



UNIVERSITY OF LEEDS

This is a repository copy of *Adaptive capacity in urban areas of developing countries*.

White Rose Research Online URL for this paper:

<https://eprints.whiterose.ac.uk/169211/>

Version: Accepted Version

Article:

Flórez Bossio, C, Ford, J orcid.org/0000-0002-2066-3456 and Labbé, D (2019) Adaptive capacity in urban areas of developing countries. *Climatic Change*, 157 (2). pp. 279-297. ISSN 0165-0009

<https://doi.org/10.1007/s10584-019-02534-2>

© Springer Nature B.V. 2019. This is an author produced version of a journal article published in *Climatic Change*. Uploaded in accordance with the publisher's self-archiving policy.

Reuse

Items deposited in White Rose Research Online are protected by copyright, with all rights reserved unless indicated otherwise. They may be downloaded and/or printed for private study, or other acts as permitted by national copyright laws. The publisher or other rights holders may allow further reproduction and re-use of the full text version. This is indicated by the licence information on the White Rose Research Online record for the item.

Takedown

If you consider content in White Rose Research Online to be in breach of UK law, please notify us by emailing eprints@whiterose.ac.uk including the URL of the record and the reason for the withdrawal request.

Adaptive Capacity in Urban Areas of Developing Countries

Camila Flórez Bossio¹, James Ford², Danielle Labbé³

¹Department of Geography, McGill University, Montreal, Canada – camila.florezbossio@mail.mcgill.ca

²Priestley International Centre for Climate, University of Leeds, Leeds, UK

³School of Urban Planning and Landscape Architecture, University of Montreal, Montreal, Canada

Abstract

Urban areas of developing countries face increasing risks due to climate change. This paper systematically identifies and examines research published between 2000 and 2017 that assesses urban adaptive capacity to climate change in developing countries. To critically examine this literature, we developed a conceptual framework of urban adaptive capacity. The framework focuses on key components of urban adaptive capacity in three dimensions: the characterization of adaptive capacity, the external factors mediating adaptive capacity, and the dynamics of adaptive capacity. The study sheds light on the spatial and scalar interactions of individuals, communities, and authorities' adaptive capacities within urban areas and highlights the importance of governance and social institutions in shaping urban adaptive capacity. The work also finds shortcomings in the current assessment of urban adaptive capacity, with key gaps including a narrow focus on the range and types of adaptive capacity; limited assessment of the multilevel determinants, place-based processes, and urban determinants that shape adaptive capacity; and a lack of consideration of adaptive capacity interactions between social entities and with regard to climate sensitivity and exposure of a given area, including the potential for maladaptation. Addressing these research gaps would contribute to generate knowledge that can adequately support adaptation planning of urban areas in developing countries.

Keywords: climate change, adaptation, adaptive capacity, urban, developing countries

Acknowledgments: This work was supported by the Fonds de Recherche du Québec - Société et Culture (FRQSC), the International Development Research Centre (IDRC) and the Social Sciences and Humanities Research Council of Canada. We also acknowledge the feedback from Oliver Coomes and Sarah Moser (McGill University).

1. Introduction

The saliency of the risks posed by climate change to urban areas of the developing world and their populations has increased considerably since the turn of the century. This has been matched by increasing scholarly interest in the opportunities and constraints for adaptation (ref). The last two decades witnessed a steady rise in the number of empirical studies on these issues that now cover most part of what is sometimes called the Global South (ref). These studies, however, tend to focus on different dimensions of adaptation, rendering the comparison of findings across urban contexts and scales difficult, let alone generalizations. This paper tackles this challenge through a synthesis and evaluation of recent scientific publications on adaptive capacity (hereafter AC) in urban areas of developing countries. At the most general level, we define AC as the ability of a system, region, community, household, or an individual to perceive, cope with, prepare for, and adapt to disturbances and uncertain social-ecological conditions (Hinkel 2011; Plummer and Armitage 2010; Smit and Wandel 2006). Since the turn of the century, this notion has acquired a pivotal position in the urban adaptation literature. It is now mobilized by research on disaster risk, vulnerability, and resilience—the three areas of investigation at the core of this scholarship (O'Brien and Selboe 2015; Romero-Lankao and Qin 2011). All three bodies of work use the concept of AC, making it a useful entry point to critically examine how urban adaptation is currently conceptualized, defined, and operationalized across disciplines and regions (Engle 2011)..

Urban areas display specific characteristics which, according to the literature, not only shape but adversely sharpen climate change impacts on them. These specificities include: the spatial concentration of population and infrastructure, urban cores' dependency on their hinterlands, the role cities play within larger socio-economic systems as hubs of political and economic power, the distinct livelihoods of urban population, and their propensity for social fragmentation (Birkmann et al. 2010; Lehmann et al. 2015; Revi et al. 2014; Rosenzweig et al. 2018a; UN-Habitat 2011). The situation is even more critical in developing countries, where economic, social, and institutional challenges exacerbate local sensitivities and decrease urban populations' capacities to adapt (Anguelovski et al. 2014; De Coninck et al. 2018; Hunt and Watkiss 2011; Pelling 2003; Satterthwaite et al. 2007). The need to better understand AC, and of ways to facilitate it in these challenging urban contexts, is pressing. Most importantly, while existing research concurs to connect weak AC with increased vulnerability, we still have a limited and fragmented understanding of what fosters AC across urban contexts of developing countries, a situation which may be related to a narrow conceptualization of AC in the larger (non-specifically urban) literature.

As Mortreux and Barnett (2017) explain, conceptualizations of AC to climate change can be organized according to two generations. Rooted in Sens's capabilities theory, the first generation apprehends AC as a broad set of resources or capitals (e.g., natural, financial) and the determinants to access them. If this conceptualization provides a straightforward way to measure and compare AC (Brooks et al. 2005; Eakin et al. 2014), it has been criticized for its failure to capture how adaptive practices emerge from the sum of resources. In other words, it leaves unanswered the critical question of how capacity becomes action (Adger

and Vincent 2005; Mortreux and Barnett 2017; Toole et al. 2016). The second generation of AC conceptualization, on which this study builds, seeks to fill this gap by focusing on the process of adaptation and by examining the attributes that enable social entities to adapt, thus extending the analysis to include psycho-social and institutional dimensions (e.g., place attachment) (Grothmann and Patt 2005; Nelson et al. 2007). Two key questions arise from this second conceptualization, which underpin this critical literature review: What do we know about the ways in which socio-cultural and urban processes shape urban AC in developing world contexts? and, how do internal dynamics of AC evolve in these urban settings?

This study uses these two questions to examine how urban AC to climate change in developing countries has been characterized and assessed in studies published between 2000 and 2017. The adaptation literature has a long history, but it is since 2000 that adaptation has emerged as central component of climate policy (Berrang-Ford et al., 2011). As the climate change adaptation literature boomed in the 2000s (Bassett and Fogelman 2013; Ribot 2011), it interfaced with calls for greater conceptual and methodological consolidation of the climate vulnerability scholarship (Crane et al. 2017). By focusing on the 2000-2017 period, this systematic literature review of empirical research on urban AC contributes to take stock of scholarly responses to this call. It does so by examining recent empirical research in light of the theoretical advances in adaptation that stemmed from important conjuncture in the research outlined above..

To this end, this study formulates a novel conceptual framework which seeks to capture how studies published since the early 2000s assess key dimensions of AC in urban settings, shedding light on the characteristics, external factors, and dynamics of AC. This framework supports the identification and discussion of four emergent research patterns within empirical studies of urban AC in developing countries: i) AC's variability across and within scales, ii) the relevancy of objective and subjective approaches to AC, iii) the importance of both governance and social institutions for AC; and iv) the limited attention paid to urban determinants in explanations of AC. Finally, we call for a better integration of theoretical debates about adaptation in empirical assessments of urban AC. More specifically, studies need to move beyond treatments of AC as static in time and space and to address the relationships between coping, adaptation, and transformation.

2. Conceptual Framework

The construction of the conceptual framework presented in this section was the first step in this study (see Methodology section). In the absence of a preexisting framework, we adopted Jabareen's (2009) qualitative method, which although not specifically tailored for systematic literature review, supports the building of conceptual frameworks to study phenomena linked to multiple scholarships (such as urban AC in the developing world). This involved a broad survey of the adaptation literature, from its foundation to now, and selective forays into the resilience and disaster risk scholarship. In a first phase, this survey involved mapping the most cited scientific papers on climate change adaptation and served to identify contributions discussing the state and frontiers of the adaptation literature. In a second phase, we identified and categorized what we called the “theorized determinants of AC” for diverse settings and scales, and

contextualized them to urban settings taking into consideration the characteristics of socio-urban systems. In doing so, we integrated linked concepts from the scholarships to depict different stages in the adaptation thinking (e.g. coping, adapting and transforming).¹ Finally, we grouped these determinants under three broad theoretical dimensions that we call: *Adaptive Capacity Characterization*, *External Factors*, and *Adaptive Capacity Dynamics*. The dimensions, their determinants, and the ways they relate to each are schematized in Figure 1. The resulting conceptual framework is described in more details below.

2.1 Adaptive capacity characterization

The first dimension is at the core of our conceptual framework as it delineates researchers' conception of the nature and extent of the AC of the urban social entity studied. It concerns what some (**ref**) have named the endogenous variables of AC. It translates into the first general question that we asked of each paper included in this systematic literature reviews: *What does this study understand adaptive capacity to be?* The determinants of AC grouped under this dimension allow us to systematize answers to this first question by examining what each study considers to be: the attributes composing AC, the agents putting it into action, the type of ability that these agents have, and the range of the capacity to adapt.

Urban AC attributes concerns the definition of adaptive capacity to climate change used in different studies. These definitions vary depending on the scholarship and object of study. They may be framed solely in response to climate change threats or to multiple threats with a special focus on climate change. Overall, these definitions refer either to: 1) a broad set of resources (e.g., financial resources) accessible to an individual or social entity to be employed when adapting (Engle 2011; Heinrichs et al. 2013); 2) a series of determinants and processes that enable the ability of an area, community or individual to adapt (e.g., social learning) (Adger et al. 2004; Smit and Wandel 2006), or 3) the ability to perceive and avoid or lessen the negative consequences of climate hazards (e.g., risk perception) (Grothmann and Patt 2005). Looking at the definitions of AC used to study urban settings, reveals the literature understandings of AC as: the ways in which individuals and groups mobilize the resources available to them, the factors that enable human responses in urban areas, and of the ability of urban actors to perceive and avoid climate change impacts.

Adaptive capacity cannot exist in a vacuum or be separated from the actor(s) that has the ability and resources to deal with climate change. As such, a second determinant that characterized how AC is mobilized in the literature concerns the agents to whom studies ascribe the capacity to act in the adaptation process. We call this determinant *adaptive capacity agency* and divide into individual, social, and institutional agency (Grothmann et al. 2013; Moser and Satterthwaite 2008). Individual agency refers to urban dwellers' ability to manage threats at the individual or household level. Social agency denotes the ability of groups of people or households and of civil society organizations to deal with threats at the community level. And institutional agency refers to the ability of urban political authorities to address

¹ The integration of concepts means that our framework can differ from scholars' conceptualization for a given determinant.

vulnerabilities and facilitate resilience by guiding decision-making and providing incentives for actors to act in certain ways in an urban system (Dodman and Satterthwaite 2008; Hughes and Sarzynski 2015).

The way AC is used in the literature is further characterized by whether the concept is conceived of as an objective or as a subjective ability to deal with climate change. We refer to this determinant as the *adaptive capacity type*. Objective AC refers to the ability of an individual or social group to deal with climate change, employing the resources available within the given factors that enhance or diminish their AC (Grothmann and Patt 2005). In this view, AC can be accounted for and measured towards the understanding of vulnerability and resilience. Alternatively, AC can be conceived of as a subjective ability concerned with the perceived ability of actors to deal with climate change given the resources available and prevailing social norms. The distinction is important because actors are not always aware of their objective ability scope which they may under- or overestimate (Gifford et al. 2011; Grothmann and Patt 2005). Subjective AC may be influenced by cognitive mechanisms (e.g., illusion of control), perceptions of risk, previous experience, and social norms (Clayton et al. 2015; Grothmann et al. 2013; Harvatt et al. 2011). This suggests that AC depends partially on each actor's perspective and can differ among actors evolving in the same urban milieu (Fuchs et al. 2017).

We call the last determinant of AC characterization *adaptive capacity range*. It concerns the way in which studies understand agents' ability to deal with extremes and manage the sensitivities of the system at stake. Studies' AC range can be organized in three levels: coping, adapting, and transforming. Coping refers to the ability to deal directly with in-the-moment and short-term climate threats with concrete actions and using existing resources (Few 2003; Yohe and Tol 2002). Adapting describes longer-term efforts to adjust to and prepare for potential climate change opportunities and risks, including actions to facilitate learning processes (Qin et al. 2015; Smit and Wandel 2006). Transforming refers to the ability to change structural conditions that are no longer desirable as they sustain the vulnerability of the system and change these conditions with the aim of increasing resilience (O'Brien 2012; Revi et al. 2014). Transformations, such as the formulation of alternative urban development paths (Revi et al. 2014), opens a range of novel policy options through non-linear changes (Fazey et al. 2018; Pelling et al. 2015). All the three levels of AC can coexist. The same urban household may, for instance, adopt a mix of coping, adapting or transforming strategies to deal the different risks it faces or with regard to different sector paths (energy, water infrastructure or market choices).

2.2 External factors shaping adaptive capacity

The second dimension that constitutes our conceptual framework concerns the factors, external to agents' character and internal logics, that directly shape the circumstances and conditions within which they are situated in the process of adapting and therefore influence the broader decision structures in which they find themselves. This corresponds to what other authors have called the exogenous variables of AC (**ref**). As with the first dimension, this second broad element of our conceptual framework translates into a general question: *What factors do studies of urban AC identify as the structural shapers of adaptive*

capacity? To systematize the treatment of answers to this question, we differentiate between processes and institutions (though we recognize that the two are interconnected). In the case of processes, we further differentiate between multi-level and place-based processes.

Processes occurring at the global, national, regional, and local levels shape actors' ability to deal with climate change. We refer to this determinant as *multilevel processes*. Studies may identify processes such as globalization, urbanization, and decentralization (Leichenko and O'Brien 2008). These processes often occur at multiple scales concomitantly and have a particular dynamic in a given urban area. For example, scholars suggest that rapid informal urbanisation processes, and the limited capacity of governments to meet housing and public services demands, leads to urban areas with higher susceptibility to extreme climate events and lower AC (Birkmann et al. 2014; Sanchez-Rodriguez 2015).

In contrast, and although they are rarely entirely disconnected from processes occurring at different scales, *place-based processes* mainly occur due to specific place traits of the urban system under analysis. These more localized social, economic, political or ecological processes influence the vulnerability of people in that particular place (Cutter et al. 2008) and shape how actors respond to hazards and thus influence urban AC (Krellenberg et al. 2014; Romero-Lankao et al. 2014). Studies may analyze place-based processes such as urban sprawl, gentrification, land tenure (in)security, mobility patterns, place identity, socio-environmental fragmentation, and socio-spatial inequalities.

Finally, the determinant concerning the formal and informal norms that evolve from social interactions and guide actors' behavior and collective action is called *institutions* (Ostrom 2014). Institutions can either facilitate or constrain adaptive actions (Bisaro et al. 2018; Matthews and Sydneysmith 2010). To schematize the studies' assessment of institution we build on Ostrom's (2005) classification of institutions relevant to socio-environmental contexts, including position, boundary, choice, aggregation, information, scope, and payoff rules.

2.3 Adaptive capacity dynamics

The last dimension in our conceptual framework concerns the constant time-space interactions between social entities and their socio-natural context which mediates how AC is practiced in a given moment and its effects over time. It leads to a third general question: *How do studies observe changes in AC change over time and space?*

A first determinant of the *AC Dynamic* dimension relates to how studies consider particular vulnerable populations in relation to the broader social setting in which they are situated and how they see this setting as affecting their AC. Specific population groups, such as the elderly, children, women, marginalized communities, and indigenous populations may be more negatively affected by external shocks given their inherent vulnerabilities, have been recognized as being particularly vulnerable to the effects of climate change (Bunce and Ford 2015; Ford 2012; Gencer 2013; Romero-Lankao et al. 2014). These groups tend to have higher levels of sensitivity and lower levels of AC to climate change. The assessment of *vulnerable*

urban populations groups involves examining the conditions that drive their vulnerability in a given urban setting, and how these conditions mediate their AC.

Climate change research findings also show that the impacts of disasters are experienced differently according to individuals and social contexts which are rarely homogenous across or within urban communities (Leichenko 2011; Shi et al. 2016). Further, the AC of a given area is relative in terms of the spatial distribution of people and their capacities (Lemos et al. 2013). We call this determinant *differentiated urban AC*. Studies' assessment of urban dweller groups may be disaggregated according to demographic and spatial determinants such as income, profession, age, gender, social group, geographic area, and length of settlement.

As discussed earlier, adaptation can further take place at different scale and different agents have the capacity to implement adaptation measures. As such, the *AC Interaction* determinant regards the examination of the dynamic relation between the AC of different entities, as the AC of an individual or group can mediate the AC of another individual or group (Romero-Lankao et al. 2014; Wilhelmi and Hayden 2010). Further, scholars suggest that there are tradeoffs between households' specific capacities (e.g., climate risk insurance) and their generic capacities (e.g., income diversification), which may contribute to maintaining poverty traps (Eakin et al. 2014).

Scholars have also underlined that one of the main challenges with climate change is that it is a continuous change process (Chelleri et al. 2015). Adapting to climate change means dealing with changing conditions that require continuous societal adjustments (from habits to laws) over time. The assessment of *AC time frame* involves examining the AC attributes that can transform over time because changing social or individual conditions may affect the extent to which individuals or groups can withstand and adapt to shocks (Ford et al. 2013; Leichenko and O'brien 2002). Further, AC put in practice (as adaptation) can lock-in risks and the future capacity of cities to respond to climatic events (Ürge-Vorsatz et al. 2018).

Finally, analyzing the relationship of *AC, exposure and sensitivity* is important to better understand the interactions between society and the environment and thus for meeting the needs of both systems along sustainable trajectories (Kates et al. 2001; Turner et al. 2003). Hence, exposure and sensitivities can shape urban AC and, conversely, the AC of urban social entities can shape future exposure and sensitivities of the urban area. At the same time, these interactions are mediated by the type of hazard and correspondingly how the hazard is shaped by the given urban setting and development.

3. Methodology

Developing the conceptual framework presented above was the first of six steps in the procedure outlined by Berrang-Ford et al. (2015) and which we followed to develop the present systematic literature review (Online Resource 1). Step two consisted in selecting the keywords to identify papers dealing with urban AC, these were: ("climat* change" OR "global warming") AND TOPIC: ("adaptive capacity" OR "coping

strategies" OR "coping capacity" OR "adaptation capacity") AND TOPIC: (urban OR cities OR city OR metropolitan).

Third, we used these keywords in the Web of Science platform to systematically collect all relevant scientific articles in English and Spanish² published between 2000 and 2017, which resulted in 341 publications. This first set of publications was narrowed down by retaining only original research articles. The citation information of the resulting corpus of 289 articles was downloaded into a bibliography manager software (EndNote).

Fourth, we reviewed each article with a finer set of inclusion criteria, so as to retain only those articles presenting empirical research relevant to urban AC in developing countries (Table 1). The United Nations (UN) country classification was used to identify developing nations (UN 2017), we included articles dealing with countries classified as "developing economies". The "focus on urban setting" criteria also needed to be defined, especially considering the diversity of definitions of "urban" used by different national statistical agencies, and their changing parameters over time. The review included all articles wherein the researchers placed a specific focus on urban areas. Finally, we retained a broad definition of the AC concept³ to avoid excluding papers that would not fit under a specific and narrow conceptualization. We nevertheless limited the review to human AC to climate change.⁴ We began applying these finer inclusion criteria by reading the articles' abstracts, which resulted in the exclusion of 185 articles. The remaining 104 articles were assessed in their entirety against the inclusion criteria listed above and also in terms of their quality. In this regard, we excluded those papers which conceptual and methodological approaches—two key focuses of our analysis—was not explicitly presented. This resulted in the selection of 38 articles to undergo a thorough full text review (Online Resource 2). Most articles excluded either did not focus on a developing country or on urban areas, or did not have AC to climate change as their primary focus. Only a handful of articles were excluded due to quality issues (Online Resource 3).

Fifth, data was extracted to a table, by reviewing each article with a conceptual framework rubric (Online Resource 4). The rubric contained 20 questions (both open- and closed-ended) organized around the three dimensions of AC presented in the conceptual framework. The rubric allowed for a consistent and exhaustive assessment of the articles. Finally, we analyzed the questionnaire results based on the three attributes of AC and by looking for trends according to year of publication and region studied.

4. Results

4.1 General research trends

² The two languages spoken by the lead author.

³ We used the following broad definition of AC: the social ability to manage climate change impacts.

⁴ Climate change is understood as any change in climate (experienced or projected) as a result of human activity or natural variation (Ford et al. 2011).

All 38 articles retained for full review were published in English⁵ from 2009 on, with the majority published between 2013 and 2017 (Online Resource 5). This trend mirrors a broadening of vulnerability research that has evolved from mainly looking at climate impacts and possible adaptation options towards assessing barriers to adaptation and examining social capacities to deal with changes and uncertainty (Eakin and Patt 2011).

In total, this review covers studies looking at 32 urban areas in 21 countries, two regions with 85 cities, and one global study on urban areas (Online Resource 6). The studies are situated in Africa (n=9), Latin America and the Caribbean (LAC) (n=11), and Asia (n=17). Approximately half of this corpus focuses on only five countries (i.e., Chile, Ghana, India, Philippines, and South Africa). Further, the majority of urban areas studied (82%) are located in middle-income countries,⁶ including both upper-middle income (one-third) and lower-middle income (two-thirds) countries. Only one urban area is located in a low-income country (Dakar, Senegal) and the few remaining urban areas studied are located in high-income countries. The urban areas studied include small cities of 200,000 or less people (n=5), medium cities of 200,000 to 1 million (n=6), large cities of 1-10 million (n=16) and mega cities of 10 million or more (n=5). A third of the articles analyze AC at the city scale (n=13) and most of the remaining articles are framed at the district or sub-district (or neighborhood) scale (n=10). Only five articles use the community (n=5), household (n=6) or individual level (n=3) as their primary scale of analysis.

The studies reviewed rely on a mix of qualitative, quantitative and spatial methods. More than half use only one of these three methods: qualitative (n=13), quantitative (n=8) or spatial (n=3) methods. Nevertheless, the distribution of study designs shows an increase in the use of mixed methods (n=14) over time, especially with regard to mixed qualitative and quantitative methods (n=11). Questionnaire surveys and interviews, and to a lesser degree focus groups, are the most common data-gathering techniques. Studies using spatial analysis are the least common (n=6), and this holds whether this method is used alone or as part of a mixed method strategy. They tend to examine AC at the city scale comparing different sectors within cities or comparing cities within larger regions.

The studies reviewed include single case studies (n=29), comparative case studies (n=6) including four south-south and two north-south⁷ urban areas comparisons, territorial studies (n=2), and one global study (n=1). Comparative case studies examine in-depth two or more urban areas within one country or region (e.g., comparing two cities in LAC), and territorial studies assess an often large number of cities within one country area (e.g., 65 cities in southern China).

The majority of studies frame the analysis of AC in responding to climatic stressors or hazards (e.g., urban heat or floods), focusing less on the possible impacts of those stressors (e.g., health impacts). More than

⁵ None of the articles in Spanish originally identified were retained for review.

⁶ Country income levels were drawn from the UN World Economic Situation and Prospects 2017, based on the per capita Gross National Income (GNI) in September 2016.

⁷ We assessed only the approach on the developing country information of the north-south studies.

half of the studies (n=22) consider multiple climatic stressors, fewer articles focus on only one climatic stressor (n=11), or otherwise define their analysis as motivated by the threat of climate change generally (n=5). Researchers design their studies to focus mostly on floods, droughts, urban heat, sea-level rise, and water scarcity.

Most of the articles reviewed were published in journals within the environmental sciences and studies disciplines (n=27). A smaller number of studies were published by journals at the interface of urban and environmental studies, and/or planning and development (n=5), by geography-focused journals (n=3) or other disciplines (n=3) such as women studies.

4.2 Adaptive capacity characteristics

The peer-reviewed literature characterizes urban AC in multiple ways. Over two-fifth (n=16) of studies do not provide an explicit explanation of what constitutes AC within their methodological approach, limiting comparison possibilities (e.g., meta-analysis). These studies assume that a low or high level of AC results (or not) in adaptation practices, and key determinants are selected to assess the level of AC. Conversely, studies that explicitly define AC (n=22) tend to assess urban AC in terms of resources and determinants that structure the ability to respond to climate variability and climate change. A less common approach is to assess urban AC in terms of processes that lead to adaptation actions.

Our analysis shows that the resources and determinants most often used to describe AC are financial (income and assets), informational, technological, access to basic services, and social capital. Determinants often utilized are knowledge, education, experience with previous hazards, awareness, risk perception, infrastructure, social networks, warning systems and to a lesser extent innovation, governance, political participation, legal structure, self-efficacy, and leadership. Wamsler et al. (2012) demonstrate how key determinants influence AC in San Salvador, El Salvador, finding a significant correlation between past disaster impacts and the use of coping strategies, indicating that previous experiences can determine AC. While several resources and determinants are considered, scholars also raise the development challenges when managing climate risks. For example, a study in Accra, Ghana, found that even though 97% of the urban traders surveyed noted that climate change negatively impacted their trading activities, the majority of respondents were unable to meet some or all their basic needs and thus adopt coping strategies in responding to climate change (Arku et al. 2017).

In the majority of studies (n=29), scholars did not refer to specific urban attributes when characterizing urban AC. Instead, they used standard AC attributes such as income and knowledge. Urban attributes entail relevancy to the settlement's characteristics (e.g., density, size), the systems that facilitate social urban life (e.g., urban governance settings, flux of resources from the hinterlands), and social-urban dynamics (e.g. social fragmentation). In the few cases (n=9) whence studies did refer to urban attributes, these included infrastructure (e.g., urban water supply), household location, property characteristics (e.g., ownership, insurance), land use regulation processes (e.g., informal settlements, urban governance), and

stability and security of the urban areas. These cases illustrated the importance of considering urban attributes. For example, in a comparative study of three urban areas in Indonesia, researchers concluded that the bigger a city is, the more the different areas of that city will have varying levels of vulnerability, while the smaller a city is, the less capacity it will have in reducing its emerging vulnerability challenges (Handayani et al. 2017).

The set of peer-reviewed studies analyzes AC agency from a mix of individual, social, and institutional stances. Half of the studies focus on one type of agency, either individual or governmental, and the other half of the studies on more than one type of agency. Altogether, individual agency is the one most often considered ($n=26$), closely followed by institutional agency ($n=22$), and then communities' social agency ($n=11$). Notably, Paterson et al. (2017) discuss the scope for local action, considering the structural aspects that shape adaptive capacity (e.g., organizational and administrative architecture) and the agency within the structures.

Whereas agency of AC is attributed to the three types of actors, the literature mostly frames AC as an objective ability to deal with climate change. Fewer than 30% of the studies ($n=11$) discuss the subjective AC of an actor or social group. Studies that do consider the subjectivities of AC mostly do so as a supplement to the analysis of objective AC. The combination of objective and subjective AC is typically done by combining resources and determinants that compose AC with climate change awareness and risk perceptions, and to a lesser extent with self-efficacy perceptions. These studies' findings show that subjective factors influence adaptation decisions. For example, in Taichung, Taiwan, the community members' risk perceptions and appraisals of their abilities to access resources and perform adaptation successfully have been shown to be key determinants of residents' willingness to take adaptive actions (Hung et al. 2016).

Regarding the range of AC, more than a third of the studies reviewed focus only on the ability to deal with short-term climate threats through concrete actions (e.g., moving furniture one floor up during floods), which corresponds to the coping level ($n=15$). Around half of the studies reviewed analyze AC in a medium time frame by considering the ability to adjust and prepare in advance for climate impacts; this includes studies that exclusively assess the adapting level, and studies that combined the coping and adapting levels ($n=17$). Few studies examine longer-term strategies that aim to change structural conditions in urban areas, the transformability level ($n=6$), and when they do, they do so primarily at a theoretical level. Schaer (2015), in her study in Dakar, does explore the effect of past maladaptation in partly determining present coping and adaptation capacity and discusses coping and adaptation strategies by their timing and by whether they support permanent transformations.

4.3 External Factors shaping urban adaptive capacity

The majority of articles reviewed consider external factors that mediate urban AC ($n=30$). This consideration ranges from the description of processes that contextualize AC to analyses of how these processes

empower (or undermine) the AC of urban actors. Several of the articles reviewed include urban vulnerability assessments that explicitly consider AC (n=17), along with exposure and sensitivity (as is common practice in the scholarship). In these cases, the external factors that shape AC are analyzed as factors shaping vulnerability and therefore AC.

Research concerned with multi-level processes tends to identify global and national processes that affect local urban circumstances. A third of the studies reviewed take into account multilevel processes (n=12). This literature frequently highlights decentralization, urban growth, and economic growth and transformation as factors directly influencing AC. For example, in Nadi, decentralization of early warning systems was shown to enhance AC, but at the same time national political instability eroded international finance, which decreased AC (Chandra and Gaganis 2016). In a global-level study, Garschagen and Romero-Lankao (2015) demonstrate that countries with rapid urbanization and economic transformation face significant challenges with respect to the lack of capacities and sensitivities, while urbanization can also be a main driver for enhancing AC. Other multilevel processes identified include migration, national political instability, institutional national fragmentation, historical processes following post-colonialism, and neoliberal reforms.

More than half of the peer-reviewed articles (n=22) describe place-based processes that influence how actors respond to climate hazards. These processes include the informality of settlements, employment, poverty, forced evictions, social segregation and marginalization, provision of city services, increased mobility, and population density. The most common place-based process, addressed in 39% of the articles reviewed (n=15), is urban spatial expansion through informal settlements. Studies concerned with this process are looking at an informal settlement or at the way informality influences the local capacities to adapt to climate change. As exemplified in Lagos, Nigeria, communities living on informal settlements are marginalized by being classified as “outside” of the city and hence excluded from the city’s regulatory and planning systems for dealing with climate hazards (Ajibade and McBean 2014). Likewise in relation to informal settlements, in San Salvador researchers found that the increasing ease of mobility leads households to default on their obligations to relatives and neighbors, as the different income levels foster individualistic behavior that result in opting out of mutual and hierarchical arrangements that could support adaptation (Wamsler and Lawson 2012).

The documentation of institutions (i.e. rules and social norms) affecting urban AC is elaborated in much more detail than the multilevel and place-based processes. The institutions identified as shaping urban AC correspond to position, boundary, choice, aggregation, and information rule types, following Ostrom’s classification (Table 2). Regarding the influence of governance institutions on institutional capacity (e.g. governmental), the literature reviewed highlights the roles and responsibilities of policymakers and stakeholders, the flexibility or rigidity of institutional procedures, leadership, elitism, turnover, and flow of information. For example, in the case of Cape Town, South Africa, Ziervogel et al. (2010) highlighted the need for cooperation between organizations and leaders within the water sector to facilitate the AC of the

city. Frick-Trzebitzky (2017) also demonstrated the importance of informal institutions for adaptation in Accra where the role of the chief contributed to or impeded adaptation to urban flooding, depending on the chief's own rationalities and institutional context.

Considering the influence of institutions on social and individual AC, several studies (n=9) found that tenure security mediates households' AC. In Korail, for example, a large informal settlement in Dhaka, Bangladesh, Jabeen et al (Jabeen et al. 2010) found inhabitants unwilling to invest in improving their living conditions because of tenure insecurity, despite the fact that some have lived there for as long as 20 years. Similarly, in urban communities in Lagos, while the authorities enforce evictions and demolitions on account of flood prevention and urban development, the inhabitants expressed a reluctance to invest in quality housing because they feared these forced actions from the authorities (Ajibade and McBean 2014).

Further, several studies mention that urban dwellers distrust local authorities (n=8), which can impact the capacity to respond and adjust the urban system to climate change. For example, in Lagos, Nigeria, social distrust prevented citizens from making use of the early warnings to floods provided by authorities (Ajibade and McBean 2014). Similarly, in Ekurhuleni, South Africa, the relationship between local governments and residents has historically been distrustful, thus shaping the risk perceptions of the latter and prompting them to pool ideas as well as financial resources to combat floods on their own rather than to rely on the government (Fatti and Patel 2013). These cases show the importance of local political interactions in shaping AC.

4.4. Adaptive capacity dynamics

The literature often disaggregates the AC of different urban dwellers groups (n=12). This is mainly done by contrasting low-income to high-income groups, low-risk to high-risk groups (measured by their exposure and/or sensitivities), and geographic areas. For example, Wamsler et al. (2012) showed a relationship between households' level of education and risk level in San Salvador and Rio de Janeiro. Their study explained the lower risks faced by people with higher levels of education because they are more likely to be responsive to disaster warnings and alerts, to accept and use institutional support, and to move to a more secure area. Further, the study shows that formal education seems to be of special importance for determining women's risk level. The urban dwellers differences in AC have also been assessed in relation to the capacity of other actors to foster adaptation (i.e. authorities).

Where only the most vulnerable populations are identified (n=16), the literature focuses mostly on one vulnerable group (e.g. urban poor) or alternatively disaggregates results and identifies particular phenomena related to a vulnerable group (e.g., women). For example, in Dakar, the most vulnerable population groups are excluded from taking part in local decision-making and thus are negatively affected by the undesirable impact of adaptation initiatives (Schaer 2015). Moreover, while a majority of studies (n=34) did not include gender considerations to characterize AC, those that did had noteworthy results. For example, studies in Delhi, India, shed light on the decision-making process of households wherein social

gender relations undermine women's adaptation decisions (Saini et al. 2015). Still in Delhi, another study found that gender roles affect the ability of poor urban women to adapt to climate-related water insecurities (Kher et al. 2015).

Six articles engage with the dynamics of AC, from considering the interaction of a person's own capacities to the individuals' capacities within the social groups. For example, in Mexico City there are tradeoffs between specific and generic capacities at the household level. Households' efforts to adapt in conditions of marginality can come at the expense of households' investment in other aspects of human welfare, reinforcing poverty traps and leading to inequity in the burden of risk management (Eakin et al. 2016). Also, a study in Malolos, Philippines, shows that some children, especially those from poor families, experience helplessness and exasperation in performing individual-level adaptations without corresponding long-term action from their community (Berse 2017). The literature highlights not only the dynamics but also the importance of studying the internal dynamics of AC at multiple scales. For example, in Paramaribo, Suriname and Georgetown, Guyana, households perform most of the preventative actions and during floods households often act collectively within their localities without contacting the authorities (Linnekamp et al. 2011).

Only four articles of the 38 examined take into account time when studying urban AC. Regarding changes of AC over time, in Concepcion, Chile, researchers concluded that all the municipalities in the area increased their level of AC between 1992 and 2002. In most municipalities, knowledge was the most important determinant of this increase. However, the relative differences in AC between rich and poor municipalities did not change significantly over the studied period, which is explained by economic conditions, location, and inequalities rising from urban sprawl. (Araya-Munoz et al. 2016). In contrast, in Santos, Brazil, a study found high adaptive capacity but a lack of progression from the perspective of local actors, which was explained by a lack of organizational integration and the dominance of the adaptation agenda by the civil defense sector (Paterson et al. 2017).

Some researchers reflected on the relationship between AC and exposure and sensitivity to climate change, showing the strong connections to the broader vulnerability research. For example, in Nadi, it was suggested that the presence of multiple exposures, of physical, social, economic, and political factors reinforced, transformed, or weakened the existing patterns of local people's AC highlighting the importance of contextual vulnerability (Chandra and Gaganis 2016). From a metalevel perspective, scholars propose that understanding the content of AC and how it interacts with exposure and sensitivity during different periods will be an important basis for responding to unexpected climatic events (Berse 2017; Hung et al. 2016; Sales 2009).

5. Discussion

This paper systematically examined how urban adaptive capacity (AC) to climate change in developing countries is being framed and assessed in the peer-reviewed literature. Our study responded to calls for thinking across urban contexts in a globalized world facing climate change (Huyssen 2008), while remaining cognizant of ongoing debates about comparability stemming from differences in methodological and theoretical approach (see Robinson 2011). We identified 38 studies published between 2000 and 2017 that examined AC to climate change in urban settings of developing countries. This is a small fraction of a larger body of urban adaptation literature, with 1,957 articles on this theme having been published during the same period.⁸ All articles assessed were published from 2009, signaling the relatively recent—yet significant—rise of scholarly interest in the question of urban AC in the developing world. However, our survey of the literature shows that urban areas of developed countries continue to receive much more attention than those located in developing countries, even though these countries are home to an increasingly important proportion of the world's urban population (UN-Habitat 2016). Moreover, research on urban AC in the context of developing countries tends to focus on a rather limited number of countries and their urban areas. This uneven geographic distribution means many countries of the Global South are “off the map” in existing urban AC research, and this despite the fact that they are expected to be significantly impacted by future climate change. There is need to research urban areas in all developing regions, including Sub-Saharan Africa, Arab states, South and East Asia, Central and South America, the Caribbean and the Pacific states. The conceptual framework presented in this paper can assist further research to characterize and examine urban AC in developing countries, especially those “off the map”.

This review also identified four emergent patterns within urban AC research and sheds light on the mismatch between theoretical debates on AC dynamics and empirical assessments. Firstly, the results support previous claims that AC varies *across* urban scales (Moser and Satterthwaite 2008; Romero-Lankao et al. 2014), including individuals, households, communities, districts, and city levels. Moreover, urban AC consistently varies *within* scales, such as between urban sub-groups and geographic locations within urban areas. Hence, it is important to contextualize and map AC as suggested by broader vulnerability researchers (Dunford et al. 2015; Lemos et al. 2013; Waters and Adger 2017). Secondly, the review showed that objective resources and processes mediate AC in urban areas and that subjective AC can directly influence the resulting adaptive practices. Articles that use an integrated framing of both objective and subjective AC in urban settings provide more nuanced results than those focusing only on one type of AC. Thirdly, the role of governance and social institutions is key to understanding the agency of actors in their path to adaptive actions. As such, our review supports previous studies concluding that governance institutions shape institutional and individual urban AC (as a two-fold capacity) (Hughes and

⁸ According to a Web of Science query for the 2000–2017 period using the following keywords: TOPIC: (urban OR cities OR metropolitan) AND TOPIC: (adaptation) AND TOPIC: (“climat* change” OR “global warming”).

Sarzynski 2015; Wamsler and Brink 2014), also illustrating that social institutions are critical in shaping individual, social, and institutional urban AC in developing countries. Fourthly, most articles fail to include specific urban determinants in their analysis and questions remain as to how and why these determinants can have different impacts in urban areas globally. In addition, it would be appropriate to explore possible interdependencies between the urban determinants and multilevel and place-based processes, which together affect urban AC.

The treatment of AC dynamics in the scholarship is found to be marginal with regard to the interactions of AC over time, between and within urban groups' capacities, and with urban exposure and sensitivities. These gaps point to a rather narrow understanding of AC as static in time and space, and non-reciprocal between social entities. Although some studies did consider differentiated AC in a given urban area, analyses of how these reinforce or diminish one another is weak. While there has been broad understanding that adaptation actions will unavoidably produce winners and losers (even with no-regret options) (Eriksen et al. 2011; O'Brien and Leichenko 2003; Sovacool et al. 2015), there is limited consideration on the effects of how AC, in a given moment, by a specific social group or in response to certain exposure, can affect AC elsewhere. Research needs to more strongly emphasize the dynamics of urban AC, including potential for maladaptation, as has been addressed in the context of land-use measures and adaption planning (Anguelovski et al. 2016). Further, considering that one third of the studies reviewed only focus on the coping level of AC, there is need to promote analysis that links coping, adapting and transforming levels of AC. This is particularly important when considering that coping responses of individuals and social entities can generate undesirable outcomes for communities in the long-term, as has been studied in rural and national settings (Fazey et al. 2010; Fazey et al. 2016). The treatment of urban AC in research as a short-term ability to deal with shocks can translate into an equivocal analysis of vulnerability to climate change and support maladaptation of urban areas and their communities. Altogether, we can observe a mismatch between theoretical papers addressing the adaptability and transformability of urban areas (Hordijk et al. 2014; Pelling et al. 2015; Rosenzweig et al. 2018b; Solecki et al. 2017; Zervogel et al. 2016) and the limited empirical papers that sought to study these processes on the ground. Studying the dynamics of urban AC has methodological challenges as to design approaches that account for multiple AC paths within urban milieus in changing socio-natural contexts and taking longer time-frames (i.e. 10 years and longer) that would allow to see the effects of AC in other entities and places. Despite these challenges, there is need to strengthen and link empirical work to the current theoretical debates on climate change adaptation in and beyond urban areas, especially the growing body of research dealing with the political nature of adaptation (Chu 2016; Chu et al. 2017; Eriksen et al. 2015; Meerow and Mitchell 2017), historical processes framing adaptation (Adamson et al. 2018), and the role of values in defining adaptation practices (O'Brien and Wolf 2010).

Ultimately, this review of urban AC literature raises a key question: How should we explain the process of adaptation? Using the concept of AC is useful to address the social urban ability to deal with climate change,

but using this concept should not restrict the analysis to a sum of characteristics that may or may not indicate possible adaptations. As Mortreux and Barnett (2017) warned, the first generation of AC research (what they define as the sum of capitals) has been unable to explain how adaptation is practiced across diverse contexts and scales. Thus, there is need for research that focuses on understanding existing adaptation processes (Mortreux and Barnett 2017). Embracing the second generation of AC by adopting an understanding of urban AC as the adaptation process that leads to adaptive practices and outcomes in specific socio-urban settings would be valuable. In this paper, such understanding eased for a better integration in the analysis of the socio-cultural and urban processes that shape urban AC and to inquire how the dynamics of AC evolve. At the same time, the understanding of urban AC as a process requires engaging with broader literatures concerned with urban space, such as urban planning, urban sociology, geography and history. All of these disciplines can contribute to equip scholarship on urban AC with a better and more in-depth understanding of the social, psychological, cultural, and political processes it seeks to understand and explain (Sanchez-Rodriguez et al. 2018).

References

- Adamson GCD, Hannaford MJ, Rohland EJ (2018) Re-thinking the present: The role of a historical focus in climate change adaptation research Glob Environ Chang 48:195-205 doi:<https://doi.org/10.1016/j.gloenvcha.2017.12.003>
- Adger WN (2003) Social capital, collective action, and adaptation to climate change Economic Geography 79:387-404
- Adger WN, Brooks N, Bentham G, Agnew M, Eriksen S (2004) New indicators of vulnerability and adaptive capacity vol 122. Tyndall Centre for Climate Change Research Norwich
- Adger WN, Vincent K (2005) Uncertainty in adaptive capacity Comptes Rendus Geoscience 337:399-410 doi:<https://doi.org/10.1016/j.crte.2004.11.004>
- Ajibade I, McBean G (2014) Climate extremes and housing rights: A political ecology of impacts, early warning and adaptation constraints in Lagos slum communities Geoforum 55:76-86 doi:10.1016/j.geoforum.2014.05.005
- Anguelovski I, Chu E, Carmin J (2014) Variations in approaches to urban climate adaptation: Experiences and experimentation from the global South Glob Environ Change-Human Policy Dimens 27:156-167 doi:10.1016/j.gloenvcha.2014.05.010
- Anguelovski I et al. (2016) Equity Impacts of Urban Land Use Planning for Climate Adaptation:Critical Perspectives from the Global North and South Journal of Planning Education and Research 36:333-348 doi:10.1177/0739456x16645166
- Araya-Munoz D, Metzger MJ, Stuart N, Wilson AMW, Alvarez L (2016) Assessing urban adaptive capacity to climate change J Environ Manage 183:314-324 doi:10.1016/j.jenvman.2016.08.060
- Arku FS, Angmor EN, Adjei GT (2017) Perception and responses of traders to climate change in downtown, Accra, Ghana Int J Clim Chang Strateg Manag 9:56-67 doi:10.1108/ijccsm-03-2016-0027

- Bassett TJ, Fogelman C (2013) Déjà vu or something new? The adaptation concept in the climate change literature *Geoforum* 48:42-53
- Berse K (2017) Climate change from the lens of Malolos children: perception, impact and adaptation *Disaster Prev Manag* 26:217-229 doi:10.1108/dpm-10-2016-0214
- Birkmann J, Garschagen M, Kraas F, Quang N (2010) Adaptive urban governance: new challenges for the second generation of urban adaptation strategies to climate change *Sustain Sci* 5:185-206
- Birkmann J, Garschagen M, Setiadi N (2014) New challenges for adaptive urban governance in highly dynamic environments: Revisiting planning systems and tools for adaptive and strategic planning *Urban Climate* 7:115-133
- Bisaro A, Roggero M, Villamayor-Tomas S (2018) Institutional Analysis in Climate Change Adaptation Research: A Systematic Literature Review *Ecol Econ* 151:34-43 doi:<https://doi.org/10.1016/j.ecolecon.2018.04.016>
- Brooks N, Neil Adger W, Mick Kelly P (2005) The determinants of vulnerability and adaptive capacity at the national level and the implications for adaptation *Global Environmental Change* 15:151-163 doi:<https://doi.org/10.1016/j.gloenvcha.2004.12.006>
- Bunce A, Ford J (2015) How is adaptation, resilience, and vulnerability research engaging with gender? *Environ Res Lett* 10:123003
- Chandra A, Gaganis P (2016) Deconstructing vulnerability and adaptation in a coastal river basin ecosystem: a participatory analysis of flood risk in Nadi, Fiji Islands *Clim Dev* 8:256-269 doi:10.1080/17565529.2015.1016884
- Chelleri L, Waters JJ, Olazabal M, Minucci G (2015) Resilience trade-offs: addressing multiple scales and temporal aspects of urban resilience *Environ Urban* 27:181-198 doi:10.1177/0956247814550780
- Chu E (2016) The political economy of urban climate adaptation and development planning in Surat, India *Environment and Planning C: Government and Policy* 34:281-298 doi:10.1177/0263774x15614174
- Chu E, Anguelovski I, Roberts D (2017) Climate adaptation as strategic urbanism: assessing opportunities and uncertainties for equity and inclusive development in cities *Cities* 60:378-387 doi:<https://doi.org/10.1016/j.cities.2016.10.016>
- Clayton S et al. (2015) Psychological research and global climate change *Nat Clim Chang* 5:640-646
- Crane TA, Delaney A, Tamás PA, Chesterman S, Ericksen P (2017) A systematic review of local vulnerability to climate change in developing country agriculture *Wiley Interdisciplinary Reviews: Climate Change* 8 doi:10.1002/wcc.464
- Cutter SL, Barnes L, Berry M, Burton C, Evans E, Tate E, Webb J (2008) A place-based model for understanding community resilience to natural disasters *Global environmental change* 18:598-606
- De Coninck H et al. (2018) Chapter 4: Strengthening and implementing the global response to the threat of climate change. In: IPCC (ed) *Global Warming of 1.5 °C - an IPCC special report on the impacts of global warming of 1.5 °C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty.*
- Dodman D, Satterthwaite D (2008) Institutional capacity, climate change adaptation and the urban poor *IDS Bulletin* 39:67-74
- Dunford R, Harrison PA, Jäger J, Rounsevell MDA, Tinch R (2015) Exploring climate change vulnerability across sectors and scenarios using indicators of impacts and coping capacity *Clim Change* 128:339-354 doi:10.1007/s10584-014-1162-8

- Eakin H, Lemos MC, Nelson DR (2014) Differentiating capacities as a means to sustainable climate change adaptation Global Environmental Change 27:1-8
doi:<http://dx.doi.org/10.1016/j.gloenvcha.2014.04.013>
- Eakin H et al. (2016) Adapting to risk and perpetuating poverty: Household's strategies for managing flood risk and water scarcity in Mexico City Environ Sci Policy 66:324-333
doi:10.1016/j.envsci.2016.06.006
- Eakin H, Patt A (2011) Are adaptation studies effective, and what can enhance their practical impact? Wiley Interdiscip Rev Chang 2:141-153 doi:10.1002/wcc.100
- Engle NL (2011) Adaptive capacity and its assessment Global Environmental Change 21:647-656
- Eriksen S et al. (2011) When not every response to climate change is a good one: Identifying principles for sustainable adaptation Clim Dev 3:7-20 doi:10.3763/cdev.2010.0060
- Eriksen SH, Nightingale AJ, Eakin H (2015) Reframing adaptation: The political nature of climate change adaptation Global Environmental Change 35:523-533
doi:<http://dx.doi.org/10.1016/j.gloenvcha.2015.09.014>
- Fatti CE, Patel Z (2013) Perceptions and responses to urban flood risk: Implications for climate governance in the South Appl Geogr 36:13-22 doi:10.1016/j.apgeog.2012.06.011
- Fazey I, Gamarra JG, Fischer J, Reed MS, Stringer LC, Christie M (2010) Adaptation strategies for reducing vulnerability to future environmental change Frontiers in Ecology and the Environment 8:414-422
- Fazey I et al. (2018) Transformation in a changing climate: a research agenda Clim Dev 10:197-217 doi:10.1080/17565529.2017.1301864
- Fazey I, Wise RM, Lyon C, Câmpeanu C, Moug P, Davies TE (2016) Past and future adaptation pathways Clim Dev 8:26-44 doi:10.1080/17565529.2014.989192
- Few R (2003) Flooding, vulnerability and coping strategies: local responses to a global threat Progress in Development Studies 3:43-58
- Ford JD (2012) Indigenous health and climate change American journal of public health 102:1260-1266
- Ford JD, Berrang-Ford L, Paterson J (2011) A systematic review of observed climate change adaptation in developed nations Clim Change 106:327-336
- Ford JD et al. (2013) The dynamic multiscale nature of climate change vulnerability: an Inuit harvesting example Ann Assoc Am Geogr 103:1193-1211
- Frick-Trzebitzky F (2017) Crafting Adaptive Capacity: Institutional Bricolage in Adaptation to Urban Flooding in Greater Accra Water Alternatives 10:625-647
- Fuchs S, Karagiorgos K, Kitikidou K, Maris F, Paparrizos S, Thaler T (2017) Flood risk perception and adaptation capacity: a contribution to the socio-hydrology debate Hydrol Earth Syst Sc 21:3183-3198 doi:10.5194/hess-21-3183-2017
- Garschagen M, Romero-Lankao P (2015) Exploring the relationships between urbanization trends and climate change vulnerability Clim Change 133:37-52 doi:10.1007/s10584-013-0812-6
- Gencer E (2013) The interplay between urban development, vulnerability, and risk management: A case study of the Istanbul metropolitan area vol 7. Springer-Verlag Berlin Heidelberg,
- Gifford R, Kormos C, McIntyre A (2011) Behavioral dimensions of climate change: drivers, responses, barriers, and interventions Wiley Interdisciplinary Reviews: Climate Change 2:801-827 doi:10.1002/wcc.143
- Grothmann T, Grecksch K, Winges M, Siebenhüner B (2013) Assessing institutional capacities to adapt to climate change: integrating psychological dimensions in the Adaptive Capacity Wheel Nat Hazards Earth Syst Sci 13:3369
- Grothmann T, Patt A (2005) Adaptive capacity and human cognition: the process of individual adaptation to climate change Global Environmental Change 15:199-213

- Handayani W, Rudiarto I, Setyono JS, Chigbu UE, Sukmawati AM (2017) Vulnerability assessment: A comparison of three different city sizes in the coastal area of Central Java, Indonesia Advances in Climate Change Research 8:286-296 doi:10.1016/j.accre.2017.11.002
- Harvatt J, Petts J, Chilvers J (2011) Understanding householder responses to natural hazards: flooding and sea-level rise comparisons Journal of Risk Research 14:63-83
- Heinrichs D, Krellenberg K, Fragkias M (2013) Urban Responses to Climate Change: Theories and Governance Practice in Cities of the Global South Int J Urban Reg Res 37:1865-1878 doi:10.1111/1468-2427.12031
- Hinkel J (2011) "Indicators of vulnerability and adaptive capacity": Towards a clarification of the science–policy interface Global Environmental Change 21:198-208
- Hordijk M, Sara LM, Sutherland C (2014) Resilience, transition or transformation? A comparative analysis of changing water governance systems in four southern cities Environ Urban 26:130-146 doi:doi:10.1177/0956247813519044
- Hughes S, Sarzynski A (2015) Building capacity for climate change adaptation in urban areas: Editors' introduction Urban Climate:1-3
- Hung HC, Yang CY, Chien CY, Liu YC (2016) Building resilience: Mainstreaming community participation into integrated assessment of resilience to climatic hazards in metropolitan land use management Land Use Pol 50:48-58 doi:10.1016/j.landusepol.2015.08.029
- Hunt A, Watkiss P (2011) Climate change impacts and adaptation in cities: a review of the literature Clim Change 104:13-49
- Huyssen A (2008) Other cities, other worlds: urban imaginaries in a globalizing age. Duke University Press,
- Jabareen Y (2009) Building a Conceptual Framework: Philosophy, Definitions, and Procedure International Journal of Qualitative Methods 8:49-62 doi:10.1177/160940690900800406
- Jabeen H, Johnson C, Allen A (2010) Built-in resilience: learning from grassroots coping strategies for climate variability Environ Urban 22:415-431 doi:10.1177/0956247810379937
- Kates RW et al. (2001) Sustainability science Science 292:641-642
- Kher J, Aggarwal S, Punhani G (2015) Vulnerability of Poor Urban Women to Climate-linked Water Insecurities at the Household Level: A Case Study of Slums in Delhi Indian J Gend Stud 22:15-40 doi:10.1177/0971521514556943
- Krellenberg K, Link F, Welz J, Harris J, Barth K, Irarrazaval F (2014) Supporting local adaptation: The contribution of socio-environmental fragmentation to urban vulnerability Appl Geogr 55:61-70 doi:10.1016/j.apgeog.2014.08.013
- Lehmann P, Brenck M, Gebhardt O, Schaller S, Süßbauer E (2015) Barriers and opportunities for urban adaptation planning: analytical framework and evidence from cities in Latin America and Germany Mitig Adapt Strateg Glob Chang 20:75-97
- Leichenko R (2011) Climate change and urban resilience Curr Opin Environ Sustain 3:164-168
- Leichenko R, O'Brien K (2008) Environmental change and globalization: Double exposures. Oxford University Press,
- Leichenko R, O'Brien KL (2002) The dynamics of rural vulnerability to global change: the case of southern Africa Mitig Adapt Strateg Glob Chang 7:1-18
- Lemos MC, Agrawal A, Eakin H, Nelson DR, Engle NL, Johns O (2013) Building adaptive capacity to climate change in less developed countries. In: Climate science for serving society. Springer, pp 437-457
- Linnekamp F, Koedam A, Baud ISA (2011) Household vulnerability to climate change: Examining perceptions of households of flood risks in Georgetown and Paramaribo Habitat Int 35:447-456 doi:10.1016/j.habitatint.2010.12.003

- Matthews R, Sydneysmith R (2010) Adaptive capacity as a dynamic institutional process: conceptual perspectives and their application. In: Adaptive capacity and environmental governance. Springer, pp 223-242
- Meerow S, Mitchell C (2017) Weathering the storm: The politics of urban climate change adaptation planning Environment and Planning A 0:0308518X17735225 doi:10.1177/0308518x17735225
- Mortreux C, Barnett J (2017) Adaptive capacity: exploring the research frontier Wiley Interdisciplinary Reviews: Climate Change 8:e467-n/a doi:10.1002/wcc.467
- Moser C, Satterthwaite D Pre-poor Climate Change Adaptation in the Urban Centres of Low- and Middle-Income Countries. In: Workshop on Social Dimension of Climate Change, 2008.
- Nelson DR, Adger WN, Brown K (2007) Adaptation to Environmental Change: Contributions of a Resilience Framework Annual Review of Environment and Resources 32:395-419 doi:10.1146/annurev.energy.32.051807.090348
- O'Brien K, Leichenko R (2003) Winners and Losers in the Context of Global Change Ann Assoc Am Geogr 93:89-103 doi:10.1111/1467-8306.93107
- O'Brien K, Selboe E (2015) The Adaptive Challenge of Climate Change. Cambridge University Press,
- O'Brien K, Wolf J (2010) A values-based approach to vulnerability and adaptation to climate change Wiley Interdisciplinary Reviews: Climate Change 1:232-242 doi:10.1002/wcc.30
- O'Brien K (2012) Global environmental change II From adaptation to deliberate transformation Progress in Human Geography 36:667-676
- Ostrom E (2005) Understanding institutional diversity
- Ostrom E (2014) Collective action and the evolution of social norms Journal of Natural Resources Policy Research 6:235-252
- Paterson SK, Felling M, Nunes LH, Moreira FD, Guida K, Marengo JA (2017) Size does matter: City scale and the asymmetries of climate change adaptation in three coastal towns Geoforum 81:109-119 doi:10.1016/j.geoforum.2017.02.014
- Pelling M (2003) The vulnerability of cities: natural disasters and social resilience. Earthscan,
- Pelling M, O'Brien K, Matyas D (2015) Adaptation and transformation Clim Change 133:113-127
- Plummer R, Armitage D (2010) Integrating perspectives on adaptive capacity and environmental governance. In: Adaptive capacity and environmental governance. Springer, pp 1-19
- Qin H, Romero-Lankao P, Hardoy J, Rosas-Huerta A (2015) Household responses to climate-related hazards in four Latin American cities: A conceptual framework and exploratory analysis Urban Climate 14:94-110
- Revi A et al. (2014) Towards transformative adaptation in cities: the IPCC's Fifth Assessment Environ Urban 26:11-28 doi:10.1177/0956247814523539
- Ribot J (2011) Vulnerability before adaptation: Toward transformative climate action Global Environmental Change 21:1160-1162 doi:<http://dx.doi.org/10.1016/j.gloenvcha.2011.07.008>
- Robinson J (2011) Cities in a World of Cities: The Comparative Gesture Int J Urban Reg Res 35:1-23 doi:10.1111/j.1468-2427.2010.00982.x
- Romero-Lankao P, Hughes S, Qin H, Hardoy J, Rosas-Huerta A, Borquez R, Lampis A (2014) Scale, urban risk and adaptation capacity in neighborhoods of Latin American cities Habitat Int 42:224-235 doi:10.1016/j.habitatint.2013.12.008
- Romero-Lankao P, Qin H (2011) Conceptualizing urban vulnerability to global climate and environmental change Curr Opin Environ Sustain 3:142-149
- Rosenzweig C, Solecki W, Romero-Lankao P, Mehrotra S, Dhakal S, Bowman T, Ibrahim SA (2018a) Climate Change and Cities: Second Assessment Report of the Urban Climate Change Research Network. In: Rosenzweig C, Romero-Lankao P, Mehrotra S, Dhakal S, Ali Ibrahim S, Solecki WD (eds) Climate Change and Cities: Second Assessment

- Report of the Urban Climate Change Research Network. Cambridge University Press, Cambridge, pp xvii-xlii. doi:10.1017/9781316563878.007
- Rosenzweig C, Solecki W, Romero-Lankao P, Mehrotra S, Dhakal S, Ibrahim SA (2018b) Pathways to Urban Transformation. In: Rosenzweig C, Romero-Lankao P, Mehrotra S, Dhakal S, Ali Ibrahim S, Solecki WD (eds) Climate Change and Cities: Second Assessment Report of the Urban Climate Change Research Network. Cambridge University Press, Cambridge, pp 3-26. doi:10.1017/9781316563878.008
- Saini S, Aggarwal S, Punhani G (2015) Urban Poor Women and Climate Change in India: Enhancing Adaptive Capacity Through Communication for Development. In: Filho WL (ed) Climate Change in the Asia-Pacific Region. Climate Change Management. pp 67-88. doi:10.1007/978-3-319-14938-7-5
- Sales RFM (2009) Vulnerability and adaptation of coastal communities to climate variability and sea-level rise: Their implications for integrated coastal management in Cavite City, Philippines Ocean Coastal Manage 52:395-404 doi:10.1016/j.ocecoaman.2009.04.007
- Sanchez-Rodriguez R (2015) Adaptation to climate change in rapidly growing cities. In: Seto K, Solecki W, Griffin C (eds) Handbook on Urbanization and Global Environmental Change. Routledge, London,
- Sanchez-Rodriguez R, Ürge-Vorsatz D, Barau AS (2018) Sustainable Development Goals and climate change adaptation in cities Nat Clim Chang 8:181-183 doi:10.1038/s41558-018-0098-9
- Satterthwaite D, Hug S, Pelling M, Romero-Lankao P (2007) Adapting to climate change in urban areas: the possibilities and constraints in low-and middle-income nations vol 1. lied,
- Schaer C (2015) Condemned to live with one's feet in water? A case study of community based strategies and urban maladaptation in flood prone Pikine/Dakar, Senegal Int J Clim Chang Strateg Manag 7:534-551 doi:10.1108/ijccsm-03-2014-0038
- Shi L et al. (2016) Roadmap towards justice in urban climate adaptation research Nat Clim Chang 6:131 doi:10.1038/nclimate2841
- Smit B, Wandel J (2006) Adaptation, adaptive capacity and vulnerability Global environmental change 16:282-292
- Solecki W, Pelling M, Garschagen M (2017) Transitions between risk management regimes in cities Ecol Soc 22 doi:10.5751/ES-09102-220238
- Sovacool BK, Linnér B-O, Goodsite ME (2015) The political economy of climate adaptation Nat Clim Chang 5:616 doi:10.1038/nclimate2665
- Toole S, Klocker N, Head L (2016) Re-thinking climate change adaptation and capacities at the household scale Clim Change 135:203-209 doi:10.1007/s10584-015-1577-x
- Turner BL et al. (2003) A framework for vulnerability analysis in sustainability science Proceedings of the national academy of sciences 100:8074-8079
- UN-Habitat (2011) Global report on human settlements: cities and climate change. . London
- UN-Habitat (2016) World Cities Report, Urbanization and Development: Emerging Futures. Nairobi, Kenya
- UN (2017) World Economic Situation and Prospects 2017. New York
- Ürge-Vorsatz D et al. (2018) Locking in positive climate responses in cities Nat Clim Chang 8:174-177 doi:10.1038/s41558-018-0100-6
- Wamsler C, Brink E (2014) Moving beyond short-term coping and adaptation Environ Urban 26:86-111 doi:10.1177/0956247813516061
- Wamsler C, Brink E, Rentala O (2012) Climate Change, Adaptation, and Formal Education: the Role of Schooling for Increasing Societies' Adaptive Capacities in El Salvador and Brazil Ecol Soc 17:19 doi:10.5751/es-04645-170202

- Wamsler C, Lawson N (2012) Complementing institutional with localised strategies for climate change adaptation: a South-North comparison Disasters 36:28-53 doi:10.1111/j.1467-7717.2011.01248.x
- Waters J, Adger WN (2017) Spatial, network and temporal dimensions of the determinants of adaptive capacity in poor urban areas Glob Environ Change-Human Policy Dimens 46:42-49 doi:10.1016/j.gloenvcha.2017.06.011
- Wilhelmi OV, Hayden MH (2010) Connecting people and place: a new framework for reducing urban vulnerability to extreme heat Environ Res Lett 5:7 doi:10.1088/1748-9326/5/1/014021
- Yohe G, Tol RS (2002) Indicators for social and economic coping capacity—moving toward a working definition of adaptive capacity Global Environmental Change 12:25-40
- Ziervogel G, Cowen A, Ziniades J (2016) Moving from Adaptive to Transformative Capacity: Building Foundations for Inclusive, Thriving, and Regenerative Urban Settlements Sustainability 8:20 doi:10.3390/su8090955
- Ziervogel G, Shale M, Du ML (2010) Climate change adaptation in a developing country context: The case of urban water supply in Cape Town Clim Dev 2:94-110 doi:10.3763/cdev.2010.0036