Progress and gaps in climate change adaptation in coastal cities across the globe

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Abstract

Coastal cities are at the frontlines of climate change impacts, resulting in an urgent need for substantial adaptation. To understand whether and to what extent cities are on track to prepare for climate risks, this paper systematically assesses the academic literature to evaluate climate change adaptation in 199 coastal cities worldwide. We show that adaptation in coastal cities is rather slow, of narrow scope, and not transformative. Adaptation measures are predominantly designed based on past and current, rather than future, patterns in hazards, exposure, and vulnerability. City governments, particularly in high-income countries, are more likely to implement institutional and infrastructural responses, while coastal cities in lower-middle income countries often rely on households to implement behavioral adaptation. There is comparatively little published knowledge on coastal urban adaptation in low and middle income economies and regarding particular adaptation types such as ecosystem-based adaptation. These insights make an important contribution for tracking adaptation progress globally and help to identify entry points for improving adaption of coastal cities in the future.

Coastal cities are engines of economic growth and innovation, yet they are also hotspots of disasters and climate risk [1–3]. These cities face increasing environmental changes such as record-breaking sea-surface temperatures [4] and a resulting increase in hazards such as tropical cyclones, floods and heat-waves [5,6]. Such changes dynamically interact with urban vulnerabilities driven by, for example, inequality, poverty, and inadequate infrastructure [7]. Yet coastal urban risk is not uniform, as climate change impacts and risks vary across coastal cities depending on local geomorphological conditions, climatic and human drivers of coastal change, urban development and other factors ([6]:2169) [8,9]. In the face of future increases in urbanization and climate change impacts, coastal cities are under pressure to adapt and reduce current as well as future risks to ensure sustainable and equitable urban development [10,11]. As centers of economic activities and key players in the global political economy with significant capacities, coastal cities have the potential to shape and advance the future of climate adaptation in meaningful and innovative ways [12]. Even though the need for transformative adaptation in coastal cities, i.e. adaptation that changes the fundamental attributes of a social-ecological system in anticipation of climate change and its impacts [13], has been stressed in principle (e.g. [2,14], little is known about the actual progress of adaptation in coastal cities across the globe.

Given the unique challenges and opportunities in coastal cities as hotspots of risk and centers of economic activity, we argue that assessing their current state of adaptation is important, not least as a knowledge base for tracking countries' progress in climate action within the Global Stocktake under the Paris Agreement [15]. Understanding how coastal cities are responding to climate impacts is crucial for identifying successes and gaps, and for advancing global adaptation efforts at large. Studies have assessed different types of urban adaptation, for example, institutional [16] or ecosystem-based [17], urban adaptation policies in particular regions (e.g. [18]), certain actor types involved in urban adaptation (e.g. [19]), adaptation efforts in cities in particular regions (e.g. [20–22]) or coastal urban adaptation planning [23]. However, a systematic global assessment of the literature on empirical evidence for implemented coastal urban adaptation, including its response types, actors and level of transformation, does not yet exist. Such an assessment is particularly relevant in the face of the latest Intergovernmental Panel on Climate Change's (IPCC) report's finding that coastal cities tend to implement adaptation interventions reactively in response to high-impact events such as floods and storms [24] and that many gaps remain in urban adaptation to climate change induced hazards across country regions [12].

Important questions that need to be addressed include: How are coastal cities adapting and do they engage in transformative adaptation? To which hazards are coastal cities adapting and in how far are future trends in exposure and vulnerability considered? Which response types are implemented? Which actors implement adaptation? This study extends earlier assessments of the state of adaptation more generally [25] by analyzing the empirical evidence of coastal urban responses to climate change in a systematic way. To do so, we assessed the state of adaptation in coastal cities as reported in the scientific literature between 2013 and 2020. Coastal cities here are defined by the presence of central functions like markets, medical services, and schools, relative importance for the surrounding area (i.e., regardless of population size), and geographical position in the zone of geophysical influence of coastal dynamics. Our sample covers adaptation activities in 199 cities, reported in 683 articles, of which 182 were qualitatively coded using a questionnaire composed of 30 questions (see online methods for details). Our analysis is hence limited to what is being reported in the scientific literature and might include some hard-to-quantify biases that need to be addressed through additional data sets in the future. However, we argue that it nevertheless can provide highly relevant insights not only on urban adaptation research but also on the patterns of actual adaptation activities as adaptation research has been expanding massively, now capturing a wide spectrum of activities on the ground. Studies like these, therefore, provide an increasingly important knowledge base for tracking adaptation activities [25]

This study has two main objectives: (1) to provide a first global stocktake of empirical evidence of adaptation in coastal cities, including gaps and shortcomings, and (2) to inform policy and practice for coastal city adaptation in order to advance effective adaptation strategies in response to current and projected climate impacts.

Results

Coastal urban adaptation across the globe

The considered literature covers adaptation evidence from all country regions and income groups, yet with some considerable differences (see Fig. 1; for a detailed list of countries covered in the sample see SM.1). Most publications (31%) present evidence for adaptation from coastal cities in Asia, followed by North America (23%), Europe (15%), and Africa (13%). Compared to the global share of inhabitants living in the low-coastal elevation zone (LCEZ) between 0 and 10 meters above sea level [26,27], some country regions are overrepresented. This is most evident for North America, Australasia, and Small Island States which are home to 5%, 0.6% and 0.5% of the global population in the LCEZ, respectively. However, in our sample of coastal urban adaptation evidence, they represent 23%, 11%, and 3% of assessed coastal cities. Other regions are underrepresented in our sample in this regard. This is most evident for Asia given its high number of inhabitants in the LCEZ. While inhabiting 75% of the global population in the LCEZ, only 31% of our assessed urban coastal adaptation evidence stems from this region.

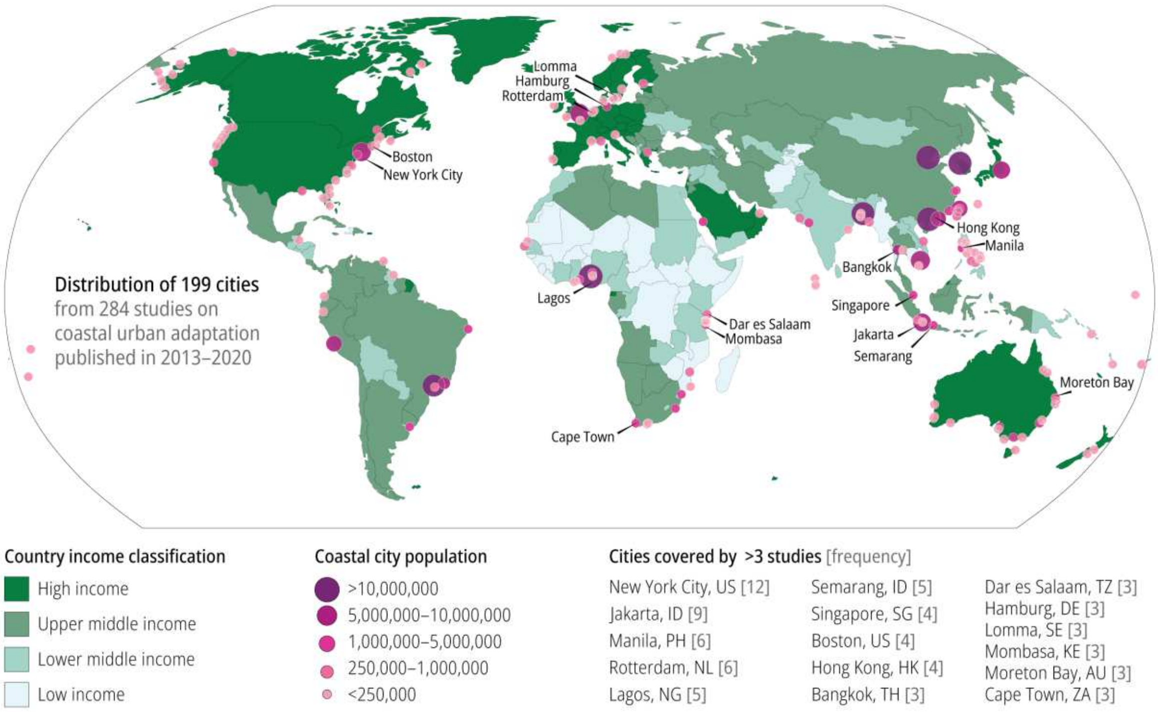


Figure 1: Geographical and economic distribution of coastal cities in the assessed literature.

Considering the income levels, the majority of adaptation in coastal cities is reported from high-income economies (56%). This is in stark contrast to the fact that only 16% of the population located in the LCEZ lives in high income economies. Nineteen percent of the reported coastal cities are in upper-middle-income economies and 23% in lower-middle-income economies. Given that upper-middle income countries inhabit roughly one third (34%) and lower-middle income countries even 43% of the global population in the LCEZ [26,27], coastal cities in these income groups are considerably underrepresented in our sample, meaning in the academic literature. Only two percent of the reported activities are in coastal cities in low-income economies such as Mozambique (Maputo, Beira, Inhambane) and Niger (Lagos). In comparison to their global population share living in the low-coastal elevation zone of around 8%, coastal cities in this income group are also underrepresented in our sample.

In terms of the coverage of different sizes of coastal cities (see SM.2), the assessed literature mostly presents evidence for adaptation in coastal cities with less than 250.000 inhabitants (48% of the reported cases). This pattern can partly be explained by our definition of “coastal city” based on their central functions, rather than population thresholds. Evidence for adaptation from mid-sized coastal cities with 250.000 to 1 million inhabitants is less well-covered in our sample; examples mostly are in North America and Europe. Thirty-five percent of the reported adaptation happens in coastal cities with more than 1 million inhabitants, with a majority of cases in Africa and Asia. Some megacities (i.e., cities with more than ten million inhabitants) such as New York, Jakarta, Manila and Lagos are covered by multiple studies (see Fig. 1). Most empirical evidence for adaptation in coastal megacities stems from Asia (57%), which aligns with the fact that out of 20 coastal megacities 15 are located in Asia [28] as well as with the high share of overall population in the LCEZ in Asia, where 75 percent of the population live in this zone [26,27].

Hazards and trends of exposure and vulnerability

In terms of hazards, the adaptation activities reported in the sample predominantly address sea level rise, different types of flooding and, to a lesser extent, storm surge, cyclones and erosion (see Fig. 2). A majority of the assessed cases (65%) considers more than one hazard. Such consideration of multiple hazards is most evident for the combination of sea level rise with storm surge, coastal flooding and pluvial flood events as well as coastal erosion. This finding suggests that multi-hazard considerations nowadays play a strong role in urban climate risk assessments, in line with what the conceptual literature would be calling for [6,9].

Regarding time scales and scenarios of hazards, studies predominantly consider past and current events (Figure 2). Oftentimes studies consider future hazard trends in principle but not in a quantified manner. While modeled trends and scenarios are quite frequently used as a basis for adaptation to sea level rise, flooding and storm surges, they are much less common for other hazards.

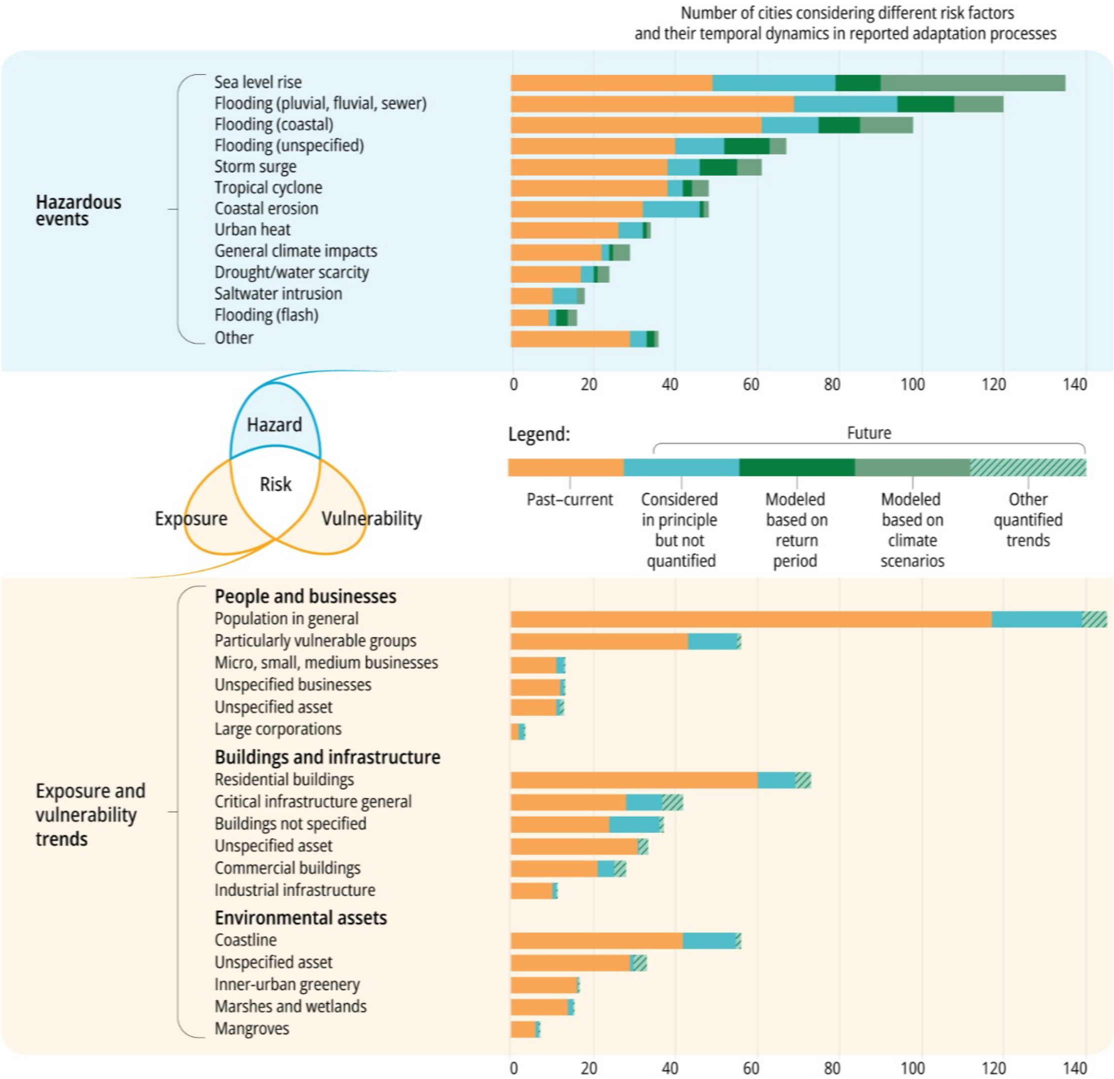


Figure 2: Consideration of risk factors in coastal urban adaptation

The picture is even more striking regarding how other risk factors, notably the exposure and vulnerability of people and assets in coastal cities, are considered. In the vast majority of coastal cities, reported adaptation considers only past and current patterns, with the population being the most important element considered, followed by particularly vulnerable groups, residential buildings and the coastline (Fig. 2). In cases where future trends in exposed and vulnerable assets are considered, they are accounted for in a general or conceptual way, but not in terms of quantified scenarios. Across our sample, the consideration of the presented elements at risk correlates weakly with a country's income level. The higher the income group, the more likely that exposure and vulnerability aspects are considered (see SM.3).

Responses and actors

Most of the reported adaptation in coastal cities can be categorized as technological/infrastructural and behavioral/cultural adaptation (Fig. 3). But combinations of these two, as well as technological and institutional responses were also frequently reported. Ecosystem-based responses are least reported across all world regions, in particular in low, lower-middle and upper-middle income countries.

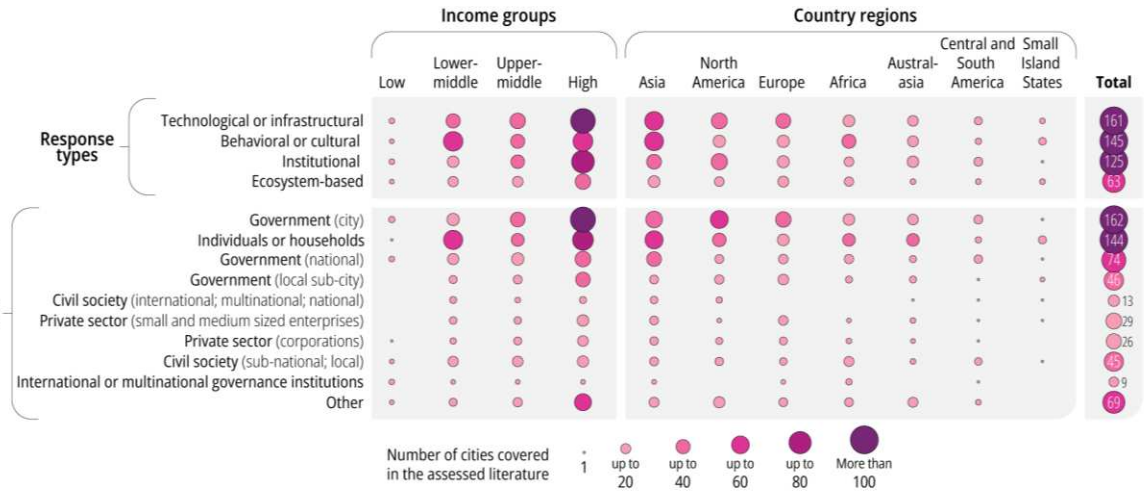


Figure 3: Response types and involved actors across income groups and country regions of the assessed coastal cities

The prominence of different response and actor types varies across country and income groups (see Fig. 3) as well as city size. Most cases reporting technological or infrastructural responses are from coastal cities in high-income countries. The coverage of institutional responses shows a similar pattern. A correlation analysis confirms that the higher the Gross National Income (GNI) per capita, the more likely that institutional adaptation (Spearman's rho = 0.24, $p<0.01$) and the less likely that behavioral adaptation (Spearman's rho = -0.35, $p<0.01$) is mentioned (SM.4). Institutional responses are mostly reported to be implemented by state-actors, especially city governments (SM.5) the most mentioned actor type across our sample. Correlation analysis reveals that the higher the GNI per capita, the more likely that the city government is assessed as an actor in adaptation (Spearman's rho = 0.30, $p<0.01$), and the less likely that individuals/households are mentioned (Spearman's rho = -0.23, $p<0.01$) (SM.6). Also, our analyses reveal that the bigger a city, the less likely that individual/household adaptation action is mentioned (Spearman's rho = -0.30, $p<0.01$) and the more likely that city government is assessed as actor involved in adaptation (Spearman's rho = 0.20, $p<0.01$) (SM.6).

Reported behavioral or cultural responses are most likely to be assessed together with individuals or households as implementing actors (SM.7). This response type dominates the reported adaptation evidence in coastal cities in lower-middle income countries. Accordingly, individuals and households are mostly reported as adaptation actors here, while state actors such as city and sub-city governments are less frequently assessed as implementers. In contrast to this trend, we find a low involvement of individuals in low-income economies. However, the very small number of cases in the low income category needs to be considered here.

While the assessed literature mostly presents adaptation evidence implemented by one type of actor– in our sample mostly city governments followed by individuals/households–there is also reported evidence for multiple actors involved in urban adaptation. In many cases, individuals/households and city governments are mentioned together. Additionally, combinations of city and national government, or a combination of the two with sub-city local government, are reported more frequently than other combinations (SM.8).

Looking at adaptation types across country regions (Fig. 3, SM.7), urban behavioral adaptation is significantly less likely to be reported in North American coastal cities (Spearman's rho = -0.21, $p<0.01$) and coastal cities in Central and South America but more likely to be reported in coastal cities in Africa and Asia. For the latter two, we find less evidence for institutional and ecosystem-based adaptation; these adaptation categories are more likely to be assessed in Europe and North American coastal cities. Evidence for technological adaptation measures is most likely to be assessed in European coastal cities; research on institutional adaptation evidence features highest in North and South America.

Speed, scope, depth and evidence of risk reduction due to adaptation

Transformative adaptation can be assessed along the dimensions of depth (i.e. how deep institutional and other changes are), speed (i.e. how fast adaptation is planned and implemented), and scope (i.e. with which geographical and sectoral breadth adaptation happens) [25,29]. Overall, we find that reported adaptation remains at rather low depth, scope and speed in coastal cities, across all income groups and country regions, with little evidence of reduced risks due to adaptation. Neither income level nor population size predicts more or less transformative adaptation (SM.9).

	Depth of adaptation			Scope of adaptation			Speed of adaptation		
Income groups	Low	Mid.	High	Low	Mid.	High	Low	Mid.	High
Low	50%	50%	0	33%	67%	0	0	0	100%
Lower-middle	61%	34%	5%	70%	23%	6%	76%	17%	7%
Upper-middle	59%	30%	10%	54%	35%	10%	62%	21%	16%
High	60%	30%	10%	61%	24%	15%	70%	16%	14%
Total share	60%	31%	9%	62%	26%	12%	69%	17%	13%

Proportion of adaptations reported with high level of confidence

Figure 4: Depth, scope, and speed of the reported adaptation across income groups

The sample shows little evidence of deep coastal urban adaptation across income groups (see Fig. 4). Few examples of urban adaptation with deeper changes, meaning entirely new practices involving deep structural reform, a fundamental change in mindset, major shifts in perceptions or values, and/or changing institutional or behavioral norms, stem from cities in high-income economies and from cities in Small Island States. Given the small number of cases which feature such more fundamental forms of adaptation, we provide an aggregated overview of specific studies in the following.

Some cases reported self- or state-led resettlement [30,31] to adapt to climate change impacts in coastal cities. In cities such as Singapore and Hong Kong [32] and several Swedish cities [33], existing infrastructural measures are complemented by preparedness and recovery measures as well as ecosystem-based approaches. Progress in the institutionalization and mainstreaming of basin-wide planning, the integration of adaptation into mitigation and development planning, as well as the establishment of legislation to reinforce adaptation in sectors like construction, are considered as evidence of more transformative adaptation in coastal cities. We also identified evidence for medium adaptation depth across income groups, where the assessed responses reflect a shift away from existing practices, norms, or structures to some extent. In coastal cities located in high-income countries in Europe such as Rotterdam, Dordrecht and Helsinki, medium depth adaptation is linked to the testing of innovative, design-oriented adaptation approaches, the development of collaborative governance approaches as well as public-private partnerships for improving funding and innovation [34–38]. In smaller U.S. coastal cities such as Dunedin and Fernandina Beach, changes towards cross-sectoral, comprehensive and more integrative risk management plans (Diaz et al. 2016, Butler 2016) were described. Bigger U.S. cities such as New York and Miami Beach are implementing both large-scale infrastructure investments for flood protection [39–41] and planning and/or complementary adaptation measures such as ecosystem-based and soft adaptation approaches [39,42].

In Asian cities in lower-middle and upper-middle income countries, medium depth adaptation includes changes in adaptive behavior of individuals and households, for example, through changes in livelihoods or migration [31,43–46] as well as at institutional scale adaptations, for example, through the establishment of new institutions responsible for adaptive planning, disaster risk reduction planning across scales or mainstreaming climate change policies in other sectors [47–49]. The only city in a low income country with evidence of medium depth adaptation is Maputo, which has mainstreamed climate change adaptation in its development plans, attributed clear responsibilities for addressing climate change impacts and started participatory urban planning processes [50].

For the majority of cities covered in our sample, adaptation remains at low depth across income groups and country regions meaning that evidence for adaptation represents largely expansions of existing practices, with minimal change in underlying values, assumptions, or norms. Examples are a continuous focus on traditional infrastructural measures to avoid flooding [51,52], continued uptake of flood insurance [53], or incremental adaptation in the form of reactive coping due to limited capacities [54,55].

The scope of responses in our sample is mostly narrow, both across income groups as well as country regions, meaning that evidence for coastal urban adaptation measures is largely localized and fragmented, with limited evidence of coordination or mainstreaming across sectors, jurisdictions, or levels of governance.

The speed of coastal urban adaptation is mostly considered low, especially in high, upper-middle and lower-middle income countries and a majority of country regions. This means that adaptations are incremental, consisting of small steps and slow implementation.

Given that depth, scope, and speed of adaptation were evaluated as rather low across our sample, it is not surprising that there is little evidence for risk being reduced through these measures. While we identified some cases that present evidence for risks being overcome through, for example, ecosystem-based [56,57] and technological/infrastructural adaptation (e.g. [41,58]), some are linked to negative side-effects or lacking long-term perspectives (e.g. [59]) or even represent maladaptation (e.g. [52,60,61]).

Discussion

Based on the analysis of adaptation in coastal cities as reported in the academic literature, we highlight five key findings that have significant implications for research and policy-making in the field of coastal urban adaptation to climate change.

First, our assessment shows that the knowledge about and coverage of adaptation in coastal cities are highly uneven, with some cities receiving a lot of scientific attention and large gaps remaining. For example, small and mid-sized cities in Africa, Asia and Central and South America are currently not part of the global scientific debate. In our assessment, coastal cities in low-income, lower-middle, and upper-middle income countries are underrepresented. Against the background that cities in Africa, Asia and Central and South America are expected to experience a highly dynamic interplay of urbanization, highly vulnerable informal settlements and future climate change impacts ([62]:7) this is a significant gap in research that needs to be addressed urgently.

Second, we found that by and large, hazards, exposure and vulnerability are considered on the basis of past and current events and conditions. The use of future climate scenarios or other quantitative assessment taking into account future hazard trends remains scarce and the picture is even more troublesome in terms of the future trends of exposure and vulnerability. Most reported adaptation is not based on a thorough consideration, let alone quantified scenarios, of future developments in the exposure and vulnerability of at-risk people, infrastructure, ecosystems and other assets. This leads to skewed assumptions on future risk, jeopardizing the relevance and validity of the knowledge base for adaptation planning. While this finding confirms earlier observations with respect to the low consideration of future exposure and vulnerability trends in National Adaptation Plans (NAPs) [63] and cities [23], it is nevertheless striking given the high importance of dynamic changes in these domains for changing future risk in coastal cities, for example, through further coastal urbanization or ongoing socio-economic marginalization in many coastal cities [6,7].

Third, we find that the lower the income group of the country the coastal cities are located in, the more likely individuals/households are reported as prime adaptation actors. At the same time government responses and planned adaptation are more often reported in coastal cities in wealthier countries. This suggests that residents with limited resources in poorer coastal cities have to carry most of the adaptation burden [64] which is often met with behavioral changes because of the lack of institutional and/or technological support. These results corroborate other studies regarding the inequality in the urban adaptation gap ([62]:34), [24]:941)), which is most pronounced among the poor.

Fourth, the bigger a city, the more likely that technological responses and protection are assessed. This relationship was also found in other studies [65]. At the same time, there is a lack of reported empirical evidence on ecosystem-based adaptation. Technology-based measures such as flood-barriers or pumping installations are essential protective mechanisms in the short- and mid-term, e.g. for storm water management. However, they can lead to a lock-in and maladaptive path dependency in the long-term if coastal hazards continue to rise and hard protection fails or reaches limits of financial and technical feasibility as well as cultural acceptance [66,67]. More research on alternative and complementary adaptation measures is therefore needed to guide mixed approaches in the future.

Fifth, our findings suggest urgent needs for transformative adaptation in coastal cities. Across all regions and income groups, reported adaptation in coastal cities remains at rather low depth, scope and speed. Neither income level nor population size predicted more or less progressive adaptation behavior. Given the high exposure and vulnerability of many coastal cities already today, this finding is alarming as climate change will exacerbate existing risks and vulnerabilities. This finding affirms other assessments of urban adaptation [24] and stresses the persistent need for transformative adaptation in coastal cities. It is possible that the cumulative effects of incremental responses could, over time, lead to meaningful and even transformative adaptation. However, the speed and amount of change needed to mitigate current and future risks, could mean that incremental adaptation is tantamount to playing "catch-up" as climate impacts accelerate.

The extreme changes in the oceans and coasts seen in the recent past, with e.g. new temperature records [4,68,69] and low sea ice extent [70], highlights the scale and speed of adaptation that will be needed. Yet, our findings suggest that adaptation in coastal cities is rather slow, narrow and fragmented – in other words non-transformative – in an environment that is transforming rapidly. Yet, the findings presented here point towards an increasing range of adaptation activities in coastal cities and can help to identify and fill existing gaps.

Online methods

We base our findings on the combination of a systematic review of scientific literature on coastal urban adaptation to climate change across three reference databases (see Fig. 1) with a content analysis based on a coding protocol, following the GAMI process.

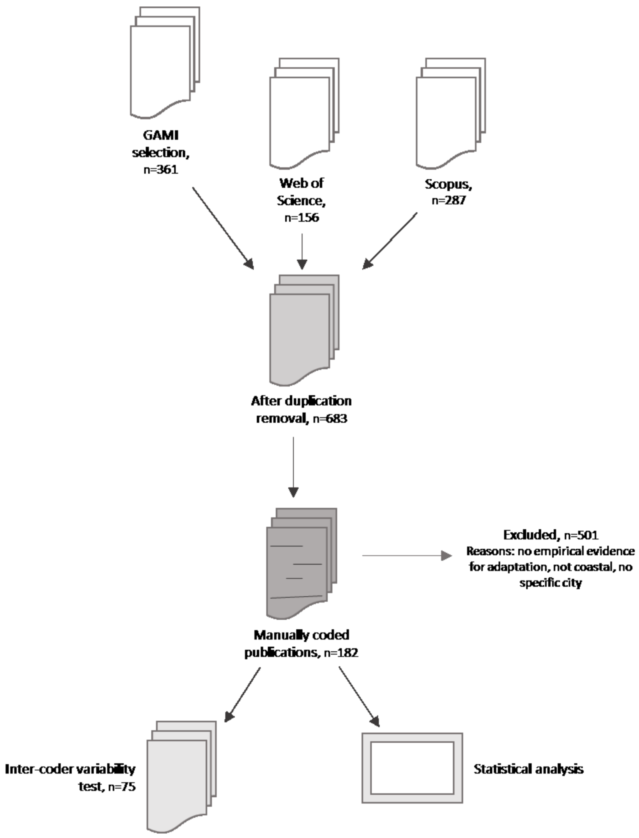


Figure 1: Workflow

Relevant peer-reviewed, scientific, English-language literature on the topic of coastal urban adaptation was identified in a four-tiered search process.

Literature search and data extraction

Publications of the category "cities and settlements by the sea" were extracted from the GAMI database, a systematic dataset of over 1600 articles on climate adaptation. After a preliminary overview of the 361 resulting publications, additional searches in Web of Science and Scopus, and lively discussions among the co-authors–most of whom are well-acquainted with the literature in this particular field–it was decided that the GAMI selection did not adequately represent the large pool of existing literature on coastal urban adaptation. Hence, in a second step, a search string based on boolean search terms was used to systematically search the reference databases Web of Science (Core Collection) and Scopus for relevant literature for the years 2013 to 2020. With this we extended the original GAMI search by one year; we did not include 2021 and 2022 based on the coding time-frame. While the basis of the search string was adopted from the GAMI process [71,72], it was extended by tailored search terms to yield more topic-relevant publications. The search strings and respective hits can be found in the (SM.10). In a final step, the results of all three searches were combined and duplications were removed.

Screening

A total of 683 scientific publications entered the screening process in which the coders assessed if a publication should be included in the analysis. Strict inclusion/exclusion criteria (SM.11) guided their decisions. A total of 501 publications were excluded because they did not present empirical evidence for adaptation and/or did not focus on a coastal city.

Coding

Included publications were analyzed via a systematic content analysis. Using the online survey platform SoSci Survey, coders completed one coding-questionnaire per city covered in the manuscript. This means that for one publication, several questionnaires could have been completed in the case that it dealt with two or more cities. In total, 182 publications (SM.12) covering 284 cases from 199 cities and/or settlements with central functions such as schools, supermarkets and medical services were included in the coding and statistical analysis, as well as four unspecified urban areas.

Data quality

Coder consistency and reliability was ensured by an introduction to the commonly developed questionnaire, a code book/protocol with detailed definitions of all codes (SM.13), a pre-coding period with interim meetings to discuss issues and confusions as well as multiple other meetings with all involved coders. The coding included among others the following categories: hazard type, exposure and vulnerability, actor type, response type, and–as indicators for transformational adaptation–the depth, speed and scope of adaptation (see SM.13 for the full list of codes and variables). About 10 percent of the entire dataset, i.e. 72 publications, was double coded to check inter-coder reliability. For 12.8%, conflicts regarding inclusion/exclusion arose. Of the 16 fully double-coded publications, inter-coder variability rose to a maximum of 22.2%, meaning a convergence in roughly 80% of provided answers, which was accepted as sufficient to consider the dataset as robust. Fourth, the data in the form of codes were extracted from the platform, cleaned and statistically analyzed in IBM SPSS Statistics 23, following the original GAMI approach [71,73,74].

Data analysis

To get an overview of the dataset, descriptive statistical analyses were performed assessing the frequency and proportion of all variables. To identify potential patterns, frequencies were assessed across the World Bank income economies categories (hereafter income groups) [75] as well as across country regions following the classification used in [25]. Moreover, we used different correlation tests to explore potential relationships between Gross National Income (GNI) per capita as well as city size (in terms of population) and patterns of actor involvement, adaptation type and depth, and speed and scope of adaptation. To conduct a cross-sectional comparison of population data in the Low Elevation Coastal Zone (LECZ) across different regions, we utilized "The Low Elevation Coastal Zone (LECZ) Urban-Rural Population and Land Area Estimates, Version 3" dataset [26]. Within this dataset, we specifically selected the population data from "Gridded Population of the World, Version 4 (GPWv4), Revision 11" and the elevation data from "CoastalDEM90" as core datasets, due to their particular applicability in global-scale and coastal analyses. The objective was to evaluate the existence of any relationship between these two variables (GNI per capita and city size) and in particular to determine their potential impact on our assessed variables. The Spearman rank correlation was employed to ascertain the relationship between GNI per capita and city size with actor involvement. The correlation coefficient ranges between -1 and 1, indicating negative and positive correlations respectively. The significance of the correlation is determined by the t-test, which assesses the hypothesis that the correlation is different from zero. A significant t-value (usually $p < 0.05$) would indicate a statistically significant correlation between the variables. The relationship between adaptation actors and response categories was determined using the chi-square test, a common statistical method for measuring the association between binary variables. The strength and direction of the association are represented by the Phi coefficient. This coefficient, like the Spearman correlation, ranges from -1 to 1, with values close to -1 indicating a strong negative association, values close to 1 indicating a strong positive association, and values close to 0 indicating a weak or no association. The significance of the Phi coefficient is also determined using a chi-square test, with a significant result indicating a statistically significant association between the binary variables.

References

1. Hallegatte, S. Future flood losses in major coastal cities. *NATURE CLIMATE CHANGE* **3**, 5 (2013).
2. Kuhl, L. *et al.* Transformational Adaptation in the Context of Coastal Cities. *Annual Review of Environment and Resources* **46**, 449–479 (2021).
3. Pelling, M. *The Vulnerability of Cities: Natural Disasters and Social Resilience*. (Routledge, 2003). doi:10.4324/9781849773379.
4. Jones, N. The ocean is hotter than ever: what happens next? *Nature* **617**, 450–450 (2023).
5. Becker, M., Karpytchev, M. & Hu, A. Increased exposure of coastal cities to sea-level rise due to internal climate variability. *Nat. Clim. Chang.* **13**, 367–374 (2023).
6. Glavovic, B. *et al.* Cross-Chapter Paper 2: Cities and Settlements by the Sea. in *Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (eds. Pörtner, H.-O. et al.) 2163–2194 (Cambridge University Press, 2022). doi:10.1017/9781009325844.019.
7. Garschagen, M. & Romero-Lankao, P. Exploring the relationships between urbanization trends and climate change vulnerability. *Climatic Change* **133**, 37–52 (2015).
8. Magnan, A. K. *et al.* Sea level rise risks and societal adaptation benefits in low-lying coastal areas. *Sci Rep* **12**, 10677 (2022).
9. Magnan, A. K. *et al.* Status of global coastal adaptation. *Nat. Clim. Chang.* (2023) doi:10.1038/s41558-023-01834-x.
10. Rosenzweig, C. *et al.* Climate Change and Cities: Second Assessment Report of the Urban Climate Change Research Network: Summary for City Leaders. in *Climate Change and Cities: Second Assessment Report of the Urban Climate Change Research Network* (eds. Rosenzweig, C. et al.) xvii–xlii (Cambridge University Press, 2018). doi:10.1017/9781316563878.007.
11. Wolff, C., Nikoletopoulos, T., Hinkel, J. & Vafeidis, A. T. Future urban development exacerbates coastal exposure in the Mediterranean. *Sci Rep* **10**, 14420 (2020).
12. Adelekan, I. *et al. What the latest science on impacts, adaptation and vulnerability means for cities and urban areas. Indian Institute for Human Settlements*. https://iihs.co.in/knowledge-gateway/climate-change-in-cities-and-urban-areas-impacts-adaptation-and-vulnerability/ (2022) doi:10.24943/SUPSV209.2022.
13. IPCC. Annex II: Glossary. in *Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (eds. Möller, V. et al.) (2022).
14. Solecki, W., Pelling, M. & Garschagen, M. Transitions between risk management regimes in cities. *E&S* **22**, art38 (2017).
15. United Nations Framework Convention on Climate Change (UNFCCC). Paris Agreement. (2016).
16. Patterson, J. J. More than planning: Diversity and drivers of institutional adaptation under climate change in 96 major cities. *Global Environmental Change* **68**, 102279 (2021).
17. Frantzeskaki, N. Seven lessons for planning nature-based solutions in cities. *Environmental Science & Policy* **93**, 101–111 (2019).
18. Aguiar, F. *et al.* Adaptation to climate change at local level in Europe: An overview - ScienceDirect. *Environmental Science & Policy* **86**, 38–63 (2018).
19. Klein, J., Juhola, S. & Landauer, M. Local authorities and the engagement of private actors in climate change adaptation. *Environment and Planning C: Politics and Space* **35**, 1055–1074 (2017).

20. Dilling, L., Pizzi, E., Berggren, J., Ravikumar, A. & Andersson, K. Drivers of adaptation: Responses to weather- and climate-related hazards in 60 local governments in the Intermountain Western U.S. *Environ Plan A* **49**, 2628–2648 (2017).
21. Filho, W. L. *et al.* Strengthening climate change adaptation capacity in Africa- case studies from six major African cities and policy implications. *Environmental Science & Policy* **86**, 29–37 (2018).
22. Reckien, D. *et al.* Quality of urban climate adaptation plans over time. *npj Urban Sustain* **3**, 1–14 (2023).
23. Olazabal, M., Gopegui, M. R. de, Tompkins, E. L., Venner, K. & Smith, R. A cross-scale worldwide analysis of coastal adaptation planning. *Environ. Res. Lett.* **14**, 124056 (2019).
24. Dodman, D. *et al.* Cities, settlements and key infrastructure. in *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (eds. Pörtner, H.-O. et al.) 907–1040 (Cambridge University Press, 2022). doi:10.1017/9781009325844.008.
25. Berrang-Ford, L. *et al.* A systematic global stocktake of evidence on human adaptation to climate change. *Nat. Clim. Chang.* **11**, 989–1000 (2021).
26. Center for International Earth Science Information Network - CIESIN - Columbia University & CUNY Institute for Demographic Research - CIDR - City University of New York. Low Elevation Coastal Zone (LECZ) Urban-Rural Population and Land Area Estimates, Version 3. (2021).
27. MacManus, K., Balk, D., Engin, H., McGranahan, G. & Inman, R. Estimating Population and Urban Areas at Risk of Coastal Hazards, 1990-2015: How Data Choices Matter. *Earth System Science Data* (2021).
28. United Nations, D. of E. and S. A., Population Division. *World Urbanization Prospects The 2018 Revision (ST/ESA/SER.A/420)*. https://population.un.org/wup/publications/Files/WUP2018-Report.pdf (2019).
29. Termeer, C. J. A. M., Dewulf, A. & Biesbroek, R. Transformational change: governance interventions for climate change adaptation from a continuous change perspective. *Journal of Environmental Planning and Management* **60**, 558–576 (2016).
30. Albert, S. *et al.* Heading for the hills: climate-driven community relocations in the Solomon Islands and Alaska provide insight for a 1.5 °C future. *Reg Environ Change* **18**, 2261–2272 (2018).
31. Islam, Md. M., Sallu, S., Hubacek, K. & Paavola, J. Migrating to tackle climate variability and change? Insights from coastal fishing communities in Bangladesh. *Climatic Change* **124**, 733–746 (2014).
32. Chan, F. K. S., Chuah, C. J., Ziegler, A. D., Dąbrowski, M. & Varis, O. Towards resilient flood risk management for Asian coastal cities: Lessons learned from Hong Kong and Singapore. *Journal of Cleaner Production* **187**, 576–589 (2018).
33. Wamsler, C. *et al.* Operationalizing ecosystem-based adaptation: harnessing ecosystem services to buffer communities against climate change. *Ecology and Society* **21**, (2016).
34. Blok, A. Climate riskscapes in world port cities: situating urban-cosmopolitan risk communities via Ulrich Beck's comparative tactics. *Global Networks* **20**, 500–521 (2020).
35. Dircke, P. & Molenaar, A. Climate change adaptation; innovative tools and strategies in Delta City Rotterdam. *Water Practice and Technology* **10**, 674–680 (2015).
36. Francesch-Huidobro, M. Collaborative governance and environmental authority for adaptive flood risk: recreating sustainable coastal cities: Theme 3: pathways towards urban modes that support regenerative sustainability. *Journal of Cleaner Production* **107**, 568–580 (2015).

37. Gersonius, B., van Buuren, A., Zethof, M. & Kelder, E. Resilient flood risk strategies: institutional preconditions for implementation. *Ecology and Society* **21**, (2016).
38. Mees, H. L. P., Driessen, P. P. J. & Runhaar, H. A. C. Legitimate adaptive flood risk governance beyond the dikes: the cases of Hamburg, Helsinki and Rotterdam. *Reg Environ Change* **14**, 671–682 (2014).
39. Jeuken, A., Haasnoot, M., Reeder, T. & Ward, P. Lessons learnt from adaptation planning in four deltas and coastal cities. *Journal of Water and Climate Change* **6**, 711–728 (2015).
40. Molinaroli, E., Guerzoni, S. & Suman, D. Do the Adaptations of Venice and Miami to Sea Level Rise Offer Lessons for Other Vulnerable Coastal Cities? *Environmental Management* **64**, 391–415 (2019).
41. Wakefield, S. Miami Beach forever? Urbanism in the back loop. *Geoforum* **107**, 34–44 (2019).
42. Pinto, P. J., Kondolf, G. M. & Wong, P. L. R. Adapting to sea level rise: Emerging governance issues in the San Francisco Bay Region. *Environmental Science & Policy* **90**, 28–37 (2018).
43. Alam, A. & Miller, F. Slow, small and shared voluntary relocations: Learning from the experience of migrants living on the urban fringes of Khulna, Bangladesh. *Asia Pac. Viewp.* **60**, 325–338 (2019).
44. Buchori, I. *et al.* Adaptation to coastal flooding and inundation: Mitigations and migration pattern in Semarang City, Indonesia. *Ocean & Coastal Management* **163**, 445–455 (2018).
45. Rahman, M. K., Paul, B. K., Curtis, A. & Schmidlin, T. W. Linking Coastal Disasters and Migration: A Case Study of Kutubdia Island, Bangladesh. *The Professional Geographer* **67**, 218–228 (2015).
46. See, J. & Wilmsen, B. Just adaptation? Generating new vulnerabilities and shaping adaptive capacities through the politics of climate-related resettlement in a Philippine coastal city. *Global Environmental Change* **65**, 102188 (2020).
47. Porio, E. Climate Change Vulnerability and Adaptation in Metro Manila: Challenging Governance and Human Security Needs of Urban Poor Communities. *Asian Journal of Social Science* **42**, 75–102 (2014).
48. Walch, C. Adaptive governance in the developing world: disaster risk reduction in the State of Odisha, India. *Climate and Development* **11**, 238–252 (2019).
49. Wong, E. *et al.* Policy Environment for the Tourism Sector's Adaptation to Climate Change in the South Pacific – The Case of Samoa. *Asia Pacific Journal of Tourism Research* **18**, 52–71 (2013).
50. Broto, V. C., Boyd, E. & Ensor, J. Participatory urban planning for climate change adaptation in coastal cities: lessons from a pilot experience in Maputo, Mozambique. *Current Opinion in Environmental Sustainability* **13**, 11–18 (2015).
51. Malott, D., Robertson, L., Hiei, K. & Werner, H. Next Tokyo 2045: A Mile-High Tower Rooted in Intersecting Ecologies. *CTBUH Journal* 30–35 (2015).
52. Neise, T. & Revilla Diez, J. Adapt, move or surrender? Manufacturing firms' routines and dynamic capabilities on flood risk reduction in coastal cities of Indonesia. *International Journal of Disaster Risk Reduction* **33**, 332–342 (2019).
53. Cannon, C., Gotham, K. F., Lauve-Moon, K. & Powers, B. The climate change double whammy: Flood damage and the determinants of flood insurance coverage, the case of post-Katrina New Orleans. *Climate Risk Management* **27**, 100210 (2020).
54. Ajibade, I., McBean, G. & Bezner-Kerr, R. Urban flooding in Lagos, Nigeria: Patterns of vulnerability and resilience among women. *Global Environmental Change* **23**, 1714–1725 (2013).

55. Okaka, F. O. & Odhiambo, B. D. O. Households' perception of flood risk and health impact of exposure to flooding in flood-prone informal settlements in the coastal city of Mombasa. *IJCCSM* **11**, 592–606 (2019).
56. Lu, F. Research on the Performance and Enlightenment of New York Storm Surge Adaptive Landscape Infrastructure. *E3S Web Conf.* **118**, 03026 (2019).
57. Moyles, C. & Craul, T. SCENIC HUDSON'S LONG DOCK PARK CULTIVATING RESILIENCE: TRANSFORMING A POST-INDUSTRIAL BROWNFIELD INTO A FUNCTIONAL ECOSYSTEM. *Journal of Green Building* **11**, 55–77 (2016).
58. Spekker, H. & Heskamp, J. Flood protection for the City of Beira. *Bautechnik* **94**, 872–874 (2017).
59. Chuang, H.-W., Shing-Ru Yang, Ting Ou, & Tzu-Ping Lin. CLIMATIC ADAPTATION OF COASTAL COMMUNITIES ON THE SOUTHWEST OF TAIWAN. *Journal of Marine Science and Technology* **24**, (2016).
60. Fenton, A., Paavola, J. & Tallontire, A. The Role of Microfinance in Household Livelihood Adaptation in Satkhira District, Southwest Bangladesh. *World Development* **92**, 192–202 (2017).
61. Fischer, A. P. Pathways of adaptation to external stressors in coastal natural-resource-dependent communities: Implications for climate change. *World Development* **108**, 235–248 (2018).
62. Revi, A. *et al. The Summary for Urban Policymakers of the IPCC's Sixth Assessment Report*. https://iihs.co.in/knowledge-gateway/the-summary-for-urban-policymakers-of-the-ipccs-sixth-assessment-report/ (2022) doi:10.24943/SUPSV511.2022.
63. Garschagen, M., Doshi, D., Moure, M., James, H. & Shekhar, H. The consideration of future risk trends in national adaptation planning: Conceptual gaps and empirical lessons. *Climate Risk Management* **34**, 100357 (2021).
64. Johnson, L. *et al.* Intervention: The Invisible Labor of Climate Change Adaptation. SSRN Scholarly Paper at https://doi.org/10.2139/ssrn.4416499 (2023).
65. Filho, W. L. *et al.* Assessing the impacts of climate change in cities and their adaptive capacity: Towards transformative approaches to climate change adaptation and poverty reduction in urban areas in a set of developing countries. *Science of The Total Environment* **692**, 1175–1190 (2019).
66. Aerts, J., Botzen, W., Bowman, M., Dircke, P. & Ward, P. *Climate Adaptation and Flood Risk in Coastal Cities*. (Routledge, 2014). doi:10.4324/9781849776899.
67. Haasnoot, M. *et al.* Defining the solution space to accelerate climate change adaptation. *Reg Environ Change* **20**, 37 (2020).
68. Hobday, A. J. *et al.* With the arrival of El Niño, prepare for stronger marine heatwaves. *Nature* **621**, 38–41 (2023).
69. Turton, S. Global average sea and air temperatures are spiking in 2023, before El Niño has fully arrived. We should be very concerned. *The Conversation* (2023).
70. Thompson, T. Arctic sea ice hits 2021 minimum. *Nature* (2021) doi:10.1038/d41586-021-02649-6.
71. Berrang-Ford, L. *et al. The Global Adaptation Mapping Initiative (GAMI): Part 1 – Introduction and overview of methods*. https://protocolexchange.researchsquare.com/article/pex-1240/v1 (2021) doi:10.21203/rs.3.pex-1240/v1.
72. Lesnikowski, A. *et al. The Global Adaptation Mapping Initiative (GAMI): Part 3 – Coding protocol*. https://protocolexchange.researchsquare.com/article/pex-1242/v1 (2021) doi:10.21203/rs.3.pex-1242/v1.

73. Thomas, A. *et al.* Global evidence of constraints and limits to human adaptation. *Reg Environ Change* **21**, 85 (2021).
74. Ulibarri, N. *et al.* A global assessment of policy tools to support climate adaptation. *Climate Policy* **22**, 77–96 (2022).
75. World Bank. World Bank Country and Lending Groups. https://datahelpdesk.worldbank.org/knowledgebase/articles/906519 (2019).

Supplement Material

1. Supplement Material - Results

SM.1: Considered countries according to World Bank income categorization

Country Name	Count	GNI	Income-Group	Count
Mozambique	4	490	Low	5
Niger	1	590		
Tanzania	10	1100	Lower Middle	67
Senegal	2	1430		
Kenya	3	1830		
Trinidad and Tobago	1	1930		
Bangladesh	9	1930		
Nigeria	6	2030		
India	3	2120		
Ghana	4	2230		
Solomon Islands	1	2370		
Vietnam	4	2570		
Kiribati	3	3430		
Vanuatu	1	3450		
Philippines	19	3850		
Micronesia	1	3930		
Indonesia	15	4050	Upper Middle	54
Samoa	2	4230		
Belize	1	4690		
Tonga	1	5150		
Fiji	3	5800		
Ecuador	2	6090		
Guyana	2	6630		
South Africa	8	6670		
Peru	1	6790		
Thailand	4	7260		
Brazil	5	9270		
Maldives	3	9640		
China	7	10310		
Oman	1	16430	High	158
Uruguay	1	17760		
Greece	1	19670		
Saudi Arabia	1	22840		
Portugal	3	23200		
Taiwan	5	26561		
Spain	1	30380		
South Korea	4	33830		
Italy	2	34910		
Japan	4	42330		
France	4	42550		
New Zealand	2	42870		
United Kingdom	3	43460		

Canada	6	46540
Germany	4	49190
Finland	3	49990
Hong Kong	3	50480
Netherlands	8	53230
Australia	25	54910
Sweden	8	56410
United States	58	58390
Singapore	4	58390
Ireland	1	63300
Denmark	3	63460
Norway	3	81640

SM.2: Covered coastal cities according to population size and country region

	Africa	Asia	Austral-asia	Central and South America	North America	Europe	Small Island States	Total globally
< 250k	14	27	21	5	37	24	8	136
250k - 1M	7	8	7	1	13	14	0	50
1M - 5M	12	24	3	2	2	5	0	48
5M - 10M	0	20	0	3	12	1	0	36
> 10M	5	8	0	1	0	0	0	14

SM.3: Correlations between exposure and vulnerability assessments and GNI per capita and urban population size

	Spearman's rho	**Buildings/ infrastructure**	**Businesses**	**Environmental assets**
GNI per capita (Atlas method (current US$)	*Correlation Coefficient*	.145*	0.014	-0.051
	Sig. (2-tailed)	0.015	0.811	0.388
City Population	*Correlation Coefficient*	-0.079	0.087	-0.020
	Sig. (2-tailed)	0.191	0.148	0.744

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

SM.4: Correlations between response type according to GAMI and GNI per capita and urban population size; significant correlations at the 0.01 level marked in grey

	Spearman's rho	Behavioral/ cultural	Ecosystem-based	Technological/ infrastructural	Institutional
GNI per capita (Atlas method (current US$)	Correlation Coefficient	-.347**	-0.001	0.095	.236**
	Sig. (2-tailed)	0.000	0.991	0.109	0.000
City Population	Correlation Coefficient	-.171**	0.098	.183**	0.099
	Sig. (2-tailed)	0.004	0.104	0.002	0.099

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

SM.5: Correlations between actor types and response categories; significant correlations at the 0.01 level marked in grey

		Individual(s), private household(s)	Civil society (sub-national)	Civil society (national, international)	City government	Sub-city local government	National government	Private Sector SMEs	Private Sector Cooperations	International governance inst.	Other
Behavioral/ cultural	Correlation Coefficient	.683**	0.000	0.012	-.380**	-.181**	-.141*	-0.042	-.129*	-0.104	-.225**
	Sig. (2-tailed)	0.000	0.994	0.838	0.000	0.002	0.017	0.481	0.030	0.079	0.000
Ecosystem-based	Correlation Coefficient	-.202**	.163**	0.086	.207**	.248**	.166**	-0.012	0.066	0.000	-0.052
	Sig. (2-tailed)	0.001	0.006	0.149	0.000	0.000	0.005	0.839	0.271	0.998	0.380
Technological/ infrastructural	Correlation Coefficient	-.222**	-0.049	0.021	.289**	0.018	.147*	0.107	.154**	-0.004	.128*
	Sig. (2-tailed)	0.000	0.412	0.719	0.000	0.765	0.013	0.072	0.009	0.945	0.031
Institutional	Correlation Coefficient	-.218**	.140*	0.077	.426**	.188**	.185**	.146*	.161**	.164**	0.020
	Sig. (2-tailed)	0.000	0.018	0.194	0.000	0.001	0.002	0.014	0.006	0.006	0.739

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

SM.6: Correlations between actor type and GNI per capita and urban population size; significant correlations at the 0.01 level marked in grey

	Spearman's rho	Individual(s), private household(s)	Civil society (sub-national)	Civil society (national, international)	City government	Sub-city local government	National government	Private Sector SMEs	Private Sector Cooperations	International governance inst.	Other
GNI per capita (Atlas method (current US$)	Correlation Coefficient	-.232**	-.142*	-0.010	.299**	.125*	-0.111	0.002	0.008	-.155**	0.115
	Sig. (2-tailed)	0.000	0.017	0.864	0.000	0.036	0.062	0.977	0.887	0.009	0.053
City Population	Correlation Coefficient	-.295**	0.085	-0.022	.199**	0.032	.155**	0.094	.174**	0.006	0.074
	Sig. (2-tailed)	0.000	0.159	0.721	0.001	0.597	0.010	0.116	0.004	0.925	0.218

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

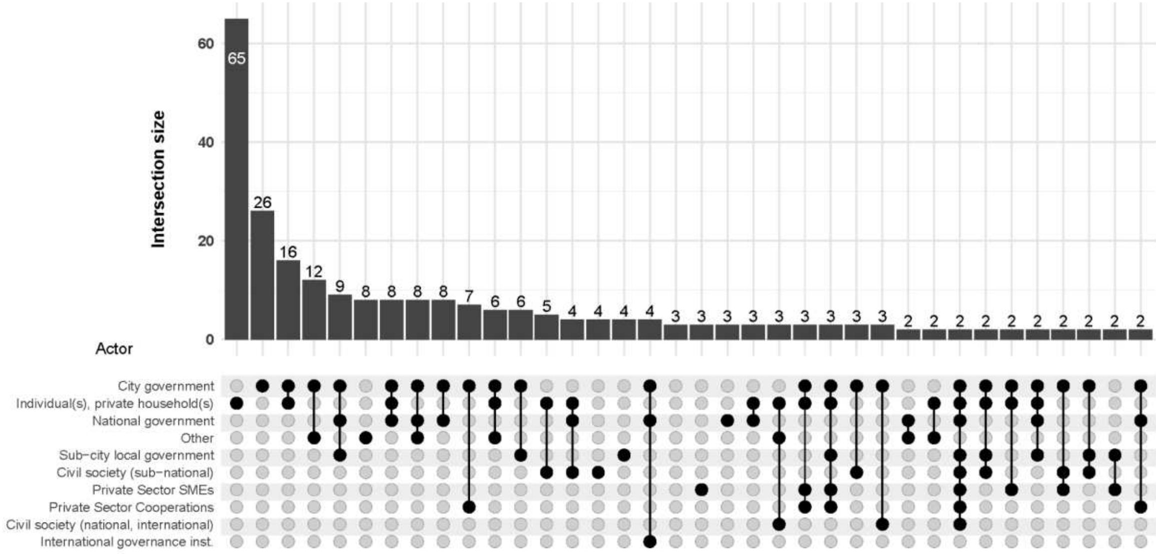
SM.7: Correlations between country region or income group and response type; significant correlations at the 0.01 level marked in grey

		Africa	Asia	Australasia	Central and South America	North America	Europe	Small Island States	Income_Group (1-4,low-high)
Behavioral/cultural	Correlation Coefficient	.157**	.131*	-0.019	-0.074	-.214**	-0.048	0.082	-.346**
	Sig. (2-tailed)	0.008	0.027	0.754	0.211	0.000	0.421	0.171	0.000
Ecosystem-based	Correlation Coefficient	0.039	-0.024	-0.105	0.014	-0.065	.123*	0.063	-0.010
	Sig. (2-tailed)	0.512	0.689	0.076	0.811	0.276	0.039	0.292	0.870
Technological/ infrastructural	Correlation Coefficient	-0.074	0.041	-0.081	0.007	-0.005	.119*	-0.066	.122*
	Sig. (2-tailed)	0.214	0.488	0.171	0.907	0.936	0.045	0.268	0.039
Institutional	Correlation Coefficient	-.119*	-.128*	0.076	.131*	.167**	-0.007	-0.108	.172**
	Sig. (2-tailed)	0.045	0.032	0.200	0.027	0.005	0.904	0.069	0.004

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

SM.8: Actor combinations



SM.9: Correlations between depth, scope and speed of adaptation and GNI per capita and urban population size

		Depth	Scope	Speed
GNI per capita (Atlas method (current US$)	*Pearson Correlation*	0.102	0.047	0.058
	Sig. (2-tailed)	0.087	0.426	0.331
City Population	*Pearson Correlation*	-0.036	0.064	-0.058
	Sig. (2-tailed)	0.546	0.289	0.337

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

2. Supplement Material - Online methods

SM.10: Search strings, combinations and resulting numbers of publications (the original GAMI-search was complemented by terms tailored to the specific research interest (added terms in italics)

	Reference data bank	Search terms	Limitations	Hits	Combined*	Combined with GAMI**
GAMI #1	GAMI	Cities and settlements by the sea		361	-	-
Reference databases	Web of Science	TS= (climat* or "global warming") AND TS= (adapt* or resilien* or "risk management" or "risk reduction") *AND TS= ("coast* city" OR "ocean cit*" OR "port cit*" OR "harbor* cit*" OR "coast* urban" OR "urban coast*" OR waterfront)*	Refined by: DOCUMENT TYPES: (Art Data Paper OR Database Review OR Review) Timespan: 2013-2020. Index EXPANDED, SSCI, A&HCI, CPCI-S, C ESCI.	156	337	GAMI #1: 683
	Scopus	TITLE-ABS-KEY (climat* or "global warming") AND TITLE-ABS-KEY (adapt* OR resilien* OR "risk management" OR "risk reduction") *AND TITLE-ABS-KEY ("coast* city" OR "ocean cit*" OR "port cit*" OR "harbor* cit*" OR "coast* urban" OR "urban coast*" OR waterfront)*	AND (LIMIT-TO (PUBYEAR , 2020) OR (LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2016) OR LIMIT-TO (PUBYEAR , 2015) OR LIMIT-TO (PUBYEAR , 2014) OR LIMIT-TO (PUBYEAR , 2013)) AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "cp") OR LIMIT-TO (DOCTYPE , "re") OR LIMIT-TO (DOCTYPE , "le"))	287		

* titles that appeared in both searches were deleted; ** Combination from WoS and Scopus combined with GAMI #1; publications appearing in both searches were only counted once

SM.11: Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria	Examples for inclusion/exclusion
Population/ Problem (P)		
Focused on adaptation to actual, projected, or perceived impacts of *climate change*.	Focused on responses to environmental variability that are not conceptually linked to climate change.	*Example of document that would be excluded*: Responses to flooding or heat waves with no justification or mention in full text that variability may be affected by climate change. *Note*: evidence of detection and attribution is not required, but there must be some justification for how climate can, or may in the future, be an important driver of impacts.
Interest (I) and Context (Co)		
Substantive focus on *adaptation* to climate change	Primary focus on *mitigation* to climate change or on *impacts* of climate change that are not framed as potentially adaptive	*Examples of documents that would be excluded*: Energy efficiency programs; planting trees to absorb CO ; energy conservation; solar power; carbon taxation; agricultural shifts to increase soil carbon storage. *Examples of documents that would be included*: climate legislation or policy to reduce or minimize the impacts of climate change; changing crop types to move to a more climate-resilient crop; changing livelihood strategies to avoid climate risks; migration out of flood-prone areas; improving health systems or surveillance systems to prepare for changing disease incidence

Presents *empirical* data on observed/documented adaptation responses	Primary contributions are conceptual or theoretical; or presents potential adaptations, adaptation constraints, or adaptation opportunities	*Examples of documents that would be excluded*: Papers theorizing adaptation opportunities, but results are not based on empirical data collection. *Examples of documents that would be included*: Assessing or proposing potential benefits of adaptation options, adaptation planning, or assessment of constraints to, or opportunities for, adaptation. Must be based on qualitative or quantitative data collection (e.g. interviews, focus groups, policy analysis, field work). Can be secondary analysis, combining multiple empirical studies. Must be evidence in the title or abstract that there is substantial empirical data presented.
Presents empirical data on adaptation responses from *coastal cities*	Primary focus on empirical response data from non-coastal cities	*Examples of documents that would be excluded*: Empirical response data stems from a non-coastal city and is only partly compared with coastal cities. In the coding questionnaire, the document must be ticked as "non-coastal city example" to reconsider it at a later stage. *Examples of documents that would be included*: Case studies or comparative studies providing empirical response data from coastal cities. Coastal cities are defined by the presence of central functions like markets, medical services, and schools, relative importance for the surrounding area, and geographical position in the zone of influence of geophysical coastal dynamics.
Adaptation responses must be *initiated by humans*	Autonomous or evolutionary adaptations in natural systems that are not human-assisted	*Examples of documents that would be excluded*: Changing range of a species with no involvement of humans; evolutionary responses by animals or plants that are not initiated or assisted by humans. *Examples of documents that would be included*: restoration or conservation measures to protect sensitive ecosystems; fishing or hunting policies; changes to coastal management policy.
Focuses on actions that are directly aimed at *risk/vulnerability reduction*	Focuses on actions that are aimed at assessing vulnerability or proposing potential actions, with no clear evidence of activity that directly reduces risk	*Examples of documents that would be excluded*: Vulnerability assessments (including consideration of adaptive capacity); adaptation planning that does not involve actions to directly reduce risk/vulnerability; adaptation financing alone (unless funded risk reduction actions are documented). *Examples of documents that would be included:* Advocacy activities to help citizens reduce their risk; provision of climate services to aid decision-making in risk reduction; climate legislation or policy designed to minimize risk; adaptation finance that supports actions that are directly aimed at reducing risk/vulnerability.

SM.12 List of included publications

Author(s)	Title	DOI
Adelekan, I.O.	Flood risk management in the coastal city of Lagos, Nigeria	10.1111/jfr3.12179
Ajibade, I.	Planned retreat in Global South megacities: disentangling policy, practice, and environmental justice	10.1007/s10584-019-02535-1
Ajibade, I.; McBean, G.; Bezner-Kerr, R.	Urban flooding in Lagos, Nigeria: Patterns of vulnerability and resilience among women	10.1016/j.gloenvcha.2013.08.009
Akaba, S.; Akuamoah-Boateng, A.	An Evaluation of Climate Change Effects on Fishermen and Adaption Strategies in Central Region, Ghana	10.1007/978-3-319-70703-7_7
Alam, A.; Miller, F.	Slow, small and shared voluntary relocations: Learningfrom the experience of migrants living on the urbanfringes of Khulna, Bangladesh	10.1111/apv.12244
Albert, S.; Bronen, R.; Tooler, J.; Yee, D.; Ash, J.; Boseto, D.; Grinham, A.	Heading for the hills: climate-driven community relocations in the Solomon Islands and Alaska provide insight for a 1.5 °C future	10.1007/s10113-017-1256-8
Aljoufie, M.; Tiwari, A.	Climate Change Adaptions for Urban Water Infrastructure in Jeddah, Kingdom of Saudi Arabia	10.5539/jsd.v8n3p52
Allaire, M.C.	Using practical and social information to influence flood adaptation behavior	10.1002/2015WR018258
Allen, T.R.; Crawford, T.; Monz, B.; Whitehead, J.; Lovelace, S.; Hanks, A.D.; Christensen, A.R.; Kearney, G.D.	Linking Water Infrastructure, Public Health, and Sea Level Rise: Integrated Assessment of Flood Resilience in Coastal Cities	10.1177/1087724X18798380
Allgood, L.; McNamara, K.E.	Climate-induced migration: Exploring local perspectives in Kiribati	10.1111/sjtg.12202
Araos, M.; Ford, J.; Berrang-Ford, L.; Biesbock, R.; Moser, S.	Climate change adaptation planning for Global South megacities: the case of Dhaka	10.1080/1523908X.2016.1264873
Arimi, K.S.	Determinants of climate change adaptationstrategies used by fish farmers in Epe LocalGovernment Area of Lagos State, Nigeria	10.1002/jsfa.6452
Bahinipati, C.S.; Rajasekar, C.; Achary, A.; Patel, M.	Flood-induced Loss and Damage to Textile Industry in Surat City, India	10.1177/0975425317714903
Barbi, F.; Ferreira, L.D.	Governing Climate Change Risks: Subnational Climate Policies in Brazil	10.1007/s41111-017-0061-3
Bautista, E.; Hanhardt, E.; Osorio, J.C.; Dwyer, N.	New York City Environmental Justice Alliance Waterfront Justice Project	10.1080/13549839.2014.949644
Berke, P.; Yu, S.; Malecha, M.; Cooper, J.	Plans that Disrupt Development: Equity Policies and Social Vulnerability in Six Coastal Cities	10.1177/0739456X19861144
Berquist, M.;Daniere, A.; Drummond, L.	Planning for global environmental change in Bangkok's informal settlements. Journal of Environmental Planning and Management	10.1080/09640568.2014.945995

Bhullar, L.	Climate change adaptation and water policy: Lessons from singapore	10.1002/sd.1546
Birtchnell, T.; Gill, N.; Sultan, R.	Sleeper cells for urban green infrastructure: Harnessing latent competence in greening Dhaka's slums	10.1016/j.ufug.2018.05.014
Bisaro, A.	Coastal adaptation through urban land reclamation: Exploring the distributional effects	10.12854/erde-2019-453
Blersch, C.L.; du Plessis, J.A.	Planning for desalination in the context of the Western Cape water supply system	10.17159/2309-8775/2017/v59n1a2
Blok, A.	Climate riskscapes in world port cities: situating urban-cosmopolitan risk communities via Ulrich Beck's comparative tactics	10.1111/glob.12258
Bott, L.-M.; Braun, B.	How do households respond to coastal hazards? A framework for accommodating strategies using the example of Semarang Bay, Indonesia	10.1016/j.ijdrr.2019.101177
Bowden, V.; Nyberg, D.; Wright, C.	Planning for the past: Local temporality and the construction of denial in climate change adaptation	10.1016/j.gloenvcha.2019.101939
Brink, E.; Wamsler, C.	Citizen engagement in climate adaptation surveyed: The role of values, worldviews, gender and plac	10.1016/j.jclepro.2018.10.164
Broto, V.C.; Boyd, E.; Ensor, J.	Participatory urban planning for climate change adaptation in coastal cities: lessons from a pilot experience in Maputo Mozambique	10.1016/j.cosust.2014.12.005
Buchanan, M.K.; Oppenheimer, M.; Parris, A.	Values, Bias, and Stressors Affect Intentions to Adapt to Coastal Flood Risk: A Case Study from New York City	10.1175/WCAS-D-18-0082.1
Buchori, I.; Pramitasari, A.; Sugiri, A.; Maryono, M.; Basuki, Y.; Sejati, A.W.	Adaptation to coastal flooding and inundation: Mitigations and migration pattern in Semarang City, Indonesia	10.1016/j.ocecoaman.2018.07.017
Bunce, A.; Ford, J.; Harper, S.; Edge, V.; IHACC Research Team	Vulnerability and adaptive capacity of Inuit women to climate change: A case study from Iqaluit, Nunavut	10.1007/s11069-016-2398-6
Butler, W.H.; Deyle, R.E.; Mutnansky, C.	Low-Regrets Incrementalism: Land Use Planning Adaptation to Accelerating Sea Level Rise in Florida's Coastal Communities	10.1177/0739456X16647161
Button, C.; Mias-Mamonong, M.A.A.; Barth, B.; Rigg, J.	Vulnerability and resilience to climate change in Sorsogon City, the Philippines: learning from an ordinary city?	10.1080/13549839.2013.798632
Cannon, C.; Gotham, K.F.; Lauve-Moon, K.; Powers, B.	The climate change double whammy: Flood damage and the T determinants of flood insurance coverage, the case of post-Katrina New Orleans	10.1016/j.crm.2019.100210
Chan, F.K.S.; Chuah, C.J.; Ziegler, A.D.; Dabrowski, M.; Varis, O.	Towards resilient flood risk management for Asian coastal cities: lessons learned from Hong Kong and Singapore	10.1016/j.jclepro.2018.03.217
Chandra, A.; Gagains, P.	Deconstructing vulnerability and adaptation in a coastal river basin ecosystem: a participatory analysis of flood risk in Nadi, Fiji Islands	10.1080/17565529.2015.1016884

Chen, N.; Hong, H.; Gao, X.	Securing drinking water resources for a coastal city under global change: Scientific and institutional perspectives	10.1016/j.ocecoaman.2018.02.023
Chiang, Y.-C.	Exploring community risk perceptions of climate change - A case study of a flood-prone urban area of Taiwan	10.1016/j.cities.2017.11.001
Chiang, Y.-C.; Ling, T.-Y.	Exploring Flood Resilience Thinking in the Retail Sector under Climate Change: A Case Study of an Estuarine Region of Taipei City	10.3390/su9091650
Choudri, B.; Al-Busaidi, A.; Ahmed, M.	Climate change, vulnerability and adaptation experiences of farmers in Al-Suwayq Wilayat, Sultanate of Oman	10.1108/IJCCSM-11-2012-0061
Chuang, H.-W.; Yang, S.-R.; Ou, T.; Lin, T.-P.	CLIMATIC ADAPTATION OF COASTAL COMMUNITIES ON THE SOUTHWEST OF TAIWAN	10.6119/JMST-016-0714-2
Clemenz, N.; Boakye, R.; Parker, A.	Rapid Climate Adaption Assessment (RCAA) of water supply and sanitation services in two coastal urban poor communities in Accra, Ghana	10.2166/wcc.2019.204
Cloutier, G.; Papin, M.; Bizier, C.	Do-it-yourself (DIY) adaptation: Civic initiatives as drivers to address climate change at the urban scale	10.1016/j.cities.2017.12.018
Cradock-Henry, N.A.; Fountain, J.; Buelow, F.	Transformations for Resilient Rural Futures: The Case of Kaik¯oura, Aotearoa-New Zealand	10.3390/su10061952
Dahlem, J.	Analysis of Ocean-Space and Sea-Level Rise Policy in Two Coastal Cities	10.1080/08920753.2019.1596679
Dale, S.M.; Sullivan, C.A.	Are we there yet? NSW local government's progress on climate change	10.1080/00049182.2014.899030
Dannevig, H.; Hovelsrud, G.K.	Understanding the need for adaptation in a natural resource dependent community in Northern Norway: issue salience, knowledge and values	10.1007/s10584-015-1557-1
Diaz, P.; Stanek, P.; Frantzeskaki, N.; Yeh, D.H.	Shifting Paradigms, Changing Waters: Transitioning to Integrated Urban Water Management in the Coastal City of Dunedin, USA	10.1016/j.scs.2016.03.016
Dircke, P.; Molenaar, A.	Climate change adaptation; innovative tools and strategies in Delta City Rotterdam	10.2166/wpt.2015.080
Dubois, B.; Krasny, M.E.	Educating with resilience in mind: Addressing climate change in post-Sandy New York City	10.1080/00958964.2016.1167004
Duy, P.N.; Chapman, L.; Tight, M.; Linh, P.N.; Thuong, L.V.	Increasing vulnerability to floods in new development areas: evidence from Ho Chi Minh City	10.1108/IJCCSM-12-2016-0169
Egbinola, C. N.; Olaniran, H. D.; Amanambu, A. C.	Flood management in cities of developing countries: the example of Ibadan, Nigeria. Journal of Flood Risk Management, 10(4), 546-554.	10.1111/jfr3.12157
Elrick-Barr, C.E.; Smith, T.F.; Preston, B.L.; Thomsen, D.C.; Baum, S.	How are coastal households responding to climate change?	10.1016/j.envsci.2016.05.013
Elrick-Barr, C.E.; Thomsen, D.C.; Preston, B.L.; Smith, T.F.	Perceptions matter: household adaptive capacity and capability in two Australian coastal communities	10.1007/s10113-016-1016-1

Fenton, A.; Paavola, J.; Tallontire, A.	The Role of Microfinance in Household Livelihood Adaptation in Satkhira District, Southwest Bangladesh	10.1016/j.worlddev.2016.12.004
Fernandes, A.; Sousa, J.F.; Brito, S.S.; Neves, B.; Vincente, T.	Preparing Waterfront Brownfields Redevelopment for Climate Change: the Water City Project, Almada (Portugal)	10.2112/SI85-307.1
Fidel, M.; Kliskey, A.; Alessa, L.; Sutton, O.P.	Walrus harvest locations reflect adaptation: a contribution from a community-based observation network in the Bering Sea	10.1080/1088937X.2013.87961
Filho, W.L.; Balogun, A.L.; Olayide, O.E.; Azeiteiro, U.M.; Ayal, D.Y.; Muñoz, P.D.C.; Nagy, G.J.; Bynoe, P.; Oguge, O,; Yannick Toamukum, N.; Saroar, M.; Li, C.	Assessing the impacts of climate change in cities and their adaptive capacity: Towards transformative approaches to climate change adaptation and poverty reduction in urban areas in a set of developing countries	10.1016/j.scitotenv.2019.07.227
Fischer, A.P.	Pathways of adaptation to external stressors in coastal natural-resourcedependent communities: Implications for climate change	10.1016/j.worlddev.2017.12.007
Flannery, W.; Lynch, K.; Cinnéide, M.	Consideration of coastal risk in the Irish spatial planning process	10.1016/j.landusepol.2014.11.001
Ford, J.D., McDowell, G.; Shirley, J.; Pitre, M.; Siewierski, R.; Gough, W.; Duerden, F.; Pearce, T.; Adams, P.; Statham, S.	The Dynamic Multiscale Nature of Climate Change Vulnerability: An Inuit Harvesting Example	10.1080/00045608.2013.776880
Francesch-Huidobro, M.	Collaborative governance and environmental authority for adaptive flood risk: recreating sustainable coastal cities Theme 3: pathways towards urban modes that support regenerative sustainability	10.1016/j.jclepro.2015.05.045
Francisco, G.S.; Solecki, W.D.; Ribalaygua Batalla, C.	Climate change adaptation in Europe and the United States: A comparative approach to urban green spaces in Bilbao and New York City	10.1016/j.landusepol.2018.08.010
Freduah, G.; Fidelman, P.; Smith, T.F.	Adaptive capacity of small-scale coastal fishers to climate and non-climate stressors in the Western region of Ghana	10.1111/geoj.12282
Galappaththi, E.K.; Ford, J.D.; Bennett, E.M.; Berkes, F.	Climate change and community fisheries in the arctic: A case study from Pangnirtung, Canada	10.1016/j.jenvman.2019.109534
Gersonius, B.; van Buuren, A.; Zethof, M.; Kelder, E.	Resilient flood risk strategies: institutional preconditions for implementation	10.5751/ES-08752-210428
Giampieri, M.A.; DuBois, B.; Allred, S.; Bunting-Howarth, K.; Fisher, K.; Moy, J.; Sanderson, E.W.	Visions of resilience: lessons from applying a digital democracy tool in New York's Jamaica Bay watershed	10.1007/s11252-017-0701-2
Gibbs, M.T.	Consistency in coastal climate adaption planning in Australia and the importance of understanding local political barriers to implementation	10.1016/j.ocecoaman.2019.03.006
Gunawansa, A.; Kua, W.H.	A Comparison of Climate Change Mitigation and Adaptation Strategies for the Construction Industries of Three Coastal Territories	10.1002/sd.527
Ha'apio, M.O.; Gonzalez, R.;	Is there any chance for the poor to cope with	10.1016/j.worlddev.2019.0

Wairiu, M.	extreme environmental events? Two case studies in the Solomon Islands	6.023
Haque, N.A.; Dodman, D.; Hossain, M.M.	Individual, communal and institutional responses to climate change by low-income households in Khulna, Bangladesh	10.1177/095624781351868 1
Hassan, I.H.; Othman, W.J.	Seaweed (Mwani) Farming as an Adaptation Strategy to Impacts of Climate Change and Variability in Zanzibar	10.1007/978-3-030-04897-6_4
Haverkamp, J.A.R.	Politics, values, and reflexivity: The case of adaptation to climate change in Hampton Roads, Virginia	10.1177/0308518X1770752 5
Haynes, K.; Tanner, T.M.	Empowering young people and strengthening resilience: youth-centred participatory video as a tool for climate change adaptation and disaster risk reduction	10.1080/14733285.2013.84 8599
Herbeck, J.; Flitner, M.	Infrastructuring coastal futures: Key trajectories in Southeast Asian megacities	10.12854/erde-2019-451
Hermen-Mercer, N.M.; Laituri, M.; Massey, M.; Matkin, M.; Toohey, R.C.; Elder, K.; Schuster, P.F.; Mutter, E.A.	Vulnerability of Subsistence Systems Due to Social and Environmental Change: A Case Study in the Yukon-Kuskokwim Delta, Alaska	10.14430/arctic68867
Hovelsrud, G.K.; Olsen, J.; Derudder, B.	Prepared and flexible: Local adaptation strategies for avalanche risk	10.1080/23311886.2018.14 60899
Huang-Lachmann, J.-T.; Lovett, J. C.	How cities prepare for climate change: Comparing Hamburg and Rotterdam	10.1016/j.cities.2015.11.00 1
Huntington, H.; Begossi, A.; Fox Geraheard, S.; Kersey, B.; Loring, P.; Mustonen, T.; Paudel, P.; Silvano, R.; Vave, R.	How small communities respond to environmental change: patterns from tropical to polar ecosystems	10.5751/ES-09171-220309
Hurlimann, A.; Barnett, J.; Fincher, R.; Osbaldiston, N.; Mortreux, C.; Graham, S.	Urban planning and sustainable adaptation to sea-level rise	10.1016/j.landurbplan.2013 .12.013
Islam, M.M.; Sallu, S.; Hubacek, K.; Paarvola, J.	Migrating to tackle climate variability and change? Insights from coastal fishing communities in Bangladesh	10.1007/s10584-014-1135-y
Jeuken, A.; Haasnoot, M.; Reeder, T.; Ward, P.	Lessons learnt from adaptation planning in four deltas and coastal cities	10.2166/wcc.2014.141
Jianjun, J.; Francisco, H.	Sea-level rise adaptation measures in local communities of Zhejiang Province, China	10.1016/j.ocecoaman.2012. 10.020
Jordhus-Lier, D.; Saaghus, A.; Scott, D.; Ziervogel, G.	Adaptation to flooding, pathway to housing or 'wasteful expenditure'? Governance configurations and local policy subversion in a flood-prone informal settlement in Cape Town	10.1016/j.geoforum.2018.0 9.029
Kalesnikaite, V.	Keeping Cities Afloat: Climate Change Adaptation and Collaborative Governance at the Local Level	10.1080/15309576.2018.15 26091
Karlsson, M.; Hovelsrud, G.K.	Local collective action: Adaptation to coastal erosion in the Monkey River Village, Belize	10.1016/j.gloenvcha.2015.0 3.002

Kashem, S.B.; van Zandt, S.	Planning for Climate Adaptation: Evaluating the Changing Patterns of Social Vulnerability and Adaptation Challenges in Three Coastal Cities	10.1177/0739456X16645167
Khan, A.; Charles, A.; Armitage, D.	Place-based or sector-based adaptation? A case study of municipal and fishery policy integration	10.1080/14693062.2016.1228520
Khan, M.I.; Kundu, G.K.; Akter, M.S.; Mallick, B.; Islam, M.M.	Climatic Impacts and Responses of Migratory andNon-Migratory Fishers of the PadmaRiver, Bangladesh	10.3390/socsci7120254
Kim, S.K.; Joosse, P.; Bennett, M.M.; van Gevelt, T.	Impacts of green infrastructure on flood risk perceptions in Hong Kong	10.1007/s10584-020-02803-5
Kithiia, J.	Resourceless victims or resourceful collectives: Addressing the impacts of climate change through social capital in fringing coastal communities	10.1016/j.ocecoaman.2015.01.020
Klein, J.	Embeddedness of climate change adaptation: established procedures and contending discourses for flood protection in Espoo, Finland	10.1080/13549839.2014.945405
Klein, J.; Juhola, S.; Landauer, M.	Local authorities and the engagement of private actors in climate change adaptation	10.1177/0263774X16680819
Koerth, J.; Vafeidis, A.T.; Hinkel, J.; Sterr, H.	What motivates coastal households to adapt pro-actively to sea-level rise and increasing flood risk?	10.1007/s10113-012-0399-x
Koertha, J.; Jones, N.; Vafeidis, A.T.; Dimitrakopoulos, P.; Melliou, A.; Koukoulas, S.	Household adaptation and intention to adapt to coastal flooding in the Axios – Loudias – Aliakmonas National Park, Greece	10.1016/j.ocecoaman.2013.05.008
Lama, P.D.	Gendered consequences of mobility for adaptation in small island developing states: case studies from Maafushi and Kudafari in the Maldives	10.24043/isj.64
Lawanson, T.; Orelaja, O.; Simire, M.	Effects of climate change on a peri-urban farming community in Lagos, Nigeria	10.1080/20421338.2014.976990
Lawrence, J.; Becker, J.	Integrating the effects of flood experience on risk perception with responses to changing climate risk	10.1007/s11069-014-1288-z
Lee, J.-S.; Kim, J.W.	Assessing Strategies for Urban Climate Change Adaptation: The Case of Six Metropolitan Cities in South Korea	10.3390/su10062065
Lo, Y.A.; Xu, B.; Chan, F.K.S.; Su, R.	Social Capital and Community Preparation for Urban Flooding in China	10.1016/j.apgeog.2015.08.003
Lu, F.	Research on the Performance and Enlightenment of New York Storm Surge Adaptive Landscape Infrastructure	10.1051/e3sconf/201911803026
Lu, Q.-C.; Zhang, J.; Peng, Z.-R.; Rahman, A.B.M.S.	Inter-city travel behaviour adaptation to extreme weather events	10.1016/j.jtrangeo.2014.08.016
Luque, A.; Edwards, G.A.S.; Lalande, C.	The local governance of climate change: new tools to respond to old limitations in Esmeraldas, Ecuador	10.1080/13549839.2012.716414
Magee, A. D.; Verdon-Kidd, D.C.; Kiem, A.S.; Royle, S.A.	Tropical cyclone perceptions, impacts and adaptation in the Southwest Pacific: an urban perspective from Fiji, Vanuatu and Tonga	10.5194/nhess-16-1091-2016

Makame, O.M.; Mwevura, Haji	Vulnerability and Adaptation Strategies of Coastal Communities to the Associated Impacts of Sea Level Rise and Coastal Flooding	10.1007/978-3-030-04897-6_3
Maldonado, J.K.; Bronen, R.; Peterson, K.; Lazrus, H.	The impact of climate change on tribal communities in the US: displacement, relocation, and human rights	10.1007/s10584-013-0746-z
Malott, D.; Robertson, L.; Hiei, K.; Werner, H.	Next Tokyo 2045: A Mile-High Tower Rooted in Intersecting Ecologies	
Marfai, M.A.; Sekaranom, A.B.; Ward, P.	Community responses and adaptation strategies toward flood hazard in Jakarta, Indonesia	10.1007/s11069-014-1365-3
Mees, H.L.P.; Driessen, P.P.J.; Runhaar, H.A.C.	Legitimate adaptive flood risk governance beyond the dikes: the cases of Hamburg, Helsinki and Rotterdam	10.1007/s10113-013-0527-2
Metclaf, S.J.; van Putten, E.; Frusher, S.; Marshall, N.; Tull, M.; Caputi, N.; Haward, M.; Hobday, A.; Holbrook, N.; Jennings, S.; Pecl, G.; Shaw, J.	Measuring the vulnerability of marine social-ecological systems: a prerequisite for the identification of climate change adaptations	10.5751/ES-07509-200235
Middelbeek, L.; Kolle, K.; Verrest, H.	Built to last? Local climate change adaptation and governance in the Caribbean - The case of an informal urban settlement in Trinidad and Tobago	10.1016/j.uclim.2013.12.003
Mills, M.; Mutafogul, K.; Archibald, C.; Bell, J.; Leon, J.X.	Perceived and projected flood risk and adaptation in coastal Southeast Queensland, Australia	10.1007/s10584-016-1644-y
Molinaroli, E.; Guerzoni, S.; Susman, D.	Do the Adaptations of Venice and Miami to Sea Level Rise Offer Lessons for Other Vulnerable Coastal Cities?	10.1007/s00267-019-01198-z
Monnereau, I.; Simpson, A.	Limits to autonomous adaptation in response to coastal erosion in Kosrae, Micronesia	10.1504/IJGW.2013.057283
Monteiro, R.; Ferreira, J.C.	Green Infrastructure Planning as a Climate Change and Risk Adaptation Tool in Coastal Urban Areas	10.2112/SI95-173.1
Morel, G.; Lima, F.R.; Martell-Flores, H.; Hissel, F.	Tools for an integrated systems approach to sustainable port city planning	10.7213/urbe.05.002.SE03
Moyles, C.; Craul, T.	Scenic Hudson's Long Dock Park Cultivating Resilience: Transforming a Post-Industrial Brownfield into a Functional Ecosystem	10.3992/jgb.11.3.55.1
Mycoo, M.A.	Autonomous household responses and urban governance capacity building for climate change adaptation: Georgetown, Guyana	10.1016/j.uclim.2014.07.009
Nalau, J.; Becken, J.; Schliephack, J.; Parsons, M.; Brown, C.; Mackey, B.	The Role of Indigenous and Traditional Knowledge in Ecosystem-Based Adaptation: A Review of the Literature and Case Studies from the Pacific Islands	10.1175/WCAS-D-18-0032.1
Neise, T., Revilla Diez, J.	Adapt, move or surrender? Manufacturing firms' routines and dynamic capabilities on flood risk reduction in coastal cities of Indonesia	10.1016/j.ijdrr.2018.10.018
Niven, R. J.; Bardsley, D.K.	Planned retreat as a management response to coastal risk: a case study from the Fleurieu Peninsula, South Australia	10.1007/s10113-012-0315-4

Noblet, M.; Brisson, G.	Adaptation to climate change in Quebec's coastal zone: a difficult transformation of public action	10.1108/IJCCSM-04-2016-0047
Nunes, A.R.	The contribution of assets to adaptation to extreme temperatures among older adults.	10.1371/journal.pone.0208121
Ofreneo, R.P.; Hega, M.D.	Women's solidarity economy initiatives to strengthen food security in response to disasters Insights from two Philippine case studies	10.1108/DPM-11-2015-0258
Oh, S.; Kim, K.; Kim, K.	Investment decision for coastal urban development projects considering the impact of climate change: Case study of the Great Garuda Project in Indonesia	10.1016/j.jclepro.2017.12.283
Okaka, F.O.; Odhimanbo, B.D.O.	Households' perception of flood risk and health impact of exposure to flooding in flood-prone informal settlements in the coastal city of Mombasa	10.1108/IJCCSM-03-2018-0026
Okaka, F.O.; Odhimanbo, B.D.O.	Urban residents' awareness of climate change and their autonomous adaptive behaviour and mitigation measures in the coastal city of Mombasa, Kenya	10.1080/03736245.2018.1500302
Pasquini, L.; Cowling, R.M.	Opportunities and challenges for mainstreaming ecosystem-based adaptation in local government: evidence from the Western Cape, South Africa	10.1007/s10668-014-9594-x
Perini, K.; Sabbion, P.	Green-blue infrastructure in urban areas, the case of the Bronx River (NYC) and Paillon (Nice)	10.13128/Techne-18407
Pinto, P.J.; Kondolf, G.M.; Wong, P.L.R.	Adapting to sea level rise: Emerging governance issues in the San Francisco Bay Region	10.31230/osf.io/mjkcu
Porio, E.	Climate Change Vulnerability and Adaptation in Metro Manila	10.1163/15685314-04201006
Prakash, M.; Cohen, R.; Hilton, J.; Khan, S.H.	An evidence based approach to evaluating flood adaptation effectiveness including climate change considerations for coastal cities: City of Port Phillip, Victoria, Australia	10.1111/jfr3.12556
Quinn, T.; Bousquet, F.; Guerbois, C.; Heider, L.; Brown, K.	How local water and waterbody meanings shape flood risk perception and risk management preferences	10.1007/s11625-019-00665-0
Rahayu, H.P.; Haigh, R.; Amaratunga, D.; Kombaitan, B.; Khoirunnisa, D.; Pradana, V.	A micro scale study of climate change adaptation and disaster risk reduction in coastal urban strategic planning for the Jakarta	10.1108/IJDRBE-10-2019-0073
Rahman, M.K.; Paul, B.K.; Curtis, A.; Schmidlin, T.W.	Linking Coastal Disasters and Migration: A Case Study of Kutubdia Island, Bangladesh	10.1080/00330124.2014.922020
Razafindrabe, BHN; Kada, R; Arima, M; Inoue, S	Analyzing flood risk and related impacts to urban communities in central Vietnam	10.1007/s11027-012-9433-z
Robb, A.; Payne, M.; Stocker, L.; Middle, G.; Trosic, A.	Development Control And Vulnerable Coastal Lands: Examples Of Australian Practice	10.1080/08111146.2018.1489791
Rosendo, S.; Celliers, L.; Mechisso, M.	Doing more with the same: A reality-check on the ability of local government to implement Integrated Coastal Management for climate change adaptation	10.1016/j.marpol.2017.10.001
Roy, A.K.; Sharma, S.	Perceptions and Adaptations of the Coastal	10.1177/097542531558518

	Community to the Challenges of Climate Change: A Case of Jamnagar City Region, Gujarat, India	2
Roy, M.; Shemdoe, R.; Hulme, D.; Mwageni, N.; Gough, A.	Climate change and declining levels of green structures: Life in informal settlements of Dar es Salaam, Tanzania	10.1016/j.landurbplan.2017.11.011
Saito, N.	Challenges for adapting Bangkok's flood management systems to climate change Norio Saito	10.1016/j.uclim.2014.07.006
Salim, W.; Bettinger, K.; Fisher, M.	Maladaptation on the Waterfront: Jakarta's Growth Coalition and the Great Garuda	10.1177/0975425318821809
Sandholz, S.; Lange, W.; Nehren, U.	Governing green change: Ecosystem-based measures for reducing landslide risk in Rio de Janeiro	10.1016/j.ijdrr.2018.01.020
Schaer. C.	Condemned to live with one's feet in water? Acase study of community based strategies and urban maladaptation in flood prone Pikine/Dakar, Senegal	10.1108/IJCCSM-03-2014-0038
Schaller, S.; Jean-Baptiste, N.; Lehmann, P.	Opportunities and barriers for urban adaptation to climate change in Latin America. Cases of Mexico City, Lima and Santiago de Chile	10.4067/S0250-71612016000300011
Schofield, D.; Gubbels, F.	Informing notions of climate change adaptation: a case study of everyday gendered realities of climate change adaptation in an informal settlement in Dar es Salaam	10.1177/0956247819830074
Schuetze, T.; Chelleri, L.	Integrating Decentralized Rainwater Management in Urban Planning and Design: Flood Resilient and Sustainable Water Management Using the Example of Coastal Cities in The Netherlands and Taiwan	10.3390/w5020593
See, J.; Wilmsen, B.	Just adaptation? Generating new vulnerabilities and shaping adaptive capacities through the politics of climate-related resettlement in a Philippine coastal city	10.1016/j.gloenvcha.2020.102188
Seekao, S.; Pharino, C.	Assessment of the flood vulnerability of shrimp farms using a multicriteria evaluation and GIS: a case study in the Bangpakong Sub-Basin, Thailand	10.1007/s12665-015-5154-4
Shi, L.; Varuzzo, A.M.	Surging seas, rising fiscal stress: Exploring municipal fiscal vulnerability to climate change	10.1016/j.cities.2020.102658
Simões, E.; de Sousa Junior, W.C.; de Freitas, D.M.; Mills, M.; Iwama, A.Y.; Gocalves, I.; Olivato, D.; Fidelman, P.	Barriers and opportunities for adapting to climate change on the North Coast of São Paulo, Brazil	10.1007/s10113-017-1133-5
Solecki, W.; Leichenko, R.; Eisenhauer, D.	Extreme Climate Events, Household Decision-Making and Transitions in the Immediate Aftermath of Hurricane Sandy	10.1515/mgrsd-2017-0029
Solecki, W.; Pelling, M.; Garschagen, M.	Transitions between risk management regimes in cities	10.5751/ES-09102-220238
Spekker, H.; Heskamp, J.	Flood protection for the City of Beira	10.1002 / bate.201710102
Stepanova, O.	Knowledge integration in the management of coastal conflicts in urban areas: two cases from	10.1080/09640568.2013.828023

	Sweden	
Storbjörk, S.; Hjerpe, M.	Sometimes Climate Adaptation is Politically Correct: A Case Study of Planners and Politicians Negotiating Climate Adaptation in Waterfront Spatial Planning	10.1080/09654313.2013.830697
Suckall, N.; Tompkins, E.; Stringer, L.	Identifying trade-offs between adaptation, mitigation and development in community responses to climate and socio-economic stresses: Evidence from Zanzibar, Tanzania	10.1016/j.apgeog.2013.11.005
Tamura, M.; Yasuhara, K.; Ajima, K.; Trinh, V.C.; Pham, S.V.	Vulnerability to climate change and residents' adaptations in coastal areas of Soc Trang Province, Vietnam	10.1504/IJGW.2018.094312
Tang, Y.-T-; Chan, F.K.S.; O'Donnell, E.C.; Griffiths, J.; Lau, L.; Higgit, D.L.; Thorne, C.R.	Aligning ancient and modern approaches to sustainable urban water management in China: Ningbo as a "Blue Green City" in the "Spong City" campaign	10.1111/jfr3.12451
Tatlonghari, G.T.; Paris, T.R.; Alston, M.; Whittenbury, K.	Gendered adaptations to climate change: A case study from the Philippines	10.1007/978-94-007-5518-5 17
Tauzer, E.; Borbor-Cordova, M.J.; Mendoza, J.; De La Cuadra, T.; Cunalata, J.; Stewart-Ibarra, A.M.	A participatory community case study of periurban coastal flood vulnerability in southern Ecuador	10.1371/journal.pone.0224171
Teicher, H.M.	Practices and pitfalls of competitive resilience: Urban adaptation as real estate firms turn climate risk to competitive advantag	10.1016/j.uclim.2018.04.008
Tillie, N.; van der Heijden, R.	Advancing urban ecosystem governance in Rotterdam: From experimenting and evidence gathering to new ways for integrated planning	10.1016/j.envsci.2016.04.016
Torabi, E.; Dedekorkut-Howes, A.; Howes, M.	Adapting or maladapting: Building resilience to climate-related disasters in coastal cities	10.1016/j.cities.2017.09.008
Torabi, E.; Dedekorkut-Howes, A.; Howes, M.	Not Waving, Drowning: Can Local Government Policies on Climate Change Adaptation and Disaster Resilience Make a Difference?	10.1080/08111146.2017.1294538
Usher, L. E.; Yusuk, J.-E.; Covi, M.	Assessing tourism business resilience in Virginia Beach	10.1108/IJTC-02-2019-0019
Valenzuela, V.P.B.; Esteban, M.; Motoharu, O.	Perception of Disasters and Land Reclamation in an Informal Settlement on Reclaimed Land: Case of the BASECO Compound, Manila, the Philippines	10.1007/s13753-020-00300-y
van Voorst, R.; Hellman, J.	One Risk Replaces Another	10.1163/15685314-04306007
Varrani, A.; Nones, M.	Vulnerability, impacts and assessment of climate change on Jakarta and Venice	10.1080/15715124.2017.1387125
Vedeld, T.; Coly, A.; Ndour, N.M.; Hellevik, S.	Climate adaptation at what scale? Multi-level governance, resilience, and coproduction in Saint Louis, Senegal	10.1007/s11069-015-1875-7
Wakefield, S.	Miami Beach forever? Urbanism in the back loop	10.1016/j.geoforum.2019.10.016
Walch, C.	Adaptive governance in the developing world:	10.1080/17565529.2018.14

	disaster risk reduction in the State of Odisha, India	42794
Wamsler, C.; Niven, L.; Beery, T.; Bramryd, T.; Ekelund, N.; Jönsson, K.I.; Osmani, A.; Palo, T.; Stahlhammar, S.	Operationalizing ecosystem-based adaptation: harnessing ecosystem services to buffer communities against climate change	10.5751/ES-08266-210131
Wang, Q.; Taylor, J.E.	Resilience of human mobility under the influence of typhoons	10.1016/j.proeng.2015.08.535
White-Newsome, J.L.; McCornick, S.; Sampson, N.; Buxton, M.A.; O'Neill, M.S.; Gronlund, C.J.; Catalano, L.; Conlon, K.; Parker, E.A.	Strategies to Reduce the Harmful Effects of Extreme Heat Events: A Four-City Study	10.3390/ijerph110201960
Wijaja, N.	Climate Change Adaptation Measures in the Coastal City of Semarang, Indonesia: Current Practices and Performance	10.5614/jpwk.2015.26.1.4
Wijaya, N.; Nitivattananon, V.; Shrestha, R.P.; Kim, S.M	Drivers and Benefits of Integrating Climate Adaptation Measures into Urban Development: Experience from Coastal Cities of Indonesia	10.3390/su12020750
Wilson, M.T.	Assessing voluntary resilience standards and impacts of flood risk information	10.1080/09613218.2019.1642731
Wong, E.; Klingt, L.; DeLacy, T.; Harrison, D.; Dominey-Howes, D.	Policy Environment for the Tourism Sector's Adaptation to Climate Change in the South Pacific – The Case of Samoa	10.1080/10941665.2012.688511
Wu, C.-F.; Hsieh, Y.-F.; Ou, S.-J.	Thermal Adaptation Methods of Urban Plaza Users in Asia's Hot-Humid Regions: A Taiwan Case Study	10.3390/ijerph121013560
Young, A.F.	Adaptation actions for integrated climate risk management into urban planning: a new framework from urban typologies to build resilience capacity in Santos (SP)	10.1186/s40410-016-0042-0
Young, D.; Essex, S.	Climate change adaptation in the planning of England’s coastal urban areas: priorities, barriers and future prospects	10.1080/09640568.2019.1617680
Zhang, T.; Bakar, S.	The Implications of Local Perceptions, Knowledge and Adaptive Strategies for Adaptation Planning in Coastal Communities in Zanzibar	10.1089/env.2016.0031
Ziervogel; G.; Pasquini, L.; Lee, J.	Understanding the Role of Networks in Stimulating Adaptation Actions on the Ground: Examples from Two African Case Studies	10.1007/978-3-319-89590-1_4

SM.13: Descriptions of all codes

Code	Options	Definition/description and examples
6. Country/ countries		Country name
7. City/cities		City name (one questionnaire per city please)
8. Actor(s)	Individual(s), private household(s)	Formal as well as informal individuals and households
	Civil society (sub-national or local)	Formal community associations
	Civil society (national, international, multinational)	Voluntary civil society organizations. Includes charities, non-profits, faith-based organizations, professional organizations (e.g. labour unions, associations, federations), cultural groups, religious groups, sporting associations, advocacy groups (e.g. NGOs).
	City government	City-level government/authorities
	Sub-city local government	Community government, municipal government
	National government	National-level government authorities, officials, bodies
	Private sector SMEs	Small and medium-sized enterprises
	Private sector corporations	Large national or international companies
	International or multinational governance institutions	Global or regional treaty body or agency (e.g. UN institutions/organizations, EU institutions, Organization of American States, African Union)
9. Hazard(s)	Increased frequency or intensity of urban heat	Including heat waves and urban heat island effect
	Drought/ water scarcity	
	Flooding - unspecified	no specific types of flooding mentioned
	Flooding - fluvial	Flooding originating from river overflows
	Flooding - pluvial	Flooding originating from precipitation
	Flooding - coastal	Storm flood, tidal flood
	Flooding - sewer	Flooding originating from sewage system, canals or drainage system
	Flooding - flash flood	Sudden and rapid flood event; can be triggered by heavy rain (particularly in dry areas), volcanic eruptions, glacier melt, hurricanes and tropical storms
	Storm surge	The temporary increase, at a particular locality, in the height of the sea due to extreme meteorological conditions (low atmospheric pressure and/or strong winds). The storm surge is defined as being the excess above the level expected from the tidal variation alone at that time and place. (IPCC 2018)
	Tropical Cyclone	Storms that develop over tropical oceans and can hit adjacent coastal areas; can be called hurricanes, typhoons, cyclones (depending on world region)
	Tornados	Storms that develop over land; they are funnel-shaped and cause a very narrow swath of destruction
	Sea level rise	
	Coastal erosion	
	Saltwater intrusion	Displacement of fresh surface water or groundwater by the advance of salt water due to its greater density. This usually occurs in

		coastal and estuarine areas due to decreasing land-based influence (e.g., from reduced runoff or groundwater recharge, or from excessive water withdrawals from aquifers) or increasing marine influence (e.g., relative sea level rise). (IPCC 2018)
	General climate impacts	No specific hazard identified
	other	
10. Exposure and vulnerability	not applicable/ not mentioned	
	Food security	Accessibility of safe, nutritious and sufficient food at all times of the year. Related to sustainable food production systems and resilient agricultural practices; equitable access to land, technology and markets and international cooperation on investments in infrastructure and technology to boost agricultural productivity
	Water and sanitation	Accessibility to safe water and sanitation; sound management of freshwater ecosystems essential to human health and to environmental sustainability and economic prosperity. Related to growing demand for water, threats to water security and the increasing frequency and severity of droughts and floods resulting from climate change
	Energy security	Concerns universal access to affordable, reliable, and modern energy services, including renewable energy, energy efficiency, and sustainable energy infrastructure
	Health & well-being	Major health priorities, including reproductive, maternal and child health; communicable, non-communicable and environmental diseases; universal health coverage; accessibility to safe, effective, quality and affordable medicines and vaccines; research and development, health financing, and capacity for health risk reduction and management
	Poverty	Social protection for the poor and vulnerable, accessibility of basic services and supports to people harmed by climate-related extreme events and other economic, social and environmental shocks and disasters
	Gender equality	Gender inequality depriving women and girls of their basic rights and opportunities. Related to legal frameworks, deeply rooted gender-based legal discrimination, unfair social norms and attitudes, decision-making on sexual and reproductive issues and low levels of political participation.
	Inequalities (other than gender)	Relates to income inequalities, social/economic/political/legal inclusion, enhanced representation for vulnerable populations, and orderly, safe, and responsible migration/mobility, equitable development assistance and financial flows

	Education	Accessibility to, and quality of, education to early childhood development, care, and education across all levels, with particular emphasis on eliminating gender disparities in education
	Peace, justice, and strong institutions	Concerns promotion of peaceful and inclusive societies for sustainable development, access to justice for all, and building effective, accountable, and inclusive institutions at all levels
	Sustainable development	Concerns the development of safe, resilient, and sustainable cities and human settlements, including affordable and safe housing, sustainable and accessible transport, equitable participation in urban planning, protection of cultural and natural heritage, responsible waste management, universal access to safe public spaces, and sustainable building
	Work and economic growth	Concerns economic growth through technological innovation, development-oriented policies, diversification, global resource efficiency, and work equity
	Consumption & production	Related to sustainable management and efficient use of natural resources, reducing food waste and post-harvest loss, sound management of wastes & chemicals, reduction across all waste streams (recycling, reducing, reusing), sustainable production practices, sustainable tourism, and market restructuring to create incentives for sustainable consumption & production.
	Infrastructure damage and/or loss	Damage or loss of infrastructure (ICT, buildings, roads, energy, health system, etc.)
	Industry, innovation and technology	Relates to the development of sustainable infrastructure and industrialization, and research and technological development to promote equity and human well-being.
	Environmental damage and/or loss	Damage or loss of ecosystem services and resources
	Out-migration	
	In-migration	
11. Elements at risk Buildings and infrastructure	Unspecified	Not described in detail
	Buildings, not specified	Buildings in general without detailed description of type or function
	Residential buildings	Residential buildings of any type (including makeshift buildings)
	Commercial buildings	Buildings for retail and other commercial purposes
	Critical infrastructure, general	e.g. transport, energy, water, hospitals
	Port infrastructure	
	Industrial infrastructure	e.g. production halls or other locations of industrial production and or development
11. Elements at risk People, groups, actors	Unspecified	
	Population in general	
	Particularly vulnerable groups	Low income groups, ethnic minorities, women, children/youth, elderly, disabled, migrants
	Large corporations	More than 250 employees (WDI Database)

	Small and medium-sized companies	Small: 10-49 employees, medium: 50-249 employees (WDI Database)
	Micro businesses	1-9 employees (WDI Database)
11. Elements at risk Environmental assets and services	Unspecified	
	Marshes	
	Wetlands	
	Coastlines/ shore	
	Mangroves	
	Inner-urban greenery	
12. Response type	Behavioral/cultural	Enabling, implementing, or undertaking lifestyle and/or behavioural change (e.g. evacuation planning, migration, livelihood diversification, change of agricultural practices)
	Ecosystem-based	Enhancing, protecting, or promoting ecosystem services (e.g. ecological restoration and conservation, afforestation, green infrastructure)
	Technological/infrastructural	Enabling, implementing, or undertaking technological innovation or infrastructural development (e.g. new crop varieties, water saving and irrigation techniques, hazard mapping and monitoring, sea walls, water storage, shelters)
	Institutional	Enhancing multilevel governance or institutional capabilities (e.g. adaptation plans, community-based adaptation, laws and regulations)
13. Response type IPCC	Protect	Site-specific features such as sea walls, dikes, dunes, and vegetation to protect the land from the sea so that existing land uses can be retained (IPCC 1992)
	Accommodate	Measures would be taken to allow for continued habitation of the area. Specific responses under this option would include erecting flood shelters, elevating buildings on pilings, converting agriculture to fish farming, or growing flood- or salt-tolerant species. (IPCC 1992)
	Advance with ground elevation	including land reclamation
	Retreat	Providing for people and ecosystems to shift landward in an optimal fashion (IPCC 1992)
14. Response	Behavioral change	Change of activities, habits, traditions to reduce risk
	Livelihood diversification	Adopt additional livelihood sources
	Livelihood change	Change from one livelihood source to another
	Migration	Change place of living
	Awareness raising	Distribution of information on hazards, potential responses
	Urban greening	e.g. Vertical and rooftop greening, parks
	Urban blue infrastructure	e.g. ponds, water fountains
	Reforestation	e.g. urban forests, Mangroves
	Renaturation	e.g. flood plains/giving space to rivers
	Protective infrastructures	e.g. dams, sea walls, flood gates, irrigation systems
	Drainage, reservoirs	e.g. water canals, polder systems, ponds, etc.
	Elevating building	

	Risk assessments and maps for planning	Qualitative or quantitative risk assessments (assessment of vulnerability, exposure, capacities)
	Risk management planning	Spatial analysis of risk (vulnerability, exposure, capacities) visualized in a map
	Early Warning System	Timely, relevant, and accurate predictions of hazards to warn the public and trigger effective response actions
	Legal instrument(s)	e.g. legal obligation for urban greening, in some countries building codes etc.
	Adaptation plan	Policy plan that details the process of analyzing, selecting and prioritizing measures in response to climate change.
	Adaptation funds	Financial means specifically dedicated for planning and implementing adaptation measures
	Resettlement/relocation	Permanent voluntary or forced relocation of exposed individuals, families or entire communities to less exposed areas
	Formal social protection schemes	e.g. health insurance, pension, etc.
	Insurance	e.g. Property or crop insurance, micro-insurance
15. Depth of response	High	Adaptations reflect entirely new practices involving deep structural reform, complete change in mindset, major shifts in perceptions or values, and changing institutional or behavioral norms.
	Medium	Adaptations reflect a shift away from existing practices, norms, or structures to some extent.
	Low	Adaptations are largely expansions of existing practices, with minimal change in underlying values, assumptions, or norms.
	Confidence in statement	not certain: Unable to decide based on the information in the article (e.g., not enough information or issue is not discussed). rather low rather high
16. Scope of response	High	Adaptations are widespread and substantial, including most possible sectors, levels of governance, and actors.
	Medium	Adaptations is expanding and/or mainstreaming to include a wider region, multiple areas and sectors, or involvement of coordinated, multi-dimensional, multi-level adaptation.
	Low	Adaptations are largely localized and fragmented, with limited evidence of coordination or mainstreaming across sectors, jurisdictions, or levels of governance.
	Confidence in statement	not certain: Unable to decide based on the information in the article (e.g., not enough information or issue is not discussed) rather low rather high
17. Speed of response	High	Adaptations are substantially exceeding business-as-usual incremental norms. Change is considered rapid in a given context.

	Medium	Adaptations are increasingly exceeding business-as-usual behavioral or institutional change to reflect accelerated adaptive responses.
	Low	Adaptations are incremental, consistent with existing behavioral or institutional change.
	Confidence in statement	not certain: Unable to decide based on the information in the article (e.g., not enough information or issue is not discussed) rather low rather high
18. Implementation tool(s)	Direct regulation	Law or policy mandating or restricting actions
	Policy Plan	Strategy or plan to shape future action (can be voluntary or mandated)
	Economic instrument(s)	e.g. financial incentives, taxes, fees, subsidies, insurance
	Information provisioning	e.g. information campaigns, education (focus on dissemination of information and knowledge)
	Capacity building	Activities to help individuals be more effective at adaptation (that aren't explicitly financial or information based), e.g. providing seeds or infrastructure
	Network	Community networks or inter-organizational collaborations to develop or implement adaptation responses
19. State of implementation	Vulnerability assessment and/or early planning	The impacts of climate change are known as least indicatively (qualitative information), taking account of the uncertainty involved in climate change scenarios. There is some evidence of vulnerability assessment. There may be evidence that some adaptation measures have been identified and plans may be made for their implementation. There is limited evidence of implementation, or only small and ad hoc adaptation implementation
	Adaptation planning and early implementation	There is widespread recognition among decision-makers of the need for adaptation measures. Impacts and vulnerability are well understood. Adaptation measures have been identified and there is evidence of at least some coordinated implementation, though measures may still be ad-hoc.
	Monitoring and evaluation after initial first implementation/ pilot	Assessment and evaluation of the first adaptation pilot to analyse the measures' acceptance, effectiveness and potential options for larger role-out.
	Implementation expanding	There is widespread recognition and acceptance of the need for adaptation measures and coordinated planning. There is evidence that adaptation has been incorporated (mainstreamed) into decision-making processes. Implementation of adaptation measures are more likely to be coordinated as part of a coherent strategy than ad-hoc.

	Implementation widespread/role out	Adaptation measures are implemented and coordinated consistently across all relevant sectors and regions, with adaptation planning standard practice and well-established within legal/institutional/cultural/social frameworks and norms.
	Evidence of reduced risk	There is moderate to substantial evidence that key indicators of vulnerability and/or risk have declined, as well as (qualitative or quantitative) evidence that adaptation efforts have contributed to these reductions. Evidence may be attribution-based or based on robust narratives and theories of change.
20. Evidence of reduced risk or vulnerability	Yes	The change must be documented to respond 'yes' for this question. Anticipated or expected reduction is not sufficient. Note that these don't need to be quantitative, but could involve theory of change, narrative justifications of change, or other.
	No	
21. Co-Benefits	Co-benefits for mitigation	**Mitigation** = A human intervention to reduce the sources or enhance the sinks of greenhouse gases (GHGs). (IPCC 2014)
	Co-benefits for health	
	Co-benefits for poverty alleviation	
	Co-benefits for ecosystems	
	Other co-benefits (specify)	**Co-benefits** = The positive effects that a policy or measure aimed at one objective might have on other objectives, thereby increasing the total benefits for society or the environment. (IPCC 2018)
22. Trade-offs	Trade-offs (free-text, quote)	Did the response create trade-offs? Describe which.
23. Limits to adaptation (The point at which an actor's objectives (or system needs) cannot be secured from intolerable risks through adaptive actions (IPCC 2018))	Limits present, but no evidence they are challenged/overcome	
	Soft limits challenged but not yet overcome	**Soft limits** = Options are currently not available to avoid intolerable risks through adaptive action. (IPCC 2018); limits to adaptation that may change in the future
	Soft limits overcome	
	Hard limits challenged but not yet overcome	**Hard limits** = No adaptive actions are possible to avoid intolerable risks (IPCC 2018); limits to adaptation that are not mutable (often bio-physical and/or physiological),
	Hard limits overcome	
24. Maladaptation	Yes (free text, quote)	
	No	
25. Quality criteria	Methodology	Are methods described transparently? Do you evaluate them as suitable and sound? Are there methodological flaws?
	Coherence	Could questions be answered directly from data (clear evidence) or was there need for interpretation?

	Adequacy	How would you evaluate the quantity (e.g. sample size) and richness (sufficient detail to gain an understanding) of the data?
	Relevance	For which context is the study relevant? Only for particular groups, regions, sectors, etc. or globally?