climate governance and policy (Castán Broto & Westman, 2020).

However, as extensively discussed in previous literature (Ford & Berrang-Ford, 2015; Magnan & Ribera, 2016; Magnan, 2016; Tompkins, Vincent, Nicholls, & Suckall, 2018), adaptation tracking (sometimes indistinctly labelled as adaptation evaluation, measurement, monitoring, or assessment) has numerous challenges and limitations due to, fundamentally, the ambiguity of the concept of adaptation (what can be considered adaptation?) and the lack of comparable, aggregable metrics. This eventually leads to a lack of consistent guidance across policy scales on how to plan and implement adaptation and how to evaluate its progress (Berrang-Ford et al., 2019; Biesbroek et al., 2018; Ford & Berrang-Ford, 2015; Ford et al., 2015; Tompkins et al., 2018).

The difficulties in assessing adaptation are not specific to the urban scale. However, it is at the local scale where most adaptation actions hit the ground and where governments and actors implementing adaptation actions are most pressured to justify their decisions and investments. Currently, one of the most important challenges in adaptation planning is the development of robust approaches for measuring the progress and effectiveness of implemented interventions (Olazabal, Ruiz de Gopegui et al., 2019). Yet, assessing the effectiveness of public adaptation policies is challenging given the lack of policy implementation globally (Araos et al., 2016; see e.g. evidence in Olazabal, Ruiz de Gopegui et al., 2019) and the uncertainty related to when and how impacts will happen (see e.g. Abadie, Galarraga, & Murieta, 2017). Thus, the evaluation of adaptation processes and outputs is, so far, the preferred option for measuring effectiveness (Berrang-Ford et al., 2019; Hallegatte & Engle, 2019). This reveals important challenges in defining ex-post evaluation frameworks for adaptation.

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Fig. 1. Cities and types of policies analysed. 59 planning documents covering three different policy scales have been identified: city scale (blue), metropolitan scale (yellow), and city-state and special cases (green) (Hong-Kong and Singapore). The types of planning documents are: joint approaches for mitigation and adaptation (circle), adaptation-only planning documents (triangle), and other types (square) e.g. sustainability, resilience, disaster risk management etc. (see Table A1). Black dots show port-cities with no adaptation-related planning according to Olazabal, Ruiz de Gopegui et al. (2019). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

At the same time, few studies to date have assessed and compared adaptation progress in cities worldwide using ex-ante approaches (examples are Araos et al., 2016; Carmin et al., 2012; Olazabal, Ruiz de Gopegui et al., 2019) and none of them, to our understanding, have developed a profound analysis of the adaptation planning process across global cities because of the efforts required to analyse large-n samples of adaptation planning city-cases.

In this paper, we develop a comprehensive assessment of adaptation planning in 59 large coastal cities of over 1 million inhabitants. Considering a set of the 136 largest port cities worldwide, the selected 59 represent the only cities with adaptation planning already in place (by April 2019) (Olazabal, Ruiz de Gopegui et al., 2019). We use the assessment framework proposed by Olazabal, Galarraga, Ford, Sainz de Murieta, Lesnikowski (2019) to assess how likely local adaptation policies are to be effective, implemented and sustained in the long-term. This study offers results which are critical for the improvement of adaptation planning and action on the ground and for guiding sound scientific research on urban adaptation planning practice.

2. Data and methods

2.1. The sample

Government-led adaptation initiatives across the 136 largest coastal port cities worldwide were documented In Olazabal, Ruiz de Gopegui et al. (2019). Local-level adaptation planning documents from 59 cities covering both Global North and Global South contexts were collected (see Fig. 1 and Table A1 in the Annex for the full list of documents collected). Here, we assess these local-level adaptation planning documents and the accompanying information available in public governmental websites. This documented public material is the best information available that can be used for comparative purposes, avoiding subjective self-reported information by governments.

Adaptation planning documents were originally identified both at local (city-level) and/or metropolitan policy scales (Olazabal, Ruiz de Gopegui et al., 2019). For the present study, we have selected one policy scale and related planning document per location, prioritising those with more detailed descriptions of policy processes, assessments and/or implementations plans. For example, we might have selected a metropolitan climate adaptation strategy over a local resilience plan if the former was richer in terms of adaptation-related content[1]. This study focuses on actual intentional public policy on climate change adaptation, i.e., we do not consider public policies that, although incentivise adaptation, are not motivated by the responsibility to act against climate change (Dupuis & Biesbroek, 2013). The documents, which are generally labelled as strategies or plans, are diverse in typology (covering broader or narrower topics such as climate adaptation, climate change, resilience, coastal management, master plans, disaster risk reduction, development, environment, or sustainability), but all include adaptation-related content. The sample, listed in Table A1 (in Annexes) and illustrated in Fig. 2, includes basic information such as city of reference, country, world region, policy scale, and typology.

Most plans[2] address adaptation-only (A) or combine mitigation and adaptation (A/M), i.e. the preferred option to plan for adaptation is through climate change focused plans. One third (34%) integrate adaptation-related content such as resilience plans, disaster risk reduction plans or master plans (Fig. 2a). Africa and Oceania have the lowest representation in this sample (Fig. 2b), however, with different implications. In the case of Oceania, only 6 large coastal cities were originally analysed in Olazabal, Ruiz de Gopegui et al. (2019), from which 5 had adaptation planning in place. In the case of Africa, however, local adaptation planning was found in only 3 out of 19 large coastal cities, 2 of which were located in a more developed country (South Africa). Fig. 2c shows the year of publication of the documents. Adaptation planning documents were collected between November 2018 and April 2019. Some documents date back to as early as 2011 and 2012, but the large majority were published after 2015 (both first generation and revised plans), which coincides with the wave of *urban pragmatism* (Castán Broto & Westman, 2020). The proportion of revised plans also increases after this date. Altogether, the percentage of revised

[1] In two cases, planning documents are labelled as regional but have, in practice, metropolitan nature (Miami's Southeast Florida Regional Climate Action Plan and Adelaide's Resilient East Regional Climate Change Adaptation Plan). See Table A1.

[2] We use, hereafter, the term "plan" to refer to planning documents identified in the sample, regardless of how they have been labelled (strategy, plan, action plan, policy, planning project… see table A1).

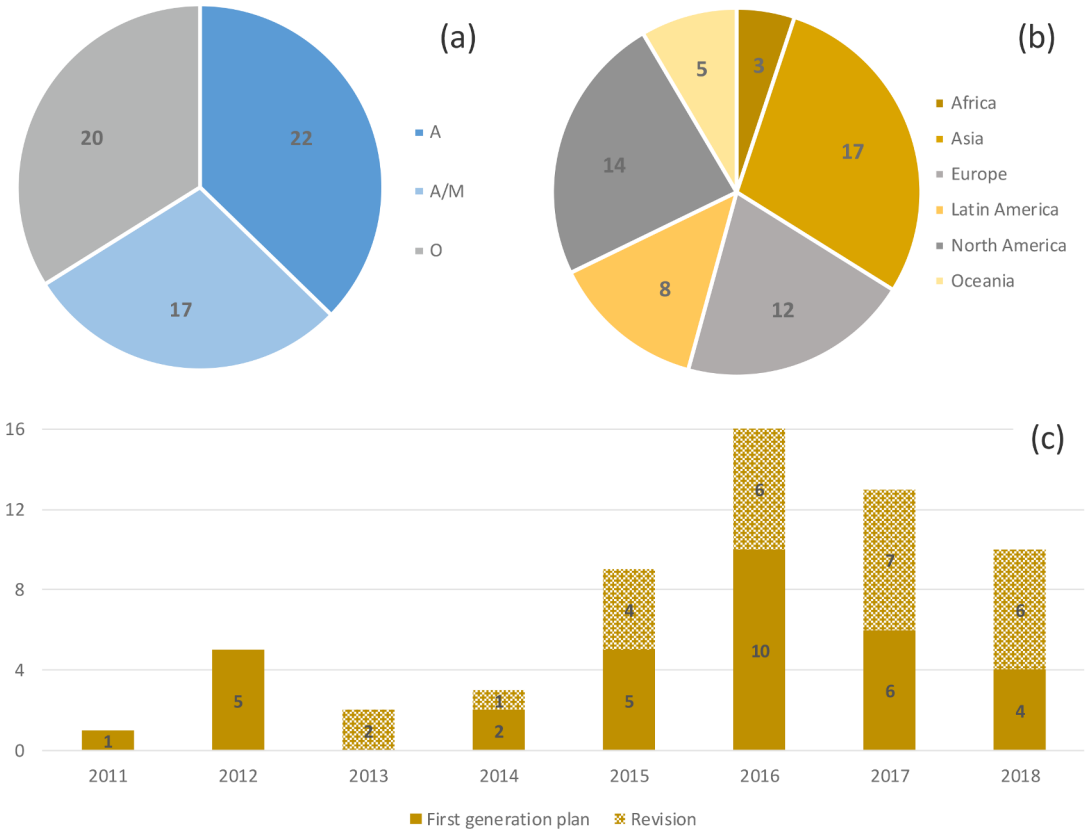

Fig. 2. Basic statistics of the sample data. (a) Typologies of plans (A: adaptation, A/M: mitigation and adaptation; O: others – see Table A1), (b) Distribution by world region and (c) publication year and evolution of plans. Source: Olazabal, Ruiz de Gopegui et al. (2019).

plans relative to the total number of plans is 43% which provides a good opportunity to test the practical space for learning and improvement.

2.2. Assessment method

The assessment method used in this study was proposed and validated by Olazabal, Galarraga et al. (2019). It has been applied in cities across Spain (Sainz de Murieta, Olazabal, & Sanz, 2020) and a version of the tool is being used by members of the RegionsAdapt initiative within Regions4[3]. It is inspired by the concept of credibility widely used in policy sciences and coined in the field of climate change by Averchenkova and Bassi (2016) who, in the context of mitigation pledges, argue that credibility is essential for climate finance to enable trust among actors. Something credible justifies confidence (OED, 2013). The study by Olazabal, Galarraga et al. (2019) is the first to use this concept in the field of adaptation with the purpose of informing policy making, investment, and funding strategies on adaptation given the need to generate reliable adaptation progress data. The APC (Adaptation Policy Credibility) method proposed by Olazabal, Galarraga et al. (2019) merges previous proposals from the scientific literature that address different parts of the adaptation policy process and outputs such as plan quality (Baynham & Stevens, 2014; as in, e.g., Preston, Westaway, & Yuen, 2011; Woodruff & Stults, 2016), adaptive capacity and readiness (as in Ford & King, 2015; Heidrich et al., 2013), policy process (as in Dupuis & Biesbroek, 2013), and legitimacy (as in Adger, Arnell, & Tompkins, 2005). The APC method is described as an ex-ante evaluation tool that assesses how likely local adaptation policies are to be effective, implemented and sustained in the long term. Source data include main documents related to adaptation planning and accompanying information that can be found in public governmental sites. The assessment framework includes three major areas: policy and economic credibility, scientific and technical credibility, and legitimacy, which are divided into 7 components and 17 indicators (see Table 1). For the operational assessment, 53 metrics are proposed (see Table A2). A comprehensive description of these indicators and metrics can be found in Olazabal, Galarraga et al. (2019), where the validity of the methodological approach was demonstrated through a pilot assessment. In this study, we aim to further expand on this approach through a large global comparative assessment.

Most metrics are qualitative and respond to a binary evaluation (e.g., Yes or No) (see evaluation methods for each metric in Table A2). Contents of planning documents and accompanying public information (found in planning appendices and governmental websites) were analysed in order to evaluate the metrics. In some cases, other types of public sources were consulted to collect public data such as GDP of the city (M#5) or public concern about climate change (M#16). Importantly, the method does not rely on primary sources for data collection (i.e. surveys to local government representatives), to avoid subjective self-reported data that may hinder comparability of the study results (Olazabal, Galarraga et al., 2019). Applying APC, Sainz de Murieta et al (2020) compared results of primary and secondary data collection sources and concluded that cities self-reported slightly better scores, apparently because they were evaluating aspects of the adaptation policy process that had never been publicly documented. Whilst this demonstrates that much may be happening behind the scenes (especially in cities where, due to politics, transparency is still an issue), we argue here that publicly documented information is a much more reliable source for assessments that aim to be comparable and replicable. Moreover, the APC framework itself includes a “Legitimacy”

[3] Network of Regional Governments for Sustainable Development. https://www.regions4.org/project/regionsadapt/

Table 1
Operational framework for the assessment of local adaptation policies (Olazabal, Galarraga et al., 2019).

Major areas	Components	Indicators	No. Metrics
Policy and economic credibility	1. Resources	1. Funding	3
		2. Consistency	2
		3. Prioritisation and timing	3
	2. Reliability	4. Past performance	3
		5. Assigned responsibilities	3
	3. Institutional, Public and Private Support	6. Public opinion	1
		7. Legislation and regulatory nature	2
		8. Network membership	1
		9. Leadership and support	5
Scientific and technical credibility	4. Usable Knowledge	10. Impacts and vulnerability assessment	4
		11. Adaptation options assessment	4
	5. Monitoring, Evaluation and Reporting (MER)	12. MER processes	6
	6. Adaptive Management	13. Learning mechanisms	3
		14. Uncertainty awareness	1
Legitimacy	7. Legitimacy	15. Transparency and dialogue	5
		16. Engagement of stakeholders and civil society	3
		17. Equity and justice	3
3 areas	**7 components**	**17 indicators**	**53 metrics**

component that precisely supports this methodological decision through Indicator 15 “Transparency and dialogue”.

Once data has been collected, responses are evaluated: positive responses are awarded with 1 point; otherwise, 0 points. For a few open questions, (e.g. M#5: *Overall plan budget relative to the GDP of the city (%)*, or M#6: *Number of measures*[4] *(N) contained in a plan relative to resources*), a specific evaluation method that translates responses into 1 or 0 is proposed. To calculate an overall score for each city case, metrics are equally weighted and sub-metrics normalised. The maximum score a local adaptation planning case can get is 53, equal to the total number of metrics.

Two analysts (the authors) were responsible for data collection, analysis and coding. Local policy documents were jointly selected from the original set published in Olazabal, Ruiz de Gopegui et al. (2019). Metrics were coded in three stages. In the first stage, the 53 metrics across the 59 city cases were coded by one analyst[5]. In the second stage, each individual case was discussed between the two analysts. In the last stage, the scores for each metric across the 59 cases were compared in order to guarantee replicability and coherency of the outcomes. The APC provides transparency in the evaluation method and the triple-stage coding process enables a reduction in ambiguities, especially in relation to data sources (policy document contents, annexes, city official websites or others) (see notes in Table A2).

In line with previous efforts (see e.g. Preston et al., 2011; Araos et al., 2016; Heidrich et al., 2013; Lesnikowski, Ford, Biesbroek, Berrang-Ford, & Heymann, 2016; Woodruff & Stults, 2016), the APC method allows the building of composite indices or sub-indices. This generates a huge amount of information that can be used to extract lessons and good practices, and to identify improvement areas and aspects where local governments need external support. However, combining metrics can also risk losing sight of the complex interactions that may arise among the components that are being compared - a main disadvantage of an indicator-based assessment approach (Olazabal, Galarraga et al., 2019). To avoid falling into simplistic evaluations, in this study we show results in aggregated and disaggregated forms and include as many city planning examples as possible that may be useful for illustrating the applicability of the assessment method.

[4] ‘Measures’ are understood here as the number of concrete actions contained in the planning document. These are also labelled across the literature as policies, options or initiatives, to name some examples.

[5] Using online language translators in cases other than Spanish, Portuguese, English or French.

3. Results and discussion

3.1. Overall city scores

The vast majority of cities show a large space for improvement and there are not significant world regional differences (Fig. 3; see final scores for each city in Table A1). With notable exceptions (Istanbul and the three Korean cities, Incheon, Busan, and Ulsan), most cities in Asia score poorly, below the mean. Importantly, most Asian plans have been recently published (after 2016) and more than half are revised plans. A similar pattern can be found in Australia (with the exception of Sydney), although the sample is smaller. Only two cases (Baltimore Disaster Preparedness Planning Project, 2018, and Los Angeles Hazard Mitigation Plan, 2018, both in United States, US) score higher than 30 (out of a total of 53). Coincidentally, these are the only plans in the sample where climate change adaptation is integrated in a disaster risk reduction plan.

Scholars have recently been engaging in debates on the benefits of dedicated plans vs. mainstreaming practices (Lyles, Berke, & Overstreet, 2018; Reckien et al., 2019; Woodruff, Meerow, Stults, & Wilkins, 2018), but there is little generalised evidence on how these different practices may affect implementation (and eventually effectiveness) and how they perform worldwide, since most comparative studies so far are concentrated in a few developed regions (mainly, North America and Europe). Our sample does not have equal representation of plans therefore it is not possible to perform significance tests (see Table A1 and Fig. 4), however, some preliminary conclusions could be drawn. Fig. 4a compares A/M, A and O plans. Plans classified as “others” (O) in this study cover a wide variety of plans. Fig. 4b shows how disaster risk reduction (DRR) plans (2, US) appear to have the highest credibility scores. This supports the idea that dealing with adaptation using a focused approach, intended specifically to reduce risks, is beneficial (Lyles et al., 2018). However, it also appears to be true in cases where adaptation is mainstreamed in a well-established policy area with a strong regulatory framework (such as DRR). A greater number of cases with global coverage is required to support these results and to assess potential differences across regional planning cultures.

Overall, the total mean score is 20.4 (see Fig. 3 and Fig. 5). Some city planning processes score as low as Hong Kong’s Climate Action Plan 2030+, 2017 (9.5), or as high as the Los Angeles Hazard Mitigation Plan, 2018 (40).

An interesting output is the aggregated value per indicator (Fig. 6), equal to the sum of plan scores for each indicator. This analysis offers perhaps the best method for identifying those indicators where efforts have been most invested, and those that, in turn, require more

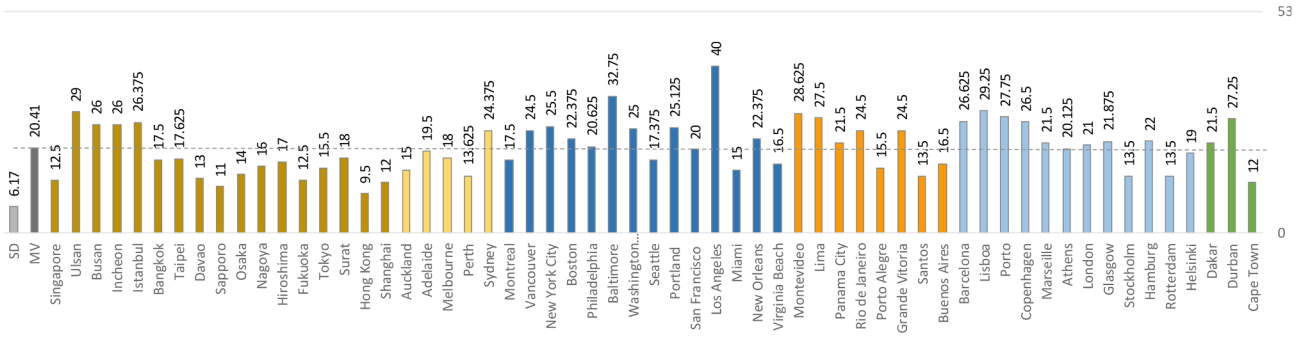

Fig. 3. Final aggregated scores per city. The maximum score is 53, equal to the total number of metrics used in the assessment of adaptation planning. Different colours denote different world regions. MV: mean value, SD: standard deviation.

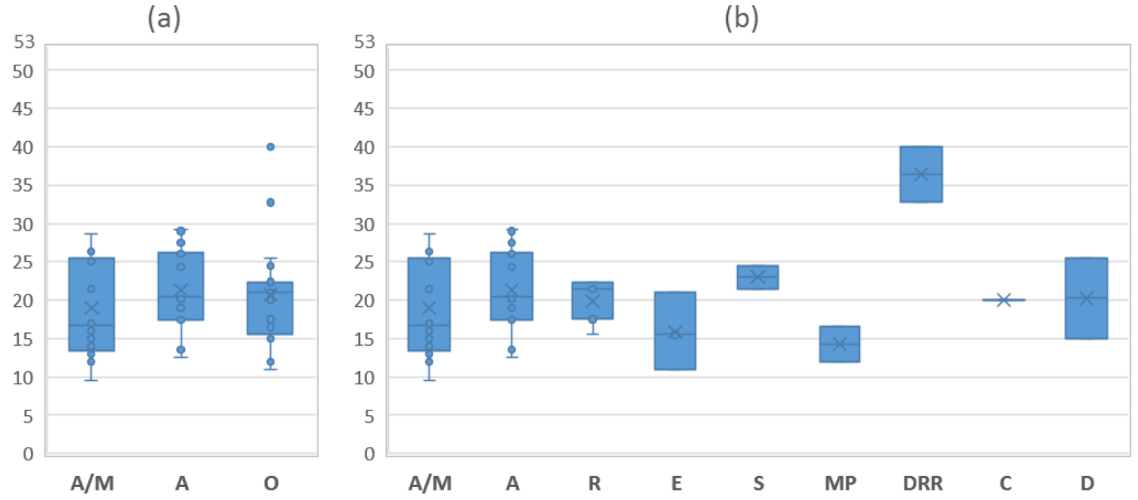

Fig. 4. Scores per type of policy. Note: A/M (adaptation and mitigation), A (adaptation only), O (others), which include types of plans such as R (resilience), S (sustainability), MP (master plan), E (environment), DRR (disaster risk reduction), C (coastal) and D (development). See Table A1.

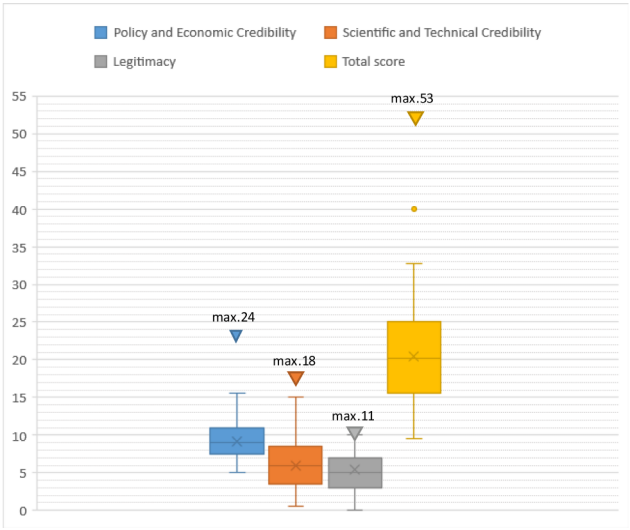

Fig. 5. Distribution of scores per major evaluation areas. The maximum total score is 53, equal to the total number of metrics used in the assessment of adaptation planning. The maximum scores per evaluation area are: Policy and economic credibility (max. 24), Scientific and technical credibility (max. 18) and Legitimacy (max. 11).

attention. Fig. 6 provides a global view of the performance of each indicator. In the following sections, we use this figure for discussion including examples of *good* and *not-so-good* practices.

3.2. Best performing indicators

"Public opinion" (#6, refers to public concern for climate change), "network membership" (#8, refers to the involvement of cities in international networks) and "engagement of stakeholders and civil society" (#16, refers to the participation of the public, communities, organisations, and businesses) are the indicators with the highest scores overall (52, 50 and 40.7 respectively, over 59) (see Fig. 6). Local surveys show a general pattern of concern for climate change. Lack of data is conducive to a zero score, except in the case of Athens, where less than half of the population (48.9%) consider climate change and extreme weather as serious environmental problems. The vast majority of the sample cities are members of at least one city network (commonly two or three, either international or regional, such as for example, C40, Covenant of Mayors or Climate Alliance). Engagement of stakeholders and civil society has also become a common practice and cities like, for example, Bangkok, have performed workshops with the public and private sector, civil society and academia. Rio de Janeiro also formed a strategic group composed of civil society, the third sector, governments, private sector, universities, and media to lead its planning process and created a reference network including local resilience networks to validate decision-making outcomes.

"Past performance" (#4, refers to both previous mitigation and adaptation actions) also achieved a high score (38.3 out of 59). Even if many adaptation plans are first generation plans, most European and North American cities, for example, had previously implemented mitigation policies, with evidence of emissions reductions as a result of the plan (e.g. Miami, where implementation of the Plan from 1993 to 2005 resulted in an estimated total reduction of approximately 34,062,831

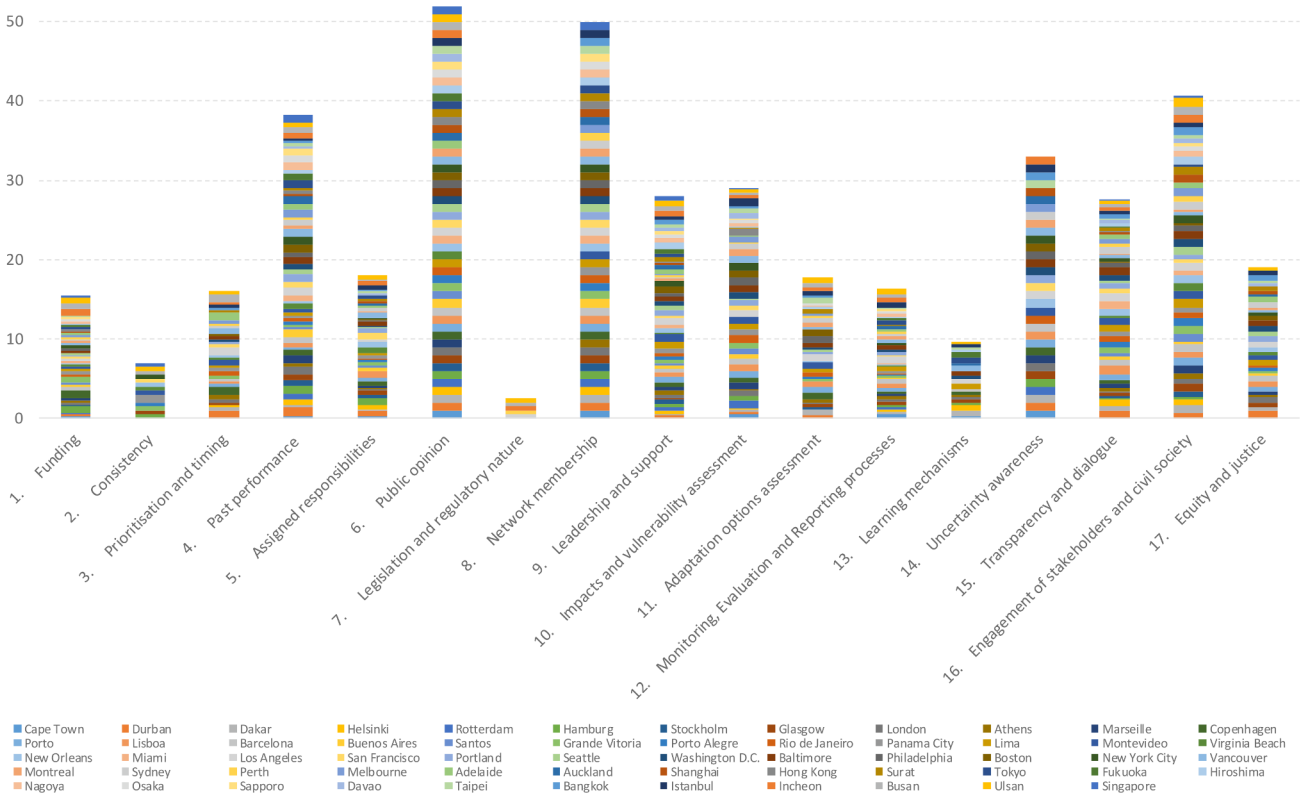

Fig. 6. Aggregated scores per indicator. Each column represents the aggregate score for each of the 17 indicators, considering all individual city scores. The maximum aggregate score per indicator is 59, equal to the total number of cities analysed in this global assessment.

tons of CO_2 with respect to the business as usual scenario, even though total CO_2 emissions increased by over 8.5 million tons during the last 17 years; or Singapore, where emissions per dollar of GDP had decreased by 37 per cent from 2000 to 2014, according to reports). In the sampled cities, no history of abolishment of previous environmental policies or institutional bodies (i.e. evidence of revocation, annulment, or early termination due to known or unknown reasons related to finance, politics or other factors) was found by the analysts[6], which, according to Averchenkova and Bassi (2016), offers credibility to current environmental initiatives.

Other adaptation planning aspects are assessed as being positive, with certain room for improvement. "Leadership and support" from public and private bodies (#9), for example, achieved a medium score (28, see Fig. 6). This score ranged between city cases, for example, Cape Town and Vancouver has no documented evidence of leadership, while Montevideo has its plan framed within the National Plan for Response to Climate Change and is led by the Municipalities of Canelones, Montevideo and San José, with support from public bodies like UNDP Uruguay, and private lobbies.

"Impacts and vulnerability assessment" (#10) also reached a medium score. Most policies include house-level or district-level risk assessments (Cape Town, Lima, Taipei), but few consider cascading impacts. Exceptions are, for example, the London Strategy that identifies interdependencies and potential cascading failures from disruption to infrastructure; or Istanbul that identifies chain effects in critical infrastructures. While the consideration of climate scenarios is rather common, few also incorporate social and/or economic city scenarios (Olazabal, Ruiz de Gopegui et al., 2019). Nagoya Low Carbon City Strategy, for example, considers future population estimations; and Rotterdam compares two possible socio-economic scenarios: one with growing population and economy and a second scenario where population shrinks, and the economy barely grows. This practice, however, is rare.

Many policies consider uncertainty in the design of the plan and the assessment of adaptation options by using different scenarios and selecting low regret measures. Based on this, the indicator of "uncertainty awareness" (#14) scores relatively well. One of the main axes of the Shanghai Master Plan, for example, is "Flexible Adaptation: To keep in mind the uncertainty of urban development, improve the multi-scenario planning strategy, create a new flexible functional layout model, establish the space reserving mechanism and constant evaluation & adjustment mechanism, and construct a flexible spatial strategy and management mechanism". Another example is the Incheon Plan, which develops a risk assessment taking into account probability and uncertainty, with measures proposed accordingly.

"Transparency and dialogue" (#15, refers to the establishment of mechanisms to develop transparent processes to increase acceptance and legitimacy) is another indicator that had an average score. This indicator scored zero when there was no description of the process of screening, definition and approval of the plan or there was no evidence of the participation of different departments or a formal exposition process (e.g. Rotterdam, Auckland, Tokyo or Osaka). However, many achieved relatively high scores (e.g. Durban, Lisbon and Baltimore meet all the aforementioned criteria and provide sufficient evidence of participatory processes).

3.3. Aspects that need to improve and good practices

"Funding" (#1) is not well accomplished in general as also identified by previous tracking studies (Aguiar et al., 2018; Dulal, 2019; Simonet & Leseur, 2019; Stults & Woodruff, 2017). According to Ford and King (2015, p. 513), adaptation funding should relate to "the capital costs of interventions and their maintenance over time, and also

[6] However, the authors recognise the difficulties in finding this information in public sources, especially in countries with less political transparency or where an online translator was required to collect the information.

the associated human resources necessary to successfully identify, implement, monitor, and maintain adaptation efforts, along with costs of funding research projects and programs". To be credible, adaptation plans should also assign economic resources to implementation and monitoring (Olazabal, Galarraga, Ford, Lesnikowski, & Sainz de Murieta, 2017). In our sample, planning documents tend to omit information regarding budget for the implementation, and when they include it, information is not measure-specific, which inhibits effective resource assignation and implementation. Notably, as discussed later, budgets for monitoring and evaluation activities are never included. Even in cases where funding information is included there is room for improvement. "Plan Clima" in Barcelona, for instance, which scores high (26.6 over 53) compared to the mean (20.4), only includes the budget for citizen climate projects for the annual year of 2018. Montevideo assesses costs and benefits for only 11 strategic adaptation lines, those that had enough information to carry out the economic evaluation and subsequent prioritisation. Woodruff and Stults (2016) conclude that the use of external funding for the creation of plans leads to lower quality plans, probably due to less motivational environments. Many cities in our sample received (total or partial) external funding, either from global institutions like IDB (Panama, Grande Vitoria) or 100 RC (Dakar, Bangkok, Athens), from private foundations (Boston's plan was partially funded by the Barr Foundation and Sherry and Alan Leventhal Family Foundation, apart from the Commonwealth of Massachusetts Executive Office of Energy and Environmental Affairs), or from national or regional institutions (plans from Lisbon and Porto were partially funded by the European Economic Area Grants; Davao City's Action Plan was funded by the US Agency for International Development, the World Food Program and UN Habitat). Overall, the Copenhagen Climate Adaptation Plan is a model for funding aspects. The plan clearly specifies the budget for each of the actions proposed, it is funded with own resources and partially secures funding for implementation, mentioning, for example, that "projects launched in 2011 are incorporated into the ordinary budget of the Technical and Environmental Administration. Other project proposals are waiting for funding" (p. 85). All 3 Korean policies examined also provide a detailed budget for the measures proposed, although these do not secure implementation funds.

"Consistency" (#2, refers to the coherence of the adaptation economy in terms of what is contained in the plan relative to the resources of the city), is not well accomplished through the plans. In the literature, the number of adaptation measures is often used as a sole proxy for adaptation progress (see e.g. Araos et al., 2016). However, the number of adaptation measures also needs to be consistent with the resources of a city and the assets that need to be protected. In an attempt to consider this, the APC assessment method states that, "extensive adaptor" cities (planned measures $N > 17$ according to Araos et al., 2016) need to fully or partially secure funding for implementation to be consistent. Additionally, the plan budget relative to the GDP of the city (%) is set to a minimum of 0.193% as a reference (minimum extent of the adaptation economy in a city calculated with data from Georgeson, Maslin, Poessinouw, & Howard, 2016). The vast majority of city cases score 0 for this indicator, which responds to three situations: (i) no budget is defined (ii) when the budget is defined, the budget is irrelevant compared to the gross domestic product (GDP) of the city (as is the case for Copenhagen, Icheon and Grande Vitoria, whose climate plan budget is just 0,0002%, 0,005%, and 0,0001% of city GDP, respectively), or, finally (iii) when there are a relatively high number of measures, funds for implementation are not secured (as is the case of the Climate Change Policy of Cape Town, that contains 68 measures; or Rio de Janeiro with 80 measures). Remarkably, Panama City performed best across the sample. With 13 planned measures, its overall plan budget (about M$983) is relatively high (2,62%) compared to the GDP of the city (about M$37,488). Theoretically, then, the planned adaptation investments in this city are adjusted to the assets that need to be protected.

There is widespread consensus on the importance of setting climate change adaptation priorities (Füssel, 2007; Smit, Pilifosova, Burton, Challenger, Huq, Klein, & Smith, 2001). Most cities score low in "prioritisation and timing" (#3, refers to setting priorities and criteria for implementation and beyond), which resonates with previous adaptation tracking studies (Aguiar et al., 2018; Stults & Woodruff, 2017). The economic evaluation of Montevideo's plan, for example, is set for a period of 20 years, "a period long enough to carry out the policies involving the selected measures" (p. 96), however lacking any further specification regarding action implementation time. Tokyo's Climate Change plan, for example, establishes temporal horizons for achieving certain targets, but not for actions themselves. Many cities, like Rotterdam, Porto, Santos, San Francisco, and Shanghai, do not set criteria for prioritising actions and do not demonstrate capacity or resources for evaluating such criteria. In contrast, Los Angeles' plan can be referred to as a good practice example since it classifies proposed measures into ongoing projects, short term (1–5 years), long term (> 5 years), and performs a cost-benefit analysis in order to prioritise implementation. Another example is the plan of Greater Adelaide (Resilient East Regional Climate Change Adaptation Plan, 2016), which sets a similar action timetable and establishes a series of criteria, prioritising measures that are relevant for the spatial scale defined by the plan, that are cross-sectoral, that provide multiple benefits, and that are able to benefit from a coordinated regional response.

The indicator "assigned responsibilities" (#5, refers to allocation of responsibilities and human resources for implementation) is one of the most important indicators of credibility for effective implementation. On the one hand, readiness for adaptation is dependent on both the provision of human resources for implementation (Ford & King, 2015) as well as the specific allocation of responsibilities. Indeed, previous adaptation tracking studies (Aguiar et al., 2018) have identified unclear assignation of responsibilities as a barrier to adaptation. On the other hand, effective implementation also depends on the involvement of critical departments in the writing of the plan. For example, Woodruff and Stults (2016) and (Lyles et al., 2018) found that local adaptation plans written by planning departments correlate with higher quality plans for the US. In our sample, many plans have been written by government offices outside of the planning department, like the city/metropolitan government (Stockholm, Dakar, Incheon), environmental or sustainability department (Lima, Baltimore, Hong Kong) or emergency management department (Los Angeles). Plans rarely assign a coordinator for the implementation phase, nor parties responsible for each measure contained in the plan. When they do, the assignation is not specific. For example, Porto (Estratégia Municipal de Adaptação às Alterações Climáticas do Porto, 2016) assigns the implementation of various measures to the *Municipal Directorate of Civil Protection, Environment and Urban Services*, even though this governmental area seems to be composed of smaller subdivisions, such as the Department of Environmental Planning and Management, Department of Urban Planning or the Department of Public Space.

Legislation and regulatory nature (#7, refers to the existing regulatory frameworks and binding nature of adaptation measures) is the lowest ranked indicator in the sample. Adaptation tracking studies in Europe (Heidrich et al., 2016; Lee, Yang, & Blok, 2020) note the important influence of higher-level climate policies on local climate planning. However, our results show that only a few plans claim to be developed in response to any compulsory legislative framework. Exceptions are Los Angeles (complying with federal and state hazard mitigation planning requirements to establish eligibility for funding under the US Federal Emergency Management Agency, FEMA, grant programs), Perth (complying with WALGA's Policy Statement on Climate Change, endorsed by the State Council), Incheon, Ulsan and Busan in Korea (which follow Article 38 of the Enforcement Decree of the Act that stipulates that local governments must establish and implement a detailed implementation plan for climate change adaptation measures). No plan in our sample has stated a legally binding nature, aligning with previous findings in, for example, the US (Stults & Woodruff, 2017).

To guarantee that planned adaptation actions are adequate and reasonable, a preliminary list of options needs to be identified and evaluated (see e.g. Stults & Woodruff, 2017), a list of evaluation criteria (Noble, Huq, Anokhin, Carmin, Goudou, Lansigan, Osman-Elasha, & Villamizar, 2014) and connection to risk levels need to be provided to verify that planned actions are indeed adequate for dealing with expected changes (Olazabal, Ruiz de Gopegui et al., 2019), and potential barriers to adaptation or to implementation need to be considered (Moser & Ekstrom, 2010). In our sample, the indicator *adaptation options assessment* (#11) is also poorly accomplished. We have not found a plan that fulfilled all requirements of the APC assessment (see Table A2). Most of the plans do not document how the final set of measures have been selected (this is the case, for example, in Durban, Porto Alegre and Washington D.C.). Many plans do not present adaptation actions connected to the impact and level of risk identified. Often, measures are just grouped depending on the kind of hazards they address (e.g. floods, heatwaves, sea-level rise…), such as in Lisbon, Portland, Tokyo and Dakar. Often, city cases do not document relevant criteria for evaluating adaptation options, or only consider a few (e.g. Perth considers "timing" or "timeframe for implementation"; Barcelona considers actions' integration with broader social goals). An assessment of potential adaptation barriers is usually not undertaken (e.g. Athens, Panama, New York, Nagoya). Remarkably, Philadelphia (Growing Stronger: Toward a Climate Ready Philadelphia, 2015) performed exceptionally, as a methodology for evaluating and selecting adaptation strategies, according to criteria such as cost, flexibility, co-benefits and potential barriers to implementation. The plan also includes an evaluation of the efficacy of each strategy, and actions with medium-to-high efficacy scores were selected to be implemented in the near term. Some of these actions were linked to the previous risk assessment. For example, "*when possible, site new public infrastructure outside of the sea level rise and storm surge zone*" (p. 25); "*preserving open space in flood hazard areas and channel migration zones*" (p. 51). In a context where, globally, only 15% of adaptation planning documents justify adaptation measures using climate knowledge generated through risk assessments and climate scenarios (Olazabal, Ruiz de Gopegui et al., 2019), Philadelphia's plan is a best-practice model. In line with previous tracking studies (Aguiar et al., 2018; Dulal, 2019; Le, 2019), we find, however, that this area of practice needs to be broadly improved to move from reactive to proactive action.

Echoing previous studies (Araos et al., 2016; Guyadeen et al., 2019; Woodruff & Stults, 2016), MER processes (#12) also seem to have room for improvement in most cities. While the number of city governments reporting monitoring activities has apparently increased (results from Olazabal, Ruiz de Gopegui et al., 2019 as compared to Araos et al., 2016), the level of detail reported seems to be relatively poor. In our sample, many plans do not define a MER process (Stockholm and Santos, for example, just vaguely mention that it is necessary to monitor the risks and follow the plan implementation, but they don't define how to do this or when they expect to dedicate efforts to MER process design). In many cases, MER responsible parties are loosely (or directly not) defined (Montevideo, for example, indicates that "the commitment to follow up and monitor the plan to keep it in line with the changing context is part of the management responsibility assumed by each departmental government" p. 67). In the majority of the cases where MER processes are clearly defined, they do not allocate a budget (see e.g. cases from Helsinki, Baltimore, and Istanbul). Monitoring objectives and indicators are not defined (such as in Panama, Washington D.C. and Fukuoka), while in some cases this task is proposed to be developed in the future (see e.g. Helsinki, which includes "select and compile monitoring indicators" as one of its proposed measures). Importantly, cities have not yet started to reflect on how to evaluate outcomes from monitoring processes (e.g. Lima, Montreal, Nagoya), which is a key aspect in decision-making for adaptation management. In most documented cases, results are not reported to any higher-level authority or organisation through an official process (see Virginia Beach, Vancouver, Incheon), which reduces credibility in the process (Olazabal, Galarraga et al., 2019). Among the cities that most appropriately incorporate MER processes, the Los Angeles Hazard Mitigation Plan is definitely a model example, since it defines a *Plan Maintenance Strategy* specifying the schedule of monitoring, evaluation and revision of the plan every 5 years (complying with FEMA's rules), it assigns a responsible steering committee for this task, and also provides a *Progress Report Template* with the necessary monitoring indicators. Moreover, the plan must be reviewed, revised and resubmitted for approval in order to remain eligible for benefits under the DMA (Disaster Mitigation Act, US).

In general, cities have not yet started to establish "learning mechanisms" (#13), as found in other studies (see, e.g., Woodruff & Stults, 2016). Linked to MER systems and their evaluation processes, learning mechanisms need to be established, as one of the main goals in adaptive management (Preston et al., 2011). Adaptive management, the "process of iteratively planning, implementing, and modifying strategies for managing resources in the face of uncertainty and change" which "involves adjusting approaches in response to observations of their effect and changes in the system" (IPCC, 2014), is a pending task in local adaptation planning according to our results. Cities do not yet define readjustment processes or they roughly refer to it but do not specify how they plan to do it (for example, Durban Climate Change Strategy, 2015, *"will be revised and updated regularly",* p. 2; or for the Athens' plan (Climate Adaptation Strategy: Making Athens a Greener and Cooler City, 2017) *"whenever necessary, the team will make proposals for updating the Action Plan to the relevant municipal bodies",* p. 28). Tools and indicators are thus not considered (for example, in Hamburg, Baltimore and Tokyo) and responsible parties are not assigned (see e.g. Barcelona, Auckland or Hiroshima).

Finally, equity and justice (#17, refers to the consideration of contextual inequity and social vulnerability factors to achieve equitable and just adaptation opportunities) is another indicator that has clear room for improvement in most plans. Our results echo recent findings related to the 100 Resilient Cities program by Fitzgibbons and Mitchell (2019). We have not found sufficient evidence in most plans as to how they have considered equity and justice issues. We looked at how plans were addressing different social characteristics or needs affecting vulnerability or resilience, and whether adaptation measures were directed towards reducing vulnerability or increasing resilience in marginalised groups or deprived areas. In some cases, this care for equity and justice is left half-way or to be developed in the future. For example, Panama considered social and economic diversity in its participatory process in order to prioritise adaptation action in different sectors, but these groups were not involved in the development of such adaptation actions. Another example is Helsinki's plan, which proposes as a future action to *"study the groups vulnerable to climate change and extreme weather events, and identify their needs during disruptions"* (p. 21). Communities or social advocacy groups are rarely involved when assessing vulnerability and framing socially adequate actions. Sometimes, only governmental actors are involved, such as in Athens, where only health-related public officers were involved. Only the Durban Climate Change Strategy documents potential beneficiaries of proposed adaptation measures. The Durban plan stands out in our sample, since it also addresses vulnerability in the most marginalised and disadvantaged groups and develops adaptation measures accordingly. It acknowledges that informal settlements, where 23% of Durban's population resides, are expected to be most affected by climate change, and proposes measures like *"identifying and prioritizing the relocation or upgrading of informal and low-income settlements that are vulnerable to flooding and coastal erosion"* (p. 15).

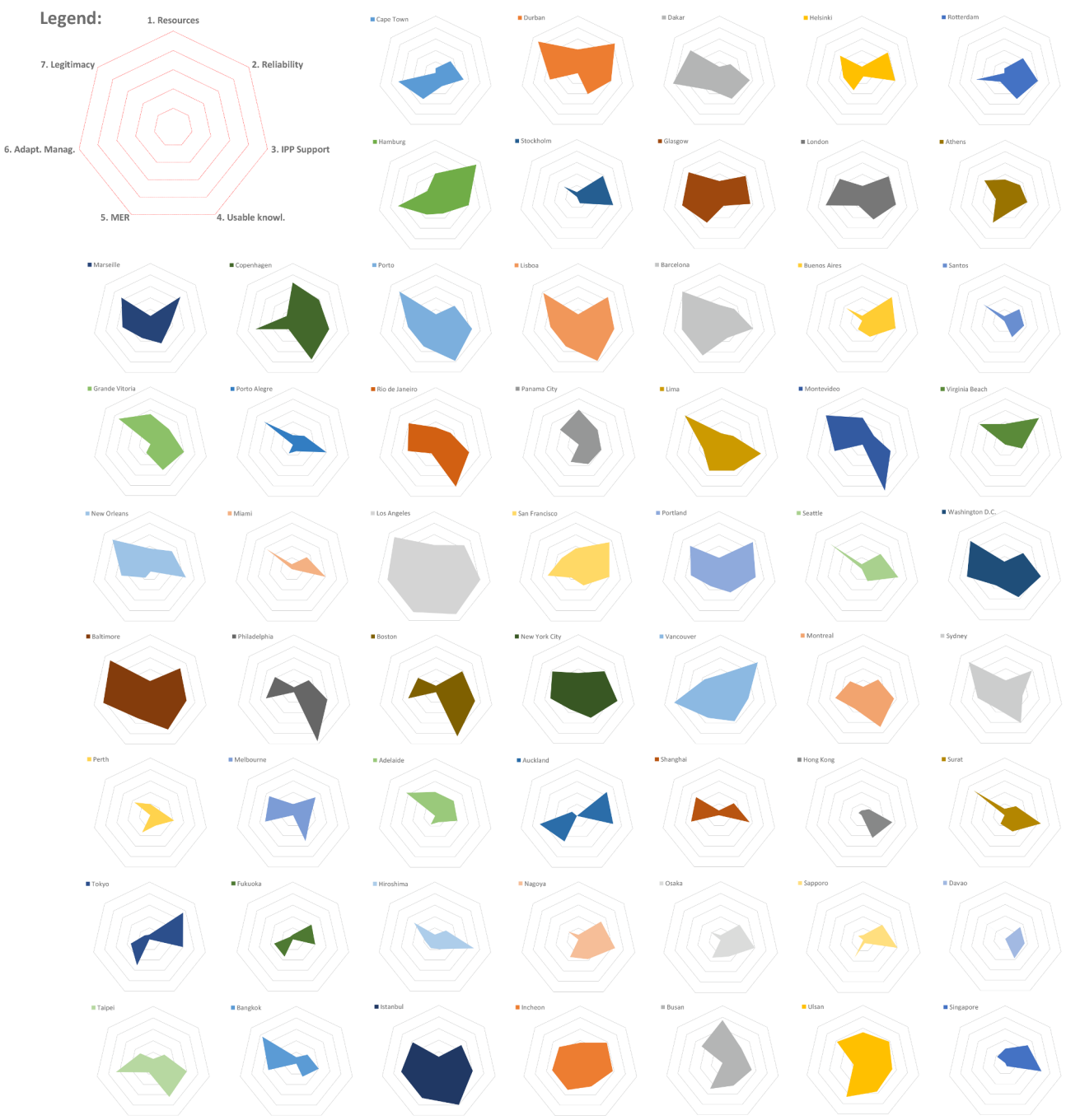

Fig. 7. Individual city performance on the 7 components. The performance of each city is illustrated on a spider diagram which demonstrates the performance of each city based on the 7 components of the APC assessment framework (see legend at the top of the figure): 1. Resources, 2. Reliability, 3. Institutional, Public and Private (IPP) Support, 4. Usable Knowledge, 5. Monitoring, Evaluation and Reporting (MER), 6. Adaptive Management and 7. Legitimacy. The larger the coloured shadow, the better the overall performance of the city in terms of its adaptation planning process.

3.4. Individual city performance at a glance

We show the overall performance of the 59 city cases in Fig. 7. The larger the coloured shadow, the better the performance. This visualisation helps to recognise that adaptation planning in large cities is unlikely to be effective unless more resources are invested to improve aspects of adaptation planning such as those mentioned in previous sections. In general, these results align with outputs from previous studies (Sainz de Murieta et al., 2020 in medium-sized cities in Spain), where the same key areas were highlighted as aspects where further efforts needed to be invested.

However, it is also important to recognise that local adaptation planning in large cities worldwide is currently in its early stages. Most of the plans studied are first generation plans and, if a process of revision and update is well-established, this offers a great opportunity for establishing knowledge transfer mechanisms among cities through international city networks (e.g. C40, Covenant of Mayors…) in order to strengthen learning processes and transfer good practices. However, despite the strong association between transnational city networks and the existence of local adaptation processes (Heikkinen, Karimo, Klein, Juhola, & Ylä-Anttila, 2020; Reckien, Flacke, Olazabal, & Heidrich, 2015), network membership does not explain higher or lower

credibility scores in large cities as, all of the sampled cities are members of one or more city networks. This points out to other context-specific institutional, political, social and economic aspects which may help explain the generalised lack of credibility of current local adaptation practice.

All in all, there are a number of local adaptation planning cases with relatively high performance-indicator rankings (e.g. from Los Angeles, Baltimore, Barcelona, Istanbul or Incheon) and where good practices can be found. Also, areas in need of improvement can be easily identified across the sample. For example, the Los Angeles Hazard Mitigation Plan, which has the highest score, scores badly in terms of Resources (Funding, Consistency and Prioritisation & Timing), and can apply approaches and techniques used in, for example, Montevideo, Busan, Grande Vitoria, Panama City or Copenhagen.

Further research could involve studying specific cases to understand context-specific factors that have helped or have hindered adaptation planning efforts. In addition, more research is needed to understand whether the efforts identified have translated into implemented actions and adaptation outcomes, as this method infers. Although preliminary findings on (the lack of actual) implementation have been revealed (Olazabal, Ruiz de Gopegui et al., 2019), data on implementation is still scarce. Moreover, the capacity to measure adaptation outcomes is still shadowed by methodological challenges (Ford et al., 2015) and consequently, there is a disproportionate focus on process-based evaluations (Berrang-Ford et al., 2019; Hallegatte & Engle, 2019).

3.5. The opportunities and limitations of the APC framework

After the pilot study in Olazabal, Galarraga et al. (2019), which took stock of the adaptation literature and piloted the APC framework in 4 early adaptors cities, the question remains as to how strong the relationship between credibility scores and the actual effectiveness of adaptation processes. The pilot study in Olazabal, Galarraga et al. (2019) showed the usability of the framework in early adaptor cities, which have sufficient public information for the 53 metrics. However, it did not offer evidence on the actual reliability of the methodological approach comparative to less advanced cities. A safe validation of this framework would involve collecting detailed information on the actual implementation of adaptation policies as well as information on their effectiveness in reducing vulnerability or increasing resilience in a just and equitable manner (Olazabal, Galarraga et al., 2019) so that climate risks are reasonably reduced.

Assessing effectiveness involves either theoretically simulating outputs and outcomes of adaptation processes and observing their impact on vulnerability or resilience in different temporal horizons (generally not incorporated in planning documents, at least not with a sufficient level of detail), or actually performing a historical analysis of climatic impacts (that mostly have not happened yet) through data that has been monitored and evaluated. Thus, data on implementation is necessary for the validation of the framework, and for recognising the weak link between implementation and effectiveness. Few tracking studies are collecting data on implementation, mainly because this information (at least public information) is rather scarce worldwide (Olazabal, Ruiz de Gopegui et al., 2019). In this study, we have performed an Independent Samples T-test with data on implementation[7] collected in Olazabal, Ruiz de Gopegui et al. (2019) and mean credibility scores (the final score for each city case and the scores of the three major areas). Results (see Tables A3 and A4) show that there is a slight tendency for higher credibility scores among policies with evidence of implementation, but results are, however, non-significant ($p > 0.05$).

The APC framework has been developed based on the evidence found in the scientific literature around determinants for successful adaptation. It evaluates the most relevant areas that are important for plan quality in the context of adaptation. Because of the above-mentioned limitations (i.e. lack of data on implementation and effectiveness), it is hard to ensure the reliability of the APC method for assessing how likely adaptation policies are to be "effective in reducing or avoiding impacts of climate change in the long-term" (Olazabal, Galarraga et al., 2019, p. 3). However, as it stands, the APC framework remains the most robust method for comparatively informing adaptation progress decisions and investments across policy scales. Future work should focus on collecting data on outputs and outcomes of adaptation in a way that the causes and effects of adaptation processes can be more accurately established.

4. Conclusions

The assessment approach used in this global comparative exercise was originally intended for application in large-n assessments in order to observe global progress on adaptation based on ex-ante evaluations of existing local adaptation planning (Olazabal, Galarraga et al., 2019). The work presented in this article sets out to meet this objective.

Our assessment of adaptation planning in large cities worldwide delivers concerning results. According to available documents, planned adaptation is overall not likely to be effectively implemented, nor does it show sufficient capacity to reduce vulnerability, increase resilience, or to sustain action in the long term. Formal public adaptation planning in large cities worldwide is, in its current form, unlikely to be effective.

Our study points to various scientific, policy and planning areas where greater efforts are required. In particular, this study reveals that adaptation needs to be integrated in current institutional and regulatory frameworks in order to guarantee sustainable adaptation action in the long-term. Methodologies for understanding and examining the adaptation solution space in cities need to be developed and used in real practice since according to our results, adaptation decisions are hardly ever adequately informed by climate or local knowledge or pay sufficient attention to the needs of vulnerable groups. Adaptation finance frameworks are lacking in real practice, which inhibits far-reaching adaptation action.

Finally, based on our results, we presume that current approaches to adaptation monitoring, evaluation, reporting and learning (MERL) are not yet sufficiently mature for use in urban planning practice and, similarly, existing MERL frameworks (used in environment or sustainability evaluations) are not usable or compatible with adaptation governance needs. Either way, further research should be directed to this aspect, which may greatly influence future adaptation outcomes. This links to another important message of our work - the lack of actual data on implementation and effectiveness - which will become increasingly available once monitoring and evaluation efforts grow. This will enable an improved understanding on how policy processes connect to adaptation success, and a revision of evaluative proposals such as the one used here.

There is significant room for improvement in local adaptation planning in large cities worldwide. Studies of the kind presented in this article, can provide guidance on current gaps and offer examples of good practices which, as revealed, can be found in cases across the world. Nevertheless, further work is required to connect research efforts in the growing area of local adaptation tracking in order to facilitate replicability and comparability between studies, as well as to consolidate methodological approaches.

CRediT authorship contribution statement

Marta Olazabal: Conceptualization, Methodology, Formal analysis, Investigation, Writing - original draft, Visualization, Supervision,

[7] This is a binary parameter for which any evidence of implementation (no matter how weak it was) was coded as 1. Inexistent or non-available public information regarding implementation was coded as 0. Olazabal et al. (2019b) found proof of implementation in just 50% (29 out of 30) of the policies.

Project administration, Funding acquisition. **Maria Ruiz De Gopegui:** Formal analysis, Investigation, Writing - original draft, Visualization.

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Annexes

Table A1
Sample of local adaptation planning documents and basic characteristics. Notes: Type of policy: A/M (adaptation and mitigation), A (adaptation only), Others: R (resilience), S (sustainability), MP (master plan), E (environment), DRR (disaster risk reduction), C (coastal), D (Development); Policy scale: M (metropolitan), C (city), CS (city-state); Policy Stage (according to policy lifetime): P (planned), BI (being implemented), I (implemented). Source: Revised from Olazabal, Ruiz de Gopegui et al. (2019).

Id	Name of the policy	Name of City	Country	World Region	Year of publication	Type of policy	Policy scale	Policy stage	Evidence of implementation	Final score
1	City of Cape Town Climate Change Policy (Policy Number 46824)	Cape Town	South Africa	Africa	2017	A/M	M	BI	N	12
2	Durban Climate Change Strategy	Durban	South Africa	Africa	2014	A/M	M	BI	Y	27.25
3	Dakar Resilience Strategy	Dakar	Senegal	Africa	2016	R	C	P	N	21.5
4	Helsinki Metropolitan Area Climate Change Adaptation Strategy	Helsinki	Finland	Europe	2012	A	M	I	Y	19
5	Rotterdam Climate Change Adaptation Strategy	Rotterdam	Netherlands	Europe	2013	A	M	BI	Y	13.5
6	Hamburg Climate Plan	Hamburg	Germany	Europe	2015	A/M	M	BI	Y	22
7	A robust society Regional action plan for climate adaptation in Stockholm County	Stockholm	Sweden	Europe	2014	A	M	BI	Y	13.5
8	OUR RESILIENT GLASGOW A City Strategy	Glasgow	Scotland	Europe	2016	R	M	BI	N	21.875
9	London Environmental Strategy (Chapter 8 + Implementation plan)	London	England	Europe	2018	E	M	BI	N	21
10	Climate Action Plan Part B: Climate Adaptation Strategy: Making Athens a Greener and Cooler City	Athens	Greece	Europe	2017	A	C	BI	N	20.125
11	Plan Climat Énergie Territorial Ville de Marseille (Part D)	Marseille	France	Europe	2012	A/M	C	BI	N	21.5
12	Copenhagen Climate Adaptation Plan	Copenhagen	Denmark	Europe	2011	A	M	I	Y	26.5
13	Estratégia Municipal de Adaptação às Alterações Climáticas do Porto	Porto	Portugal	Europe	2016	A	C	BI	Y	27.75
14	Estratégia Municipal de Adaptação às Alterações Climáticas de Lisboa EMAAC 2017	Lisboa	Portugal	Europe	2017	A	C	BI	Y	29.25
15	Plan Clima 2018–2030	Barcelona	Spain	Europe	2018	A/M	C	BI	N	26.625
16	PACC - Plan de Acción frente al cambio climático 2020	Buenos Aires	Argentina	Latin America	2015	A/M	M	BI	Y	16.5
17	Plano Municipal de Mudança do Clima de Santos – PMMCS	Santos (Baixada Santista)	Brazil	Latin America	2016	A/M	C	P	N	13.5
18	Plano de Ação Vitória Sustentável	Grande Vitoria	Brazil	Latin America	2015	S	C	I	N	24.5
19	Estratégia de Resiliência de Porto Alegre	Porto Alegre	Brazil	Latin America	2016	R	C	BI	N	15.5
20	Climate Change Adaptation Strategy for the City of Rio de Janeiro	Rio de Janeiro	Brazil	Latin America	2016	A	C	BI	Y	24.5
21	Plan de Acción “Panamá Ciudad Sostenible”	Panama City	Panama	Latin America	2017	S	C	BI	Y	21.5
22	Estrategia de Adaptación y Acciones de Mitigación de la Provincia de Lima al Cambio Climático- Estrategia C.Lima	Lima	Perú	Latin America	2015	A	M	BI	N	27.5
23	Plan Climático de la Región Metropolitana de Uruguay	Montevideo	Uruguay	Latin America	2012	A/M	M	BI	Y	28.625
24	City of Virginia Beach Comprehensive Plan	Virginia Beach	U.S.A.	North America	2016	MP	C	BI	N	16.5
25	Resilient New Orleans	New Orleans	U.S.A.	North America	2015	R	C	BI	N	22.375
26	Southeast Florida Regional Climate Action Plan	Miami	U.S.A.	North America	2012	A/M	M	BI	Y	15
27	LA Hazard Mitigation Plan	Los Angeles	U.S.A.	North America	2018	DRR	C	BI	Y	40
28	San Francisco Sea Level Rise Action Plan	San Francisco	U.S.A.	North America	2016	C	C	I	N	20
29	Climate Action Plan	Portland	U.S.A.	North America	2015	A/M	M	BI	Y	25.125
30	Seattle Climate Preparedness Strategy	Seattle	U.S.A.	North America	2017	A	C	BI	Y	17.375

(*continued on next page*)

Table A1 (*continued*)

Id	Name of the policy	Name of City	Country	World Region	Year of publication	Type of policy	Policy scale	Policy stage	Evidence of implementation	Final score
31	Climate Ready DC	Washington D.C.	U.S.A.	North America	2016	A/M	C	BI	Y	25
32	Baltimore Disaster Preparedness Planning Project	Baltimore	U.S.A.	North America	2018	DRR	C	BI	Y	32.75
33	Growing Stronger: Toward a Climate Ready Philadelphia	Philadelphia	U.S.A.	North America	2015	A	C	BI	N	20.625
34	Climate Ready Boston	Boston	U.S.A.	North America	2016	R	C	BI	Y	22.375
35	OneNYC	New York City	U.S.A.	North America	2015	D	C	BI	Y	25.5
36	Vancouver Climate Change Adaptation Strategy	Vancouver	Canada	North America	2018	A	C	BI	Y	24.5
37	Climate Change Adaptation Plan 2015–2020	Montreal	Canada	North America	2015	A	M	BI	Y	17.5
38	Adapting for Climate Change. A long-term strategy for the city of Sydney	Sydney	Australia	Oceania	2017	A	C	BI	N	24.375
39	Regional Climate Change Adaption Plan. Perth's Eastern Region	Perth	Australia	Oceania	2013	A	M	BI	Y	13.625
40	Climate Change Adaptation Strategy (+Refresh)	Melbourne	Australia	Oceania	2017	A	M	BI	Y	18
41	Resilient East Regional Climate Change Adaptation Plan	Greater Adelaide	Australia	Oceania	2016	A	M	BI	Y	19.5
42	Auckland Plan 2050	Auckland	New Zealand	Oceania	2018	D	M	P	N	15
43	Shanghai Master Plan 2017–2035	Shanghai	China	Asia	2018	MP	C	P	N	12
44	Hong Kong's Climate Action Plan 2030+	Hong Kong	Hong Kong SAR	Asia	2017	A/M	CS	BI	N	9.5
45	Surat Resilience Strategy	Surat	India	Asia	2017	R	C	P	N	18
46	Tokyo Metropolitan Environmental Basic Plan (formulated March, Heisei 28)	Tokyo	Japan	Asia	2016	E	C	BI	Y	15.5
47	Fukuoka City Global Warming Countermeasure Execution Plan	Fukuoka	Japan	Asia	2016	A/M	C	BI	Y	12.5
48	Hiroshima City global warming measure implementation plan	Hiroshima	Japan	Asia	2017	A/M	C	BI	Y	17
49	Low Carbon City Nagoya Strategy Second Execution Plan 2018–2030	Nagoya	Japan	Asia	2018	A/M	C	P	N	16
50	Osaka City Global Warming Prevention Plan	Osaka	Japan	Asia	2017	A/M	C	P	N	14
51	Second Sapporo City Environment Basic Plan 2018–2030	Sapporo	Japan	Asia	2018	E	C	P	N	11
52	Davao City Climate Change Action Plan (LCCAP)	Davao	Philippines	Asia	2014	A/M	C	BI	Y	13
53	Taipei City's adaption plan	Taipei City	Taiwan	Asia	2012	A	C	BI	N	17.625
54	100 Resilient: Resilient Bangkok Strategy	Bangkok	Thailand	Asia	2017	R	M	P	N	17.5
55	ICCAP Istanbul Climate Change Action Plan	Istanbul	Turkey	Asia	2018	A/M	M	P	N	26.375
56	Second Incheon Metropolitan City Detailed Plan for Adaptation to Climate Changes	Incheon	South Korea	Asia	2017	A	M	P	N	26
57	Second Busan Metropolitan City Detailed Plan for Adaptation to Climate Changes	Busan	South Korea	Asia	2016	A	M	P	N	26
58	Second Ulsan Metropolitan City Detailed Plan for Adaptation to Climate Changes	Ulsan	South Korea	Asia	2016	A	M	P	N	29
59	Climate Action Plan - A Climate-resilient Singapore: For A Sustainable Future	Singapore	Singapore	Asia	2016	A	CS	P	N	12.5

Table A2
Assessment metrics (extension of Olazabal, Galarraga et al., 2019).

Major area	Components	Indicators	Metrics	Metric description	Evaluation method	Notes for the coding process
POLICY AND ECONO-MIC CREDIB-ILITY	Resources	1. Funding	M#1	Has an overall budget been assigned for the plan? (Y/N)	Y = 1/ N = 0	*This info should be contained in the document. If specific budgets have been assigned for all the measures, we assume there is an overall budget. In the case of adaptation-related plans (resilience, sustainability), an overall budget for the complete plan is required here.*
			M#2	Have specific budgets been assigned for each of the measures contained in the plan? (Y/N)	Y = 1/ N = 0	*This info should be contained in the document. At least one specific measure should have budget assigned, independently of its nature (mitigation, resilience, sustainability…)*
			M#3	Is the creation of the plan funded with own resources? (Y/N)	Y = 1/ N = 0	*This info should be contained in the document or official website. Note:* e.g. *100RC plans have been created (at least partially) with external resources* (i.e. *resilience officer)*
			M#4	Does the plan fully or partially secure funding for the implementation of the measures proposed? (Y/N)	Y = 1/ N = 0	*This info should be contained in the document. At least one specific measure should have funding secured, independently of its nature (mitigation, resilience, sustainability…)*
		2. Consistency	M#5	Overall plan budget relative to the GDP of the city (%)	1 if > = 0.193%; 0 if < 0.193%	*If M#1 is 0, then, M#5 is 0Only the adaptation budget should be considered for the calculation.Source for city GDP: OECD (if possible, choose the GDP of the year of the publication of the policy) or alternative sources in city/regional websites.*
			M#6	Number of measures (N) contained in a plan relative to resources	0 if N > =17 and M#4 = 0;1 in all other cases	*This info should be contained in the document.*
		3. Prioritisation and timing	M#7	Does the plan set a timetable for adaptation implementation? (Y/N)	Y = 1/ N = 0	*This info should be contained in the document. At least* e.g. *"short, medium and long term"*
			M#8	Does the plan set any criteria for prioritisation during the implementation phase? (Y/N)	Y = 1/ N = 0	*Prioritisation should determine which measures are more important than others in terms of execution and goals achievement.*
			M#9	Has the plan demonstrated capacity to evaluate these criteria on each identified option? (Y/N)	Y = 1/ N = 0	*The plan identifies methodology, indicators, or develops the evaluation to identify priorities.*
	Reliability	4. Past performance	M#10	Stage of the adaptation plan (Revised/unrevised)	Revised = 1/ Unrevised = 0	*This info should be contained in the document.*
			M#11	Performance regarding climate change mitigation policies	———	———
			M#11.1	*Has the plan been implemented or is being implemented? (Y/N)*	Y = 1 (implemented or being implemented) / N = 0	*Search in official website evidence of the status of the plan, regardless the policy lifetime.*
			M#11.2	*Is there evidence of any emissions reductions as a result of the plan? (Y/N)*	Y = 1/ N = 0	*Check progress reports or any document that reports a reduction of GHG emissions as a result of the mitigation plan. This reduction would demonstrate the total or partial achievement of emissions reduction goals established in the plan.*
			M#12	Is there a history of abolishment of previous environmental policies or institutional bodies? (Y/N)	Y = 0/ N = 1	*Search in official website evidence of any previous policy abolishment. Search also keywords (EN or original language) in an Internet search engine (e.g. Environment* OR climat* AND policy OR plan OR program AND abolish* OR cancel* OR dissolve* etc.)*
		5. Assigned responsibilities	M#13	Plan creation: has the plan been written by the planning department? (Y/N)	Y = 1/ N = 0	*This info should be contained in the document. The planning department (or de department in charge of planning) should have led or participated in the writing of the document*
			M#14	Does the plan assign a coordinator of the implementation phase? (Y/N)	Y = 1/ N = 0	*This info should be contained in the document.*
			M#15	Responsible parties for each measure:	———	*This info should be contained in the document.*
			M#15.1	*Does the plan assign responsible parties for each measure contained in the plan? (Y/N)*	Y = 1/ N = 0	*This info should be contained in the document.*
			M#15.2	*Level of specificity: have the assigned parties smaller subdivisions?* (Y/N)	Y = 0/ N = 1	*This info should be contained in the organigram for the city, normally available in the city official website.*
	Institutiona-l, public and private support	6. Public opinion	M#16	Is the public concerned (not only aware) about climate change according to last surveys? (Y/N)	Y = 1/ N = 0 (Depending on the data source this will be measured differently but, in general, 'Yes' would mean 50 or more % of population concerned about climate change)	*This info should be searched in local/regional/national surveys (in this order of preference). Public concern is preferred but public awareness (more frequently surveyed) can be also considered.*

(*continued on next page*)

Table A2 (*continued*)

Major area	Components	Indicators	Metrics	Metric description	Evaluation method	Notes for the coding process
		7. Legislation and regulatory nature	M#17	Has the plan been developed in response to any specific national or regional legislative framework that makes their development compulsory? (Y/N)	Y = 1/ N = 0	*This info is often found in the document, normally in the preamble or introductory section.*
			M#18	Legally binding nature: Is the plan a set of recommendations or does it compel implementation?	0 if 'set of recommendations'; 1 if 'compels implementation'	*This info should be contained in the document.*
		8. Networks membership	M#19	Is the city committed to any international or national climate network related to adaptation i.e. that includes adaptation-related knowledge transfer, commitment or capacitation? (Y/N)	Y = 1/ N = 0	*This info is often found in the document or in the city official website*
		9. Leadership and support	M#20	Is the plan framed in a higher-level (regional or national) plan/policy/program? (Y/N)	Y = 1/ N = 0	*This info should be contained in the document, normally in the preamble or introductory section.*
			M#21	Has the plan been led by an institutional climate champion with institutional power? (Y/N)	Y = 1/ N = 0	*This info should be contained in the document. Ideally the plan has been led by the Mayor's office (accompanied by other departments) or led by a body recognised by its climate stewardship*
			M#22	Is there a dedicated local public climate change body? (Y/N)	Y = 1/ N = 0	e.g. *Public office or public research institution dedicated (perhaps not exclusively) to climate change. Search in the city official website*
			M#23	Are there other supporting public bodies (e.g. regional authority) (Y/N)	Y = 1/ N = 0	*This info should be contained in the document (firm support from other public authorities). E.g. United Nations, World Bank, regional public institutions. Do not include them if they just participated* e.g. *in a workshop, they must have participated in the process of policy creation*
			M#24	Are there supporting private lobbies (e.g. NGOs) (Y/N)	Y = 1/ N = 0	*This info should be contained in the document. E.g. consultancies, NGOs, private research institutions. Do not include them if they just participated* e.g. *in a workshop, they must have participated in the process of policy creation*
SCIENTIFIC AND TECHN-ICAL CREDIB-ILITY	Usable knowledge	10. Impacts and vulnerability assessment	M#25	Does the plan develop a risk assessment? (Y/N)	Y = 1/ N = 0	*This info should be contained in the document. We understand risk assessment as in* IPCC (2014)*: risk should account for vulnerability, hazard and exposure.*
			M#26	What is the spatial level of the assessment? (house level, district level, city-level)	'House-level' or 'district-level' = 1; City-level = 0	*Related to #25 about risk assessment. If there are different spatial scales, take the smallest one.*
			M#27	Does the assessment consider cascading impacts? (Y/N)	Y = 1/ N = 0	*Related to #25 about risk assessment. Search in the document keywords such as "indirect*" or "cascad*". The assessment of risks should consider secondary impacts, not only the direct impacts of climate change*
			M#28	Future risks:	———	———
			M#28.1	*Are future climate scenarios taken into account? (Y/N)*	Y = 1/ N = 0	*This info should be contained in the document. Climate projections are considered valid regardless of how and whether they have been used in risk assessments or adaptation measures definition. The projection of at least one climate parameter* (e.g. *precipitation) is acceptable.*
			M#28.2	*Have social and economic city scenarios been taken into account? (Y/N)*	Y = 1/ N = 0	*This info should be contained in the document. Socio-economic projections are considered valid regardless of how and whether they have been used in risk assessments or adaptation measures definition. The projection of at least one parameter* (e.g. *population) is acceptable.*
		11. Adaptation options assessment	M#29	Has a preliminary list of adaptation alternatives been identified and evaluated? (Y/N)	Y = 1/ N = 0	*This info should be contained in the document. The statement of the existence of a preliminary list is enough* (i.e. *it is not necessary to list the complete preliminary list)*
			M#30	Are adaptation actions connected to the impact and level of risk identified (i.e. they are defined to eliminate the unacceptable risks)? (Y/N)	Y = 1/ N = 0	*This info should be contained in the document. Search evidence on the alignment of adaptation actions with climate scenarios or with identified*

(*continued on next page*)

Table A2 (*continued*)

Major area	Components	Indicators	Metrics	Metric description	Evaluation method	Notes for the coding process
						risks. Measures or actions should be defined to address specific risks or specific climate scenarios.
			M#31	Are the following criteria considered in the evaluation of actions?	———————	———————
			M#31.1	*Effectiveness (Y/N)*	Y = 1/ N = 0	*This info should be contained in the document. Related to M#29. If M#29 is 0, then all sub-metrics under M#31 are 0.*
			M#31.2	*Efficiency (benefits/costs) (Y/N)*	Y = 1/ N = 0	*(see M#31.1)*
			M#31.3	*Integration with broader social goals (Y/N)*	Y = 1/ N = 0	*(see M#31.1)*
			M#31.4	*Environmental sustainability (e.g. by implementing a Strategic Environmental Assessment - SEA) (Y/N)*	Y = 1/ N = 0	*(see M#31.1)*
			M#31.5	*Flexibility and robustness (against different scenarios) (Y/N)*	Y = 1/ N = 0	*(see M#31.1)*
			M#31.6	*Timing (Y/N)*	Y = 1/ N = 0	*(see M#31.1)*
			M#31.7	*Mal-adaptation (inc. mitigation trade-offs) (Y/N)*	Y = 1/ N = 0	*(see M#31.1)*
			M#31.8	*Resources available (including information, finance, leadership, management capacity) (Y/N)*	Y = 1/ N = 0	*(see M#31.1)*
			M#32	Does the plan include an assessment or consideration of potential barriers to adaptation? (Y/N)	Y = 1/ N = 0	*This info should be contained in the document. It can involve a general identification of some barriers or a detailed evaluation.*
	Monitoring, evaluation and reporting (MER)	12. MER processes	M#33	Does the plan define a MER process? (Y/N)	Y = 1/ N = 0	*This info should be contained in the document. Monitoring is normally standing as a section per se. Sometimes an action to define a MER process is included but this will not be considered.*
			M#34	Does the plan specifically assign a responsible for the MER process? (Y/N)	Y = 1/ N = 0	*This info should be contained in the document. Responsible bodies that are not formed yet will also be considered.*
			M#35	Has the MER process been assigned a budget? (Y/N)	Y = 1/ N = 0	*This info should be contained in the document.*
			M#36	Does the plan identify monitoring objectives and indicators? (Y/N)	Y = 1/ N = 0	*This info should be contained in the document. Specific objectives or indicators to assess those specific objectives should be identified. E.g. MER should assess the damages due to flood extreme events (objective); days of duration of flood events (average) (indicator)*
			M#37	Does the plan set a method and/or process to evaluate outcomes of the monitoring process? (Y/N)	Y = 1/ N = 0	*This info should be contained in the document. The plan should propose a method or approach to assess or interpret the results of the MER process in order to make adequate decisions. Related to M#36. If M#36 is 0, then M#37 is 0.*
			M#38	Does the plan report to any higher-level authority or organisation through an official process? (Y/N)	Y = 1/ N = 0	*This info should be contained in the document or in the city official website. Note. If the city belongs to a city network* (e.g. *Covenant of Mayors) this would be 1, as monitoring results should be reported. Related to M#36. If M#36 is 0, then M#38 is 0.*
	Adaptive manage-ment	13. Learning mechanisms	M#39	Does the plan define a readjustment process i.e. an iterative process to manage existing adaptation strategies according to results of MER or new scenarios? (Y/N)	Y = 1/ N = 0	*This info should be contained in the document. The document mentions a process with a long-term view in which outputs of the MER and other parameters* (e.g. *climatic, socio-economic and urbanisation projections) are taken into account to feed a long-term city adaptation strategy. Some may be using specific methods such as 'adaptation pathways'.*
			M#40	Does this process include a set of indicators / warning metrics? (Y/N)	Y = 1/ N = 0	*This info should be contained in the document. Related to M#39. If M#39 is 0, then M#40 is 0.*
			M#41		Y = 1/ N = 0	

(*continued on next page*)

Table A2 (*continued*)

Major area	Components	Indicators	Metrics	Metric description	Evaluation method	Notes for the coding process
				Does the plan specifically assign a responsible party for readjustment process? (Y/N)		*This info should be contained in the document. It scores even if the plan mentions a responsible body that is not formed yet. Related to M#39. If M#39 is 0, then M#41 is 0.*
		14. Uncertainty	M#42	Does the plan consider uncertainty in the design of the plan and the assessment and selection of adaptation options (low regret measures, different scenarios, flexible approach)?	1 if M#25 = 1, or M#31.5 = 1, or M#39 = 1; 0 if M#25 = 0, and M#31.5 = 0, and M#39 = 0;	*This metric depends on M#25, M#31.5 and M#39*
LEGITIMACY	Legitimacy	15. Transparency and dialogue	M#43	Is the full process of screening, scoping and definition of the plan and later approval described in the plan or in an attached document or public site? (Y/N)	Y = 1/ N = 0	*This info should be contained in the document. This metric refers to the description of the process of definition and writing of the document. (Note: Not all factors mentioned in M#43 need to be described.)*
			M#44	Are people involved in the process of plan creation (in any role such as developers, designers or participants) named in the document? (Y/N)	Y = 1/ N = 0	*This info should be contained in the document. We recognise a partial or full disclosure of names.*
			M#45	Does the plan or any attached documents related to it refer to which kind and how information (scientific or else) used to lead decisions has been produced and used? (Y/N)	Y = 1/ N = 0	*This info should be contained in the document. If different disclosure levels are provided regarding different parts of the document (risk assessment, prioritisation, etc.), the most predominant attitude towards transparency will be considered.*
			M#46	Have different departments of the city been involved in the design of the plan (Y/N)?	Y = 1/ N = 0	*This info should be contained in the document.*
			M#47	Has the plan been formally exposed to a period of public information and debate? (Y/N)	Y = 1/ N = 0	*This info should be contained in the document or in the city official website*
		16. Engagement of stakeholders and civic society'	M#48	Did the plan include a process of participation with stakeholders (including other departments) and civic organisations? (Y/N)	Y = 1/ N = 0	*This info should be contained in the document. Internal only (within the city administration, e.g. other departments) or internal/external participation of public and private stakeholders can be considered. However, participation of general public is specifically assessed in M#49*
			M#49	Did the process of participation include the public? (Y/N)	Y = 1/ N = 0	*This info should be contained in the document. Refers to the inclusion of the general public (citizens, individuals exclusively) in a process of participation and dialogue that is not (only) the public information process*
			M#50	Is there a clear evidence on the multiple expertise brought by participants (in the process of participation)? (Y/N)	Y = 1/ N = 0	*This info should be contained in the document.*
		17. Equity and justice	M#51	Is there evidence that the plan addresses vulnerability in the most marginalized and disadvantaged groups and develops adaptation measures accordingly? (Y/N)	Y = 1/ N = 0	*This info should be contained in the document. Adaptation measures should address specifically vulnerable groups' needs.*
			M#52	Were communities or social advocacy groups involved in the framing and identification of those adaptation strategies? (Y/N)	Y = 1/ N = 0	*This info should be contained in the document. A mention of those groups involved in the participation process would be sufficient.*
			M#53	Does the plan present a full understanding of the beneficiaries of the proposed adaptation measures? (Y/N)	Y = 1/ N = 0	*This info should be contained in the document. The document should mention the positively or negatively affected groups (both direct or indirect) as a result of the implementation of adaptation measures.*

Table A3
T-test results: Group statistics. Note: Evidence (no = 0; yes = 1); N is the number of policies. The groups refer to the Final score (zFinalScore) and the scores in the three major areas for evaluation in the APC framework: policy and economy (xPolicyEcon), science and technology (xScientTech) and Legitimacy (xLegitimacy).

Group Statistics

	Evidence	N	Mean	Std. Deviation	Std. Error Mean
zFinalScore	0	30	19.33333	5.502481	1.004611
	1	29	21.52155	6.706712	1.245405
xPolicyEcon	0	30	0.39833	0.091518	0.016709
	1	29	0.43993	0.110836	0.020582
xScientTech	0	30	0.32710	0.174172	0.031799
	1	29	0.36352	0.208795	0.038772
xLegitimacy	0	30	0.48740	0.246439	0.044993
	1	29	0.49893	0.260387	0.048353

Table A4
T-test results: Independent samples test.

Independent Samples Test

		Levene's Test for Equality of Variances		*t*-test for Equality of Means						
		F	Sig.	t	df	Sig.(2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
zFinalScore	Equal variances assumed	0.971	0.329	−1.372	57	0.175	−2.188218	1.594704	−5.381558	1.005122
	Equal variances not assumed			−1.368	54.155	0.177	−2.188218	1.600087	−5.395988	1.019552
xPolicyEcon	Equal variances assumed	0.572	0.453	−1.574	57	0.121	−0.041598	0.026424	−0.094511	0.011315
	Equal variances not assumed			−1.569	54.298	0.122	−0.041598	0.026510	−0.094741	0.011546
xScientTech	Equal variances assumed	1.215	0.275	−0.728	57	0.469	−0.036417	0.049990	−0.136520	0.063686
	Equal variances not assumed			−0.726	54.520	0.471	−0.036417	0.050145	−0.136929	0.064095
xLegitimacy	Equal variances assumed	0.119	0.731	−0.175	57	0.862	−0.011531	0.065986	−0.143665	0.120603
	Equal variances not assumed			−0.175	56.548	0.862	−0.011531	0.066048	−0.143814	0.120751

References

Abadie, L. M., Galarraga, I., & Murieta, E. S. de (2017). Understanding risks in the light of uncertainty: low-probability, high-impact coastal events in cities. *Environmental Research Letters, 12*, 014017. https://doi.org/10.1088/1748-9326/aa5254.

Adger, W. N., Arnell, N. W., & Tompkins, E. L. (2005). Successful adaptation to climate change across scales. *Global Environmental Change Part A, 15*, 77–86.

Aguiar, F. C., Bentz, J., Silva, J. M. N., Fonseca, A. L., Swart, R., Santos, F. D., & Penha-Lopes, G. (2018). Adaptation to climate change at local level in Europe: An overview. *Environmental Science & Policy, 86*, 38–63. https://doi.org/10.1016/j.envsci.2018.04.010.

Araos, M., Berrang-Ford, L., Ford, J. D., Austin, S. E., Biesbroek, R., & Lesnikowski, A. (2016). Climate change adaptation planning in large cities: A systematic global assessment. *Environmental Science & Policy, 66*, 375–382. https://doi.org/10.1016/j.envsci.2016.06.009.

Averchenkova, A., & Bassi, S. (2016). *Beyond the targets: assessing the political credibility of pledges for the Paris Agreement (No. Policy Brief)*. London, UK: Centre for Climate Change Economics and Policy and Grantham Research Institute on Climate Change and the Environment.

Baynham, M., & Stevens, M. (2014). Are we planning effectively for climate change? An evaluation of official community plans in British Columbia. *Journal of Environmental Planning and Management, 57*, 557–587. https://doi.org/10.1080/09640568.2012.756805.

Berrang-Ford, L., Biesbroek, R., Ford, J. D., Lesnikowski, A., Tanabe, A., Wang, F. M., ... Heymann, S. J. (2019). Tracking global climate change adaptation among governments. *Nature Climate Change, 9*, 440. https://doi.org/10.1038/s41558-019-0490-0.

Biesbroek, R., Berrang-Ford, L., Ford, J. D., Tanabe, A., Austin, S. E., & Lesnikowski, A. (2018). Data, concepts and methods for large-n comparative climate change adaptation policy research: A systematic literature review. *Wiley Interdisciplinary Reviews: Climate Change, 9*, Article e548. https://doi.org/10.1002/wcc.548.

Carmin, J., Nadkarni, N., & Rhie, C. (2012). *Progress and challenges in urban climate adaptation planning.* Massachusetts, US: Massachusetts Institute of Technology.

Castán Broto, V., & Westman, L. K. (2020). Ten years after Copenhagen: Reimagining climate change governance in urban areas. *WIREs Climate Change*. https://doi.org/10.1002/wcc.643.

Dulal, H. B. (2019). Cities in Asia: How are they adapting to climate change? *Journal of Environmental Studies and Sciences, 9*, 13–24. https://doi.org/10.1007/s13412-018-0534-1.

Dupuis, J., & Biesbroek, R. (2013). Comparing apples and oranges: The dependent variable problem in comparing and evaluating climate change adaptation policies. *Global Environmental Change, 23*, 1476–1487. https://doi.org/10.1016/j.gloenvcha.2013.07.022.

Fitzgibbons, J., & Mitchell, C. L. (2019). Just urban futures? Exploring equity in "100 Resilient Cities". *World Development, 122*, 648–659.

Ford, J. D., & Berrang-Ford, L. (2015). The 4Cs of adaptation tracking: Consistency, comparability, comprehensiveness, coherency. *Mitigation and Adaptation Strategies for Global Change, 21*, 839–859. https://doi.org/10.1007/s11027-014-9627-7.

Ford, J. D., Berrang-Ford, L., Biesbroek, R., Araos, M., Austin, S. E., & Lesnikowski, A. (2015). Adaptation tracking for a post-2015 climate agreement. *Nature Climate Change, 5*, 967–969. https://doi.org/10.1038/nclimate2744.

Ford, J. D., & King, D. (2015). A framework for examining adaptation readiness. *Mitigation and Adaptation Strategies for Global Change, 20*, 505–526. https://doi.org/10.1007/s11027-013-9505-8.

Füssel, H.-M. (2007). Adaptation planning for climate change: Concepts, assessment approaches, and key lessons. *Sustainability Science, 2*, 265–275. https://doi.org/10.1007/s11625-007-0032-y.

Georgeson, L., Maslin, M., Poessinouw, M., & Howard, S. (2016). Adaptation responses to climate change differ between global megacities. *Nature Climate Change, 6*, 584–588. https://doi.org/10.1038/nclimate2944.

Guyadeen, D., Thistlethwaite, J., & Henstra, D. (2019). Evaluating the quality of municipal climate change plans in Canada. *Climatic Change, 152*, 121–143. https://doi.org/10.1007/s10584-018-2312-1.

Hallegatte, S., & Engle, N. L. (2019). The search for the perfect indicator: Reflections on monitoring and evaluation of resilience for improved climate risk management. *Climate Risk Management, 23*, 1–6. https://doi.org/10.1016/j.crm.2018.12.001.

Heidrich, O., Dawson, R. J., Reckien, D., & Walsh, C. L. (2013). Assessment of the climate preparedness of 30 urban areas in the UK. *Climatic Change, 120*, 771–784. https://doi.org/10.1007/s10584-013-0846-9.

Heidrich, O., Reckien, D., Olazabal, M., Foley, A., Salvia, M., de Gregorio Hurtado, S., ... Dawson, R. J. (2016). National climate policies across Europe and their impacts on cities strategies. *Journal of Environmental Management, 168*, 36–45. https://doi.org/10.1016/j.jenvman.2015.11.043.

Heikkinen, M., Karimo, A., Klein, J., Juhola, S., & Ylä-Anttila, T. (2020). Transnational municipal networks and climate change adaptation: A study of 377 cities. *Journal of Cleaner Production, 257*, Article 120474. https://doi.org/10.1016/j.jclepro.2020.120474.

IPCC, 2014. Annex II: Glossary [Agard, J., E.L.F. Schipper, J. Birkmann, M. Campos, C. Dubeux, Y. Nojiri, L. Olsson, B. Osman-Elasha, M. Pelling, M.J. Prather, M.G. Rivera-Ferre, O.C. Ruppel, A. Sallenger, K.R. Smith, A.L. St Clair, K.J. Mach, M.D. Mastrandrea, and T.E. Bilir (eds.)], in: Barros, V.R., Field, C.B., Dokken, D.J., Mastrandrea, M.D., Mach, K.J., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C., Girma, B., Kissel, E.S., Levy, A.N., MacCracken, S., Mastrandrea, P.R., White, L.L. (Eds.), Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press,

Cambridge, United Kingdom and New York, NY, USA, pp. 1757–1776.
Le, T. D. N. (2019). Climate change adaptation in coastal cities of developing countries: Characterizing types of vulnerability and adaptation options. *Mitigation and Adaptation Strategies for Global Change*. https://doi.org/10.1007/s11027-019-09888-z.
Lee, T., Yang, H., & Blok, A. (2020). Does mitigation shape adaptation? The urban climate mitigation-adaptation nexus. *Climate Policy, 20*, 341–353. https://doi.org/10.1080/14693062.2020.1730152.
Lesnikowski, A., Ford, J., Biesbroek, R., Berrang-Ford, L., & Heymann, S. J. (2016). National-level progress on adaptation. *Nature Climate Change, 6*, 261–264. https://doi.org/10.1038/nclimate2863.
Lesnikowski, A., Ford, J., Biesbroek, R., Berrang-Ford, L., Maillet, M., Araos, M., & Austin, S. E. (2017). What does the Paris Agreement mean for adaptation? *Climate Policy, 17*, 825–831. https://doi.org/10.1080/14693062.2016.1248889.
Lyles, W., Berke, P., & Overstreet, K. H. (2018). Where to begin municipal climate adaptation planning? Evaluating two local choices. *Journal of Environmental Planning and Management, 61*, 1994–2014. https://doi.org/10.1080/09640568.2017.1379958.
Magnan, A. K. (2016). Climate change: Metrics needed to track adaptation. *Nature, 530*, 160. https://doi.org/10.1038/530160d.
Magnan, A. K., & Ribera, T. (2016). Global adaptation after Paris. *Science, 352*, 1280–1282. https://doi.org/10.1126/science.aaf5002.
Moser, S. C., & Ekstrom, J. A. (2010). A framework to diagnose barriers to climate change adaptation. *Proceedings of the National academy of Sciences of the United States of America, 107*, 22026–22031. https://doi.org/10.1073/pnas.1007887107.
Noble, I.R., Huq, S., Anokhin, Y.A., Carmin, J., Goudou, D., Lansigan, F.P., Osman-Elasha, B., Villamizar, A., (2014). Adaptation needs and options, in: Field, C.B., Barros, V.R., Dokken, D.J., Mach, K.J., Mastrandrea, M.D., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C., Girma, B., Kissel, E.S., Levy, A.N., MacCracken, S., Mastrandrea, P.R., White, L.L. (Eds.), Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel of Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 833–868.
OED, (2013). Credible, adj. and n. OED, Oxford English Dictionary.
Olazabal, M., Galarraga, I., Ford, J.D., Lesnikowski, A., Sainz de Murieta, E., (2017). Towards successful adaptation: a checklist for the development of climate change adaptation plans (No. 2017– 01), BC3 Working Paper Series. Basque Centre for Climate Change (BC3), Bilbao (Spain).
Olazabal, M., Galarraga, I., Ford, J., Sainz de Murieta, E., & Lesnikowski, A. (2019). Are local climate adaptation policies credible? A conceptual and operational assessment framework. *International Journal of Urban Sustainable Development, 11*, 277–296. https://doi.org/10.1080/19463138.2019.1583234.
Olazabal, M., Ruiz de Gopegui, M., Tompkins, E. L., Venner, K., & Smith, R. (2019). A cross-scale worldwide analysis of coastal adaptation planning. *Environmental Research Letters, 14*, Article 124056. https://doi.org/10.1088/1748-9326/ab5532.
Preston, B., Westaway, R., & Yuen, E. (2011). Climate adaptation planning in practice: An evaluation of adaptation plans from three developed nations. *Mitigation and Adaptation Strategies for Global Change, 16*, 407–438. https://doi.org/10.1007/s11027-010-9270-x.
Reckien, D., Flacke, J., Dawson, R. J., Heidrich, O., Olazabal, M., Foley, A., ... Pietrapertosa, F. (2014). Climate change response in Europe: What's the reality? Analysis of adaptation and mitigation plans from 200 urban areas in 11 countries. *Climatic Change, 122*, 331–340. https://doi.org/10.1007/s10584-013-0989-8.
Reckien, D., Flacke, J., Olazabal, M., & Heidrich, O. (2015). The influence of drivers and barriers on urban adaptation and mitigation plans—An empirical analysis of European Cities. *PLoS One, 10*, Article e0135597. https://doi.org/10.1371/journal.pone.0135597.
Reckien, D., Salvia, M., Heidrich, O., Church, J. M., Pietrapertosa, F., De Gregorio-Hurtado, S., ... Dawson, R. (2018). How are cities planning to respond to climate change? Assessment of local climate plans from 885 cities in the EU-28. *Journal of Cleaner Production, 191*, 207–219. https://doi.org/10.1016/j.jclepro.2018.03.220.
Reckien, D., Salvia, M., Pietrapertosa, F., Simoes, S. G., Olazabal, M., De Gregorio Hurtado, S., ... Heidrich, O. (2019). Dedicated versus mainstreaming approaches in local climate plans in Europe. *Renewable and Sustainable Energy Reviews, 112*, 948–959. https://doi.org/10.1016/j.rser.2019.05.014.
Sainz de Murieta, E., Olazabal, M., Sanz, E., 2020. ¿Están las ciudades españolas adaptándose al cambio climático? Papeles de Economía Española 160–178.
Shi, L., Chu, E., & Debats, J. (2015). Explaining progress in climate adaptation planning across 156 US municipalities. *Journal of the American Planning Association, 81*, 191–202. https://doi.org/10.1080/01944363.2015.1074526.
Simonet, G., & Leseur, A. (2019). Barriers and drivers to adaptation to climate change—a field study of ten French local authorities. *Climatic Change*. https://doi.org/10.1007/s10584-019-02484-9.
Smit, B., Pilifosova, O., Burton, I., Challenger, B., Huq, S., Klein, R.J.T., …, Smith, J., (2001). Adaptation to climate change in the context of sustainable development and equity, in: Climate Change 2001: Impacts, Adaptation, and Vulnerability., IPCC Working Group II. Cambridge University Pres, Cambridge, U.K., pp. 877–912.
Stults, M., & Woodruff, S. C. (2017). Looking under the hood of local adaptation plans: Shedding light on the actions prioritized to build local resilience to climate change. *Mitigation and Adaptation Strategies for Global Change, 22*, 1249–1279. https://doi.org/10.1007/s11027-016-9725-9.
Tompkins, E. L., Vincent, K., Nicholls, R. J., & Suckall, N. (2018). Documenting the state of adaptation for the global stocktake of the Paris Agreement. *Wiley Interdisciplinary Reviews: Climate Change, 9*, Article e545. https://doi.org/10.1002/wcc.545.
Woodruff, S. C., Meerow, S., Stults, M., & Wilkins, C. (2018). Adaptation to resilience planning: Alternative pathways to prepare for climate change. *Journal of Planning Education and Research*. https://doi.org/10.1177/0739456X18801057.
Woodruff, S. C., & Stults, M. (2016). Numerous strategies but limited implementation guidance in US local adaptation plans. *Nature Climate Change, 6*, 796–802. https://doi.org/10.1038/nclimate3012.