

Barriers and opportunities for urban adaptation planning: analytical framework and evidence from cities in Latin America and Germany

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Abstract This paper analyzes barriers and opportunities for effective adaptation planning in cities. In particular, we focus on the preparation and adoption of adaptation strategies and action plans by urban planners. For this purpose, we develop a two-tier framework of variables influencing decision-making. The framework emphasizes interaction between different commonly discussed categories of barriers (or opportunities) and their sources. We argue that whether or not urban planners take action to foster adaptation to climate change depends on three first-tier variables: information, resources, and incentives. In addition, we point out that each of these variables may itself be a function of a set of underlying second-tier variables, including actor-specific characteristics of the decision-maker, the institutional environment, and the natural and socio-economic environment. Within this framework, we specify barriers and opportunities for effective adaptation planning as hampering or promoting characteristics of these first- and second-tier variables. We apply and test the framework within the context of four case studies carried out in Lima (Peru), Santiago (Chile), Berlin and Sangerhausen (both Germany). We present anecdotal evidence, which we have gained from expert interviews in the cities. Our results indicate that the relevant categories of barriers are mainly the same across developing and developed countries. What differs is their severity. Moreover, we confirm the importance of the institutional context, including barriers and opportunities associated mainstreaming adaptation, multi-level governance and participation. Finally, our analysis reveals barriers that are specific for local or urban adaptation action, such as the strong dependency on the national regulatory framework.

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1 Introduction

It is widely acknowledged that despite efforts to reduce greenhouse gas emissions anthropogenic climate change is going to occur (Solomon et al. 2007). Impacts of climate change are likely to be particularly severe in urban areas (ICLEI 2011). This is primarily due to the high density of population and infrastructure investments and the concentration of administrative, economic and social functions. Impacts are aggravated by urban-specific land use characteristics, such as a high degree of surface sealing, which may impair rainwater drainage (Müller 2012) and reinforce the urban heat island effect (Magee et al. 1999; Romero and Molina 2008). Moreover, cities are strongly dependent on their hinterland, e.g., for food and water supply, and therefore vulnerable to climate change impacts occurring there (McEvoy et al. 2010; Hunt and Watkiss 2011).

These challenges imply an urgent need for cities to take adaptation actions. Adaptation is commonly defined as “[a]djustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities” (Parry et al. 2007, p. 869). The main objective of adaptation policies is to “reduce the vulnerability of human and natural systems to a shift in climate regime” (Fankhauser 2009, p. 5).

Despite the urgency to adapt, climate-related strategies and actions at the urban level are still in their infancy. They have primarily been implemented in a limited number of pioneer cities (London Climate Partnership 2006; Mukheibir and Ziervogel 2006; Penney and Wieditz 2007; Revi 2008; Carmin et al. 2009; Annals of the New York Academy of Sciences 2010; Hardoy and Romero Lankao 2011; Heinrichs et al. 2011; Hunt and Watkiss 2011). Moreover, most of these strategies focus on mitigation – i.e. on measures to reduce greenhouse gas emissions – rather than adaptation (Betsill and Bulkeley 2007; Bulkeley et al. 2011).

Therefore, this paper aims to contribute to the understanding of factors influencing decision-making on urban adaptation: What are relevant barriers to effective adaptation action in cities – and what are possible opportunities for progress? Our analysis addresses planned adaptation which is carried out by local municipalities. Planned adaptation is understood as “the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state” (Parry et al. 2007, p. 869). In particular, we focus on the planning process for planned adaptation, i.e. the preparation and adoption of adaptation strategies and action plans by urban planners. This is what we refer to as “adaptation planning” throughout our paper. Addressing adaptation planning in cities is particularly important as many basic services which may be affected by climate change – such as water supply or the provision of green spaces – are managed by public administrations. Moreover, adaptation actions undertaken by companies and individuals (“autonomous adaptation”) are often insufficient for a variety of reasons and require government intervention (Osberghaus et al. 2010; Heuson et al. 2012; Eisenack 2013).

To understand barriers and opportunities for adaptation planning in cities, we develop an analytical framework. We argue that whether or not a municipal decision-maker takes action depends on three first-tier variables: 1) her information about the decision-making problem, 2) her available resources, and 3) her incentives to act. In addition, we point out that each of these variables may itself be a function of a set of underlying second-tier variables, including 1) actor-specific characteristics of the decision-maker, 2) the institutional environment, and

3) the natural and socio-economic environment. Within this framework, we specify barriers and opportunities for effective adaptation planning as hampering or promoting characteristics of these variables.¹ We apply the framework to understand and organize existing barriers and opportunities for adaptation planning in four selected cities: Berlin and Sangerhausen in Germany, Santiago de Chile and Lima in Peru. The heterogeneity of the case study cities (e.g., in terms of size, economic development, and progress in adaptation planning) allows to test the suitability of the framework. Moreover, the empirical discussion is also meant to provide anecdotal evidence on barriers and opportunities in an analytical manner.

Our paper adds to a growing debate on barriers to adaptation. One avenue of this debate addresses possible typologies and frameworks to disentangle different types of barriers. Typically, one-dimensional lists of (categories of) barriers are proposed (see Section 2 for an overview). We go beyond these existing typologies by emphasizing the interactions between barriers (and opportunities) within our two-tier framework. Thereby, we mean to explore not only what types of barriers exist but also what their sources are. A second contribution made by our paper is the provision of empirical evidence on the existence and relevance of different types of barriers on the local level. There is certainly a significant amount of case studies on barriers to adaptation (see, e.g., Næss et al. 2005; Arnell and Delaney 2006; Berkhout et al. 2006; Koch et al. 2007; Inderberg 2011; Eisenack and Stecker 2012). However, only some of them address the level of local decision-makers (Crabbé and Robin 2006; Amundsen et al. 2010; Burch 2010a, b; Measham et al. 2011; Runhaar et al. 2012) and the focus is primarily on adaptation in industrialized countries. A discussion of barriers across contexts is absent (Biesbroek et al. 2013). Here, we offer a discussion and comparison of adaptation planning in municipalities in developing and developed countries within a unifying framework.

2 Analytical framework

There is a multitude of studies which propose one-dimensional lists of (categories of) barriers, or factors which may turn out to be barriers or opportunities (Füssel 2007; Reid et al. 2007; Storbjörk 2007; Adger et al. 2009; Goulden et al. 2009; West et al. 2009; Burch 2010a, b; Ford et al. 2010; Jantasami et al. 2010; Biesbroek et al. 2011; Corfee-Morlot et al. 2011; Falaleeva et al. 2011; Lebel et al. 2011; Measham et al. 2011; Runhaar et al. 2012). One of the most prominent examples is the categorization provided by the United Nations Intergovernmental Panel on Climate Change (IPCC), which distinguishes between physical and ecological limits, technological limits, financial barriers, informational and cognitive barriers, and social and cultural barriers (Adger et al. 2007). The types of barriers and opportunities identified in these studies are often the result of more or less arbitrary clustering attempts. Many of the categories overlap. Consequently, some of the authors point out that barriers are often strongly interrelated (Burch 2010a, p. 7581; Corfee-Morlot et al. 2011, p. 178; Runhaar et al. 2012, p. 780). The most important shortcomings of these contributions are, however, that they (1) are not explicit or systematic about how interactions between barriers can be characterized, and (2) do not examine the roots of barriers. As

¹ We apply a relatively broad concept of “barriers”, which may be both insurmountable (often called “limits”) or mutable (often referred to as “barriers” in the narrower sense) (Adger et al. 2007, 2009).

Biesbroek et al. (2013) put it, these studies primarily focus on “asking the questions ‘if’ and ‘which’ barriers exist” rather than to “begin asking ‘how’ and ‘why’ barriers emerge”.

Here we propose a framework which addresses the latter type of questions. For this purpose we build on some of those few studies which have already undertaken efforts to analyze barrier interactions and roots. First of all, the framework rests on Eisenack and Stecker’s (2012) approach to frame adaptations as actions.² They define actions as purposeful activities (in our case, the preparation and adoption of adaptation strategies and action plans) of an operator (in our case, planners at the level of local municipalities) towards the specific end of mitigating the impacts from climate change. Actions require the use of resources as means to reach the intended end. Based on this conceptualization, Eisenack and Stecker distinguish four possible types of barriers to action:

- missing operator, e.g. because actors are ignorant of climate change impacts,
- missing means, when a potential operator lacks sufficient resources to act,
- unemployed means, when a potential operator does not make use of available means, primarily due to adverse incentives, and
- complex actor relations, where the multitude of actors to be coordinated impairs decision-making.

For our analysis, we relabel the first three categories as information, resources and incentives. We prefer these more “neutral” categories because we are interested in highlighting variables which may generate not only barriers but also opportunities for action. These (sets of) variables which form the first tier of our framework are illustrated in Table 1. We do not consider the complexity of actor relations as a relevant category for this tier because it may eventually be one explanation for the lack of means (see further below), as Eisenack and Stecker (2012, p. 252) state themselves.

We go beyond Eisenack and Stecker’s framework by adding a second tier of underlying variables which may help to explain why certain barriers or opportunities arise. For this purpose, we make reference to Moser and Ekstrom’s (2010) concept of “structural elements of adaptation”.³ They highlight three core elements, which may help to explain why barriers emerge in the adaptation process:

- the actors, in particular their individual characteristics,
- the larger context in which actors act, including the governance system and the larger human and biophysical environment, and
- the system of concern upon which actors act (the coupled human-natural system that has to be managed).

To emphasize the actor-perspective of our framework, and to make it more tangible, we prefer to slightly reorganize and rename these variables as follows:

- actor-specific characteristics (this category corresponds to Moser and Ekstrom’s category actors but we find our label a bit more specific),
- the institutional environment, i.e. the formal and informal rules guiding interactions between actors (this category corresponds to Moser and Ekstrom’s governance system, which forms one part of the context),

² An alternative approach to framing barriers may be based on understanding adaptation as a process (see, for example, Arnell and Delaney 2006; Berkhout et al. 2006; Moser and Ekstrom 2010).

³ A quite similar distinction is made by Reser and Swim (2011).

Table 1 First-tier sets of variables and examples

Information	Resources	Incentives
• On climate stimulus	• Financial means	• Balance of costs and benefits of adaptation
• On impacts of climate change	• Personnel	• Co-costs/-benefits with other objectives of action
• On available adaptation options	• Staff expertise	• Positive/negative externalities of action
• On costs and benefits of adaptation options	• Time	

- the natural and socio-economic environment, i.e. the non-institutional context into which actors and institutions are embedded and upon which they act (this variable merges Moser and Ekstrom's human and biophysical environment and the system of concern).

Table 2 provides examples for each set of variables.

Figure 1 depicts our framework as a whole. It illustrates once more the core message of our paper: It is not only that the adoption of adaptation strategies and action plans by local municipalities is contingent on certain variables which may turn out to be barriers or opportunities for action. These variables are themselves dependent on underlying factors. For example, we argue that a lack of information (first-tier variable) on the impacts of climate change can be primarily attributed to the characteristics of one or more of the second-tier variables: (1) actor-specific characteristics (e.g., the perceptions and mental models of the decision-makers), (2) the institutions (e.g., inappropriate arrangements for information exchange and resource allocation), and/or (3) natural and socioeconomic conditions (e.g., the complexity of the ecological system).

We do not claim that this framework reflects all interdependencies between barriers and opportunities. Interactions may also arise within each tier. For example, information is a prerequisite for proper incentives. Similarly, actors' preferences surely are also shaped by the governance system over time. But we would argue that our framework indeed highlights important types of interactions and dependencies between barriers – and therefore is a step towards understanding “how” and “why” barriers and opportunities emerge. It is also important to emphasize that our framework is meant to be of descriptive rather than normative character: We use it to identify possible barriers and opportunities but we are not arguing that overcoming these barriers necessarily leads to the desired levels of urban adaptation planning (see also Moser and Ekstrom 2010, p. 22027).

Table 2 Second-tier sets of variables and examples

Actor-specific characteristics	Institutional environment	Natural and socio-economic environment
• Perceptions	• Formal and informal institutions, specifying e.g. multi-level governance, mainstreaming of adaptation, participation and organizational routines	• Intensity, velocity, spatial and temporal scale of impacts of climate change
• Preferences		• Certainty regarding these patterns
• Experiences		• Number of actors affected
• Knowledge		• Level of economic development
• Leadership		• Demographic patterns

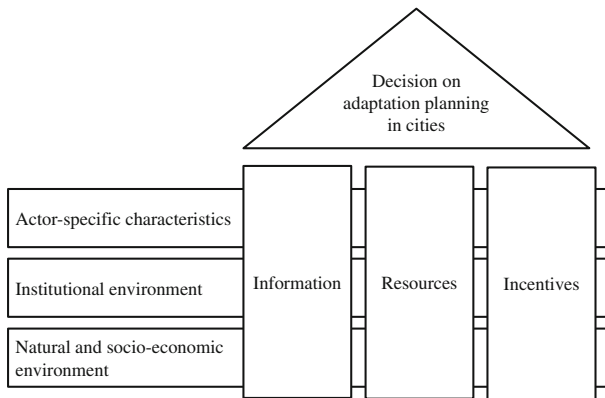


Fig. 1 Variables influencing decisions on adaptation planning in cities

3 Description of empirical case studies

3.1 Empirical approach

We have carried out case studies in Lima (Peru), Santiago de Chile (Chile), Berlin and Sangerhausen (both Germany) to test our analytical framework and to gather evidence of barriers and opportunities for adaptation planning to climate change at the local level. Table 3 provides a brief overview of the main characteristics of these cities. We have selected these cities because three of them are the political, economic and functional centers of their countries. Sangerhausen has been included in the comparison due to the fact that it is a German model city for urban adaptation to climate change. More importantly, the cities have been chosen for their heterogeneity in terms of size and population dynamics, development status (we include cities from a developing, an emerging and an industrialized economy) and progress in adaptation planning (see Section 3.2). By comparing cities with quite heterogeneous characteristics, we expect to learn more about the suitability of our framework. Moreover, this approach allows us to discuss barriers and opportunities for adaptation planning across different contexts.

In order to explore the barriers and opportunities for adaptation planning in the selected cities, we conducted expert interviews with representatives from the fields of administration, politics, science and non-governmental organizations (NGOs) (see Table 4, the index allows assigning statements presented in Section 4 to the corresponding interviews). In our case, experts are decision-makers in the field of planned climate adaptation. Interviewees were selected either because they were directly involved in the development of adaptation activities in the city, or because they were named by interviewees as experts (snowball system). To guarantee that the institutional context is shared and the case studies can be compared, selected experts had to work in similar departments or agencies (Urban Planning Agency) across the cities and be in responsible positions (e.g. head of department or project manager) (Meuser and Nagel 2005, p. 81). In total, we conducted 34 interviews with an average length of one hour.

The interviews were semi-structured and followed a uniform guideline for all case study cities. The guideline was structured roughly along the first-tier variables of the framework: information, incentives and resources (see Table 5). In each section, we asked four to five open questions to leave space for additional issues brought up by the interviewees.

Table 3 Characteristics of the case study cities

	Lima	Santiago	Berlin	Sangerhausen
Inhabitants	8.5 Million ^a	5.4 Million ^a	3.5 Million ^b	29,679 ^c
Population dynamics	Fast growing ^a	Growing ^a	Stable ^b	Shrinking ^c
Area	2,794 km ² ^a	840 km ² ^a	892 km ² ^b	0.21 km ² ^c
GDP/capita (in US\$, ppp)	7,899 (2005) ^a	16,826 (2008) ^a	35,052 (2010) ^d	23,884 (2010) ^e
Status of adaptation planning	Preparation of strategy completed, adoption pending (start of preparation in 2011)	Preparation of strategy advanced (start in 2010)	Strategy adopted (start of preparation in 2008)	Preparation of strategy completed, adoption pending (start of preparation in 2010)

^a (Rehner et al. 2010)^b (Amt für Statistik Berlin-Brandenburg 2011)^c (Statistisches Landesamt Sachsen-Anhalt 2010)^d (Eurostat 2010)^e (Landkreis Mansfeld-Südharz 2011)

Table 4 Overview of interviews

City	Interviewee	Index	Date
Lima	Employee of a Ministry	L01	19 October 2011
	Employee of a Ministry	L02	19 October 2011
	Employee of a Ministry	L03	20 October 2011
	Employee of a Ministry	L04	20 October 2011
	Employee of a Ministry	L05	20 October 2011
	Employee of the Administration	L06	20 October 2011
	Scientist	L07	24 October 2011
	Scientist	L08	21 October 2011
	Member of an NGO	L09	17 October 2011
	Member of an NGO	L10	21 October 2011
	Member of an international NGO	L11	24 October 2011
Santiago	Employee of a Ministry	S01	18 January 2012
	Employee of a Ministry	S02	24 January 2012
	Employee of a Ministry	S03	27 January 2012
	Employee of a Ministry	S04	27 January 2012
	Employee of the Administration	S05	23 January 2012
	Scientist	S06	18 January 2012
	Member of an NGO	S07	24 January 2012
Berlin	Employee of the Administration	B01	25 January 2012
	Employee of the Administration	B02	3 February 2012
	Employee of the Administration	B03	3 February 2012
	Employee of the Administration	B04	23 February 2012
	Employee of the Administration	B05	24 February 2012
Sangerhausen	Employee of the Administration	SGH01	20 April 2011
	Employee of the Administration	SGH02	20 April 2011
	Employee of the Administration	SGH03	26 April 2011
	Employee of the Administration	SGH04	26 April 2011
	Employee of the Administration	SGH05	26 April 2011
	Employee of the Administration	SGH06	12 May 2011
	Employee of a Ministry	SGH07	12 May 2011
	Employee of a Ministry	SGH08	12 May 2011
	Employee of a Ministry	SGH09	12 May 2011
	Employee of a Ministry	SGH10	12 May 2011
	Employee of a Ministry	SGH11	12 May 2011

Information on actor-specific characteristics, institutional and natural and socio-economic environment was covered indirectly by the questions. In addition, we carried out a document analysis.

For the data analysis we employed the analytical framework outlined above. First, all interviews were transcribed. Then we clustered statements made in the interviews according to the variables in the framework. These larger text segments were reduced by paraphrasing the content and then generalizing the paraphrases for the formulation of abstract categories. In comparing the categories of different actors within one case study, we formulated case-

Table 5 Interview guideline

Information

- 1.1 Which impacts will climate change have on your city? Who has access to the information on local climate change impacts and its consequences?
- 1.2 Which information do you think is necessary for political decision making? What are main barriers to the lack of information? Which national, regional or local instruments of climate adaptation strategies do you know?
- 1.3 Which (short and long term) adaptation measures do you think are important?
- 1.4 Which activities are currently being implemented in the field of climate adaptation? Which ones are planned? If none – what are the main barriers?
- 1.5 Did you accomplish a cost-benefit analysis for adaptation measures in your city?

Resources

- 2.1 What priorities do you have in municipal budgeting? What specific budgets do you have for each urban development goal? What budget do you have in your city for adaptation measures? Is the budget expected to increase in the next five years? How much is it compared to the total budget?
- 2.2 Is there a special funding for adaptation measures? Do you use international or national funding?
- 2.3 Which institution in your city is responsible for planning climate adaptation measures? Are there several institutions responsible? Who is coordinating adaptation measures, and how?
- 2.4 Which actors are involved in implementing adaptation measures? How do you judge the personnel resources available for climate adaptation in your city?

Incentives

- 3.1 Which urban development goals do you pursue by implementing or planning climate adaptation measures?
- 3.2 In your opinion, what are the most important political objectives? How important is climate change and its impacts in relation to these objectives?
- 3.3 Which goals hamper climate adaptation? Are there contradicting goals?
- 3.4 Which actors are substantially involved in the development of adaptation measures and objectives? Who is mainly pushing climate adaptation? – In which way?
- 3.5 Which risks of climate change are influencing the climate adaptation policy?

specific barriers and opportunities. Subsequently, we clustered and compared the results of the case studies to identify general barriers and opportunities for urban adaptation.

3.2 Status of adaptation planning by municipalities

Our empirical analysis aims at understanding to what extent the characteristics of the variables identified in the framework have hampered or promoted advances in adaptation planning. In particular, we focus on the preparation and adoption of local adaptation strategies and action plans by urban planners. The current status of these advances is briefly outlined in the following.

The preparatory process for Lima's adaptation strategy started in December 2011 after the regional government had established the Metropolitan Environmental Commission. This commission brings together representatives from regional, municipal and district governments as well as the business sector, academics and NGOs. Within the commission a technical working group on climate change was founded and put in charge for developing the adaptation strategy. Additional experts, e.g. from international research projects, the Ministry of the Environment and the United Nations Development Program were invited to participate in this working group. The elaboration of the strategy was eventually primarily based on contributions made by NGOs, international research projects and a Peruvian

scientific member of the IPCC. In addition, the Swiss Avina foundation provided funds for an external consultancy. The adaptation strategy was finalized in August 2012 and submitted to Lima's city council where its adoption is pending (MML 2012).

Since 2010, Santiago has been elaborating an adaptation plan that is scheduled to be terminated in 2012. Major actors are the Regional Government and the regional entity of the Ministry for Environment. Other actors involved in the planning process are the regional entities of the Ministry of Public Works, the Ministry of Housing and Urbanism and the Ministry of Health as well as the municipalities of the Metropolitan Region of Santiago. Representatives of the civil society and scientists participate in the process through round table meetings. However, the planning process for the adaptation plan in Santiago is strongly pushed by an international cooperation project. The adaptation plan is supposed to be part of Santiago's Regional Development Plan which will be adopted by the Regional Government.

In Berlin the key instrument for adaptation planning is the Urban Development Plan Climate, which was adopted by the Senate in 2010 and published in 2011. This strategic document draws on former activities concerning climate adaptation: In 2008 the Climate Protection Council, a group of 16 experts from climate science and energy industry, developed a questionnaire concerning Climate Adaptation in the Metropolitan Region Berlin – From Knowledge to Action. In response to this, the Senate Department for Health, Environment and Consumer Protection prepared a report on climate impacts for Berlin in 2009. This assessment was based on information concerning the city's sensitivity (e.g. concerning air pollution, bio-climate) documented in the city's "Environmental Atlas" since 1995. Additionally, the Senate Department of City Development developed an own model to analyze the city's bio-climate by combining projected future climate impacts on a micro-scale with health-related heat-island effects and published the maps in a report in 2010. The Urban Development Plan Climate eventually compiles this data depicting the city's vulnerable areas in 2050 concerning bio-climate (thermal stress), green and open spaces (organic carbon content), water quality and storm rainfall, and climate protection. It also provides an action plan with twelve adaptation projects that serve as good practice.

In Sangerhausen, as described for Santiago, a scientific (pilot) project facilitated the development of a local adaptation concept. The project, which was funded by the Ministry of the Environment of the State of Saxony-Anhalt, started in October 2010. The local adaptation concept and a manual on the development of local adaptation plans were published in November 2011. Actors from all relevant sectors and political and administrative levels participated in this process. Decision-makers from the state, the county and the municipal level, as well as stakeholders representing the water and the agricultural sector, forestry, different business associations, agricultural cooperatives, relevant companies and representatives of the public were involved through workshops and expert interviews. Information exchange was further promoted by a website used to communicate intermediate data. The final results regarding the changing (local) climate conditions, the vulnerability of particular sectors, existing adaptation options and tools for their prioritization were communicated in a specific and appropriate manner to the different focus groups. A follow-up project financed by the German Federal Environment Ministry, which aims to disseminate these results and promote further mainstreaming of adaptation planning has been started in the beginning of 2013.

4 Empirical results

In this section, the analytical framework developed in Section 2 is applied to present and organize the empirical results of our study. Thereby we mean to discuss and disentangle the

barriers and opportunities for adaptation planning in the four case study cities which have been reported in the expert interviews. This section is structured along the first-tier variables we identified: information, resources and incentives. For each of these variables, we discuss to what extent barriers and opportunities can be attributed to the underlying second-tier variables: actor-specific characteristics, the institutional environment and the natural and socio-economic environment. For each of the empirical findings introduced in the following we make reference to the corresponding expert interview (for the list of interviews see Table 4, codes are given in brackets).

4.1 Information

4.1.1 Actor-specific characteristics

Various actor-specific factors that negatively influence the level of information relevant for municipal decision-making have been identified. In Lima interviewees reported that due to the perception that major climate change impacts are only to be experienced in the distant future, citizens and administrative decision-makers often are not yet aware of the possible magnitude of climate change (L10, L03, L05) and the resulting need to react already in the short run in some sectors (L03, L05, L09, L10). In Santiago, experts stated similar perceptions being shared by political executives as well as urban and regional planners. Additionally, in Santiago climate change is regarded to be a topic rather belonging to the “realm of science” (S01, S05). As a consequence of this attitude, most of the political decision-makers at the national level would not be able to differentiate between the very distinct strategies to deal with the challenge of climate change, as for example mitigation, adaptation or climate system engineering (S07). Further downstream, on the local level, decision-makers as well as ordinary citizens often do not have access to information on climate change and its impacts (S01, S07). On the contrary, climate change has already been on the administrative and political agenda for many years in Berlin. In the beginning decision-makers primarily focused rather on mitigation than on adaptation activities. It is only within the last years that adaptation has gained importance at the expert and political level, inter alia due to the influence of the Stern Review report in 2006 and of the IPCC report in 2007 (B01). In retrospective, the personal contacts between the administrative staff and scientific institutions established over the years are seen as a major driver to enhance the availability of information and access to it (B05). Experiences in Sangerhausen send an ambiguous message: On the one hand, there is an increasing awareness of changing climatic conditions among the administrative staff due to the availability of information generated and distributed by initiatives on the State level. However, on the other hand, the lack of high-resolution data for the local level in combination with actor-specific characteristics, as for instance limited individual (processing) capabilities, hampers the consideration of adaptation issues on the local level. This becomes obvious, for example, when decision-makers confuse terms like weather and climate or mitigation and adaptation (SGH04, SGH11) – a phenomenon also repeatedly seen in the Latin American case studies.

An important determinant for the access to and use of information by municipal decision-makers is their personal interest and commitment. These are vital factors for acting proactively or establishing and maintaining personal contacts to other administrative or external experts. This becomes particularly apparent in the Lima case. After the change of government in 2011 many former environmental activists moved from NGOs into leading positions within ministries and public administrations on the municipal level. Due to their background, these actors seem to have strong preferences for environmental protection and

clearly push for action – despite existing information deficits and uncertainties (L09, L10). On the one hand, this environmental activism can be interpreted as an opportunity for adaptation action. On the other hand, ignoring uncertainties may also result in over- or maladaptation and constitute a barrier to attaining appropriate adaptation levels (L07).

4.1.2 Institutional environment

A main institutional barrier often referred to by interviewees in Lima is the lack of a coordinating organization and the low level of inter-organizational cooperation. Although several actors have access to relevant information, they do only collaborate on specific issues (L06). This may be considered a main reason why adaptation mainstreaming is lacking. In addition, more internal communication and a “common language” are essential prerequisites for the development of a general adaptation strategy (L06). Similarly, in Santiago interviewees regarded the non-existence of a coordinating organization which provides updated information on a regular basis as one of the principal barriers to adaptation (S02, S04, S05, S07). In contrast, in Berlin the task of moderating the adaptation process has been designated to the Division of Urban and Open Space Planning at the municipal Department for Urban Development and the Environment. One of its most relevant initiatives was the development of the “Urban Development Plan Climate” (B01). Additionally, the Geo-Information Unit is responsible for continuously updating the existing “Environmental Atlas” database. Despite these achievements, neither an institutionalization of a participatory process involving the general public nor a permanent dialogue between the different sectors has been established yet. This is a drawback of assigning this task to a single organization that selected relevant fields of action using a top-down-approach (B05). In Sangerhausen the development of the adaptation strategy for the city and the district followed a rather participatory approach. The fields of action have been identified in a bottom-up process. Information exchange and the dissemination of recommendations have been ensured through forums and working committees.

In the Latin American cities multi-level governance has remained inadequate especially with regard to the mechanisms to generate and distribute climate change-related data. In Lima, for instance, the national government is reluctant to invest in information generation and distribution to improve the existing data basis (L03, L07). In addition, key organizations are not involved in the few existing research projects as they do not collaborate officially. Thus, information exchange often depends on informal meetings (L08). In Santiago a science-policy dialogue has recently been started. However, the absence of a permanent platform for such an exchange is seen as an important barrier (S05). Moreover, due to the complexity of administrative channels, trickling down information is time consuming and not always guaranteed (S02). In contrast, in Berlin better access to scientific information can be attributed to the specific institutional setting. Urban planners have the opportunity to ask for tailor-made expertise for specific projects by consulting the Geo-Information Unit (B05). In addition, a network consisting of different administrative bodies and various scientific organizations has been established (B04). It has to be mentioned that due to the congruency of the Federal State and the City of Berlin the complexity of multi-level governance processes is substantially reduced. In Sangerhausen assessments of climate change related impacts have been conducted under the leadership of the State Ministry of the Environment. However, this positive stimulus from the State level stands in contrast to the existing intra-institutional barriers, namely insufficient systematic distribution of information within the administration (SGH01, SGH04).

A further concern of the interviewees in the Latin-American case studies is related to the lack of an institutional memory. This is due to the fact that a significant share of employees

in public administration is replaced in the course of the changes of government. Long-term planning can hardly be ensured under such circumstances as capacity needs to be rebuilt continuously (L05, S01, S04, S07). Therefore, information often has to be provided by external projects or NGOs (L11). Rotation of personnel and institutional memory were not addressed in the interviews in the German cities.

In our view, it is important to emphasize that many of the barriers mentioned in this Section on institutional aspects are strongly linked to the availability of resources (see Section 4.2). In the interviews we noticed, for instance, a very close connection between information deficits and a lack of personnel, finances and time.

4.1.3 *Natural and socio-economic environment*

In most of the cities under examination scientific information about future climate conditions is not available or characterized by high uncertainty at the local level. This observation is due to the general lack of knowledge in climate modeling and downscaling of global climate models. This lack can first of all be attributed to the complexity of the natural environment. In addition, the development status of the countries is a relevant factor in this context as far as scientific capacities are concerned. This may explain why access to information is especially a problem in developing and emerging economies, i.e. in Lima and Santiago. In Santiago, for example, experts point out that it is hard to develop an adaptation plan based on the existing assessments of local climate change impacts and that further downscaling of the projection data available at the regional level is needed (S04, S07). The lack of high resolution projection data is a major concern in Lima as well. Here the unpredictable development of the El Niño/Southern Oscillation (ENSO) phenomenon is regarded to be an additional challenge for the assessment of local climate change impacts (L07). Therefore, information on climate impacts is been seen as diffuse, disperse or simply not available, constituting a major barrier to elaborating a local adaptation plan (L06).

In contrast to the situation in both South American cities, the availability of information on changing climate conditions in Berlin and Sangerhausen is comparatively good – as more scientific input is available and local climate changes are predictable with higher degrees of probability. In Berlin, for example, the “Environmental Atlas” including data on urban climate conditions has been published and regularly updated since 1995. Furthermore, in 2009 an integrated urban climate model was developed to improve the knowledge about the future development of climate-related vulnerabilities, such as heat stress. However, according to an employee of the public administration, available projection data can only be used to a limited extent for hydrological modeling due to methodological challenges (B03). Hence, the infancy of modeling hydrological cycles at global and regional level constitutes a major barrier for further adaptation planning in Berlin.

The same barrier is been identified in Sangerhausen. Although the city administration benefits from projections of the most relevant climatic parameters and sectoral vulnerability assessments commissioned by the State Ministry of the Environment, even decision-makers on the state level consider the information available at this stage of vulnerability assessments and regional downscaling of projection data to be of limited use to assess impacts of climate change and corresponding vulnerabilities on the local level. Moreover, information on sector specific impacts and extreme events is still incomplete and only recently subject of further studies (SGH07).

Due to information barriers associated with limited knowledge on climate change and impacts at the local level, information on the economic consequences of climate change is also hardly available up to now. With the exception of Sangerhausen, in none of the cities either economic evaluations of expected climate change impact or cost-benefit-analyses to

evaluate and prioritize potential adaptation options have been applied. In Sangerhausen economic expertise has been involved in the development of the local adaptation concept. A methodological guideline for economic evaluation of adaptation measures has been developed and validated through in-depth case studies. The rationale behind this guideline is to empower decision-makers in the city administration to systematically assess positive and negative effects of adaptation measures without external support (SGH02, SGH05, SGH06).

In summary, natural conditions (highly complex climate change and climate change impacts) and socioeconomic factors (especially the development status and therewith research capacities) may explain the lack of information which has constrained adaptation planning in the cities under examination.

4.2 Resources

4.2.1 Actor-specific characteristics

For none of the cities under examination actor-specific characteristics have been reported to restrict the availability of resources.

4.2.2 Institutions

In general, the low degree of mainstreaming urban climate adaptation appears to be a major factor restricting the availability of resources for adaptation activities in Lima, Santiago and Sangerhausen. In Santiago, for example, there is no title for mitigation- or adaptation-related activities in the general budget of the national and local governments (S05, S06). As mentioned before, the situation in Berlin is slightly different. Here the institutional embeddedness of adaptation facilitates the provision of financial resources, e.g. for climate change-related analyses which have been used to develop an urban development strategy. As a consequence of the adaptation funds available, a comparatively high amount of personnel resources can be employed for support climate adaptation at the municipal level.

Effective mainstreaming of adaption is hindered by a lack of appropriate coordination across sectors (e.g., S02, S04, S05, S07, L08). Even where a coordinating organization has been established, challenges remain. In Lima several municipal and regional departments have been merged to a new environmental department, inter alia, to guide adaptation action at the local level (L06). However, the fact that the environment department is in charge implies that adaption planning is still framed and perceived as a primarily environmental issue and consequently received only little political backing (L03, L06). Even in Berlin, where coordination has been assigned to the Department of Urban Development and Environment, the coordination and involvement of a multitude of different sectors and interests is still regarded very challenging (B05).

Participation has been found to be helpful to reduce the cost of adaptation planning. Examples include the integration of scientists (disposing of own international funds) in Lima (L08) and the engagement of private investors in climate sensitive restructuring projects in Berlin (B04).

Several issues associated with multi-level governance aggravate the lack of resources. Financial constraints in Santiago's public administration can be attributed to the national government's market-oriented economic policy approach, which is characterized by low levels of public spending and by minimized regulatory market policies (S01, S02, S07). Furthermore, the fiscal federalism is poorly developed in Chile. As a consequence, even the fulfillment of essential administrative responsibilities depends on transfers from the

Common Municipal Fund (S05, S06, S07). In addition, the overlap of and the competition between numerous administrative levels make adaptation planning in Lima and Santiago particularly resource-consuming as significant financial and human resources have to be invested in coordinating the activities of the different actors (L05, L08, L10, L11, S02, S07). In contrast, adaptation action in Sangerhausen has clearly benefited from funds and support provided by state and federal organizations. In particular, Ministry of the Environment of the State of Saxony-Anhalt has strongly promoted pilot projects related to adaptation.

4.2.3 Natural and socio-economic environment

The lack of various types of resources (e.g. personal, financial) can be attributed more broadly to the general characteristics of the socio-economic environment, such as the patterns of economic development and growth, which are decisive for the availability of public funds. It has been pointed out for Sangerhausen, for example, that budget constraints are an outcome of austerity policies pursued at different political and spatial levels. However, even though financing proactive adaptation measures in general has become more complicated since the 1990s, there are examples of reactive adaptation processes for which additional resources have been provided by the State government. Such cases include adaptation actions aiming at diminishing repeated damages resulting from extreme weather events which are expected to occur more often under the conditions of climate change (SGH01, SGH02, SGH04, SGH07).

In addition, the characteristics of the socio-economic environment have a strong impact on the relative importance of adaptation needs as compared to other societal and political objectives – which in turn determines the allocation of a scarce public budget to different fields of action. In this respect, the availability of resources is strongly linked to the overall incentives for action (see Section 4.3). In Peru poverty reduction and adaptation processes in rural areas, rather than in cities, are national priorities (L03, L06, L07, L10). Therefore, hardly any national funds are available for adaptation on the municipal level. Financial support is primarily provided by international donor organizations which set up pilot research projects in Peru (L06, L09, L10). The low importance of environmental issues as a whole at the local level in Lima is illustrated by the fact that the environmental department's financial resources account for only 3 % of the municipal budget (L06). In Santiago scarce public resources are primarily used to promote activities in export-oriented sectors like fishery or agriculture, rather than used for urban adaptation (S07). In Sangerhausen the overwhelming importance of promoting job creation in an economically underdeveloped region has a negative influence on the availability of financial resources for adaptation activities at the municipal level. However, few examples show that adaptation needs are considered in the context of ongoing planning processes, even though this consideration results in noticeable investment cost increases. Despite the high level of activities concerning climate adaptation in Berlin, the importance of this policy field is also still relatively small compared to hard policy issues like economic development.

4.3 Incentives

4.3.1 Actor-specific characteristics

The individual attitudes of decision-makers are emphasized as important determinants of adaptation planning in all cities. In Chile representatives from different administrative levels attribute insufficient initiative by important policy-makers, inter alia, to a

lacking willingness to take responsibility and make political commitments (S01, S04, S05). For Sangerhausen an employee of a State ministry asserts that many local decision-makers are not yet aware of scientific insights on anthropogenic climate change and its impacts which are already available (SGH08). In contrast, actor-specific characteristics have been a driver of adaptation planning in Lima. Actors in charge of developing the local climate strategy and action plan have a background in environmental NGOs and a strong preference for environmental issues in general (L06, L08, L10). In Berlin the congruence of personal perspectives and beliefs of key actors involved in urban planning with the needs of climate change adaptation has been pointed out as a major factor promoting adaptation activities (B01).

4.3.2 *Institutional environment*

In a multi-level decision-making context, an important institutional barrier is the lacking mandate for adaptation planning assigned by the national authorities to the municipalities. In Chile no legal norms and political instruments have been adopted to guide local policy-makers in the field of adaptation (S01, S04, S07). An employee of a ministry attributes this to Chile's neoliberal governance approach which prefers market-based solutions over state intervention (S02). Likewise, it is emphasized by experts in Sangerhausen that legally binding regulations for adaptation planning are still in their infancy (SGH04, SGH07, SGH08) and responsibilities are yet to be assigned explicitly to different organizations (SGH01, SGH10). Institutionalizing adaptation more formally would not only establish incentives to act but moreover send a signal that adaptation is a national priority (SGH03, SGH10). Initial steps taken in Germany are the inclusion of adaptation concerns in the Federal Building Code and the Water Framework Directive (B02, B03). However, the diffusion and enforcement of these norms is still pending (SGH04). A notable exception in terms of national guidance is Peru where a national law requires regional authorities to adopt an adaptation strategy and action plan (L09, L10).

The lacking coordination between urban and rural administrations as well as among the regions is raised as a specific issue of multi-level governance in Peru and Chile (L08, S02, S07). This deficit hampers the implementation of adaptation measures across administrative borders. This may be particularly detrimental for large-scale challenges associated with climate change, such as impacts on water supply.

What has been a driver for adaptation-related decision-making is the fact that many international programs which grant financial support have been linked to climate issues and made contingent on the adoption of local climate policies. In Peru, for instance, this refers to funds provided by development cooperation (L09). In Germany, this is especially true for many EU programs (B02, B04).

A final set of barriers reported is linked to the institutional arrangements within local administrations. In Lima and Santiago experts from national ministries and NGOs complain about long-lived bureaucratic routines that hinder the integration of a new political issue such as adaptation (L09, S01, S02). Employees often refuse to carry additional responsibilities and work load resulting from the consideration of adaptation aspects. This effect is aggravated when employees have tenure and salaries do not include result-oriented components, as is argued in Lima (L06, L10). More generally, ministry employees in Chile and Saxony-Anhalt argue that lengthy administrative procedures for the approval of adaptation measures may distract political decision-makers (S02, SGH03, SGH10). In fact, we presume that many of these administrative barriers are associated with a lack of mainstreaming adaptation on the local level.

4.3.3 Natural and socio-economic environment

It has been reported for all cities that the very characteristics of the climate system may impair the incentives for adaptation planning. On the one hand, the expected negative impacts of climate change, i.e. the possible benefits from adaptation, may in fact be limited – as has been pointed out particularly for Berlin (B05). On the other hand, the observability of (potentially significant) impacts may be hampered for a variety of reasons. First, the system's complexity results in a lack of understanding and significant uncertainty regarding adaptation benefits in all cities (see Section 4.1). Second, many impacts cannot be observed on a continuous basis but primarily when extreme events occur. In Lima, a primary driver of action is the existence of the ENSO phenomenon which appears every 5 to 10 years (L07). Similarly, representatives of Sangerhausen's administration argue that awareness is correlated with seasonal weather trends, as these are understood by many people as indications of climate change (SGH03, SGH07). Third, many impacts occur in the future, i.e. benefits of adaptation materialize only in the long run. This is particularly problematic in the light of counter-supportive institutional framework conditions, such as short-term political cycles, that are mentioned for Lima (L08, L10), or short-term planning horizons of administrations, which are pointed out for Sangerhausen (SGH08).

In addition, the characteristics of the socio-economic environment usually imply that adaptation competes with other urgent societal and political objectives. Consequently, adaptation measures are less likely to be taken if there are no co-benefits. This issue is particularly raised by a variety of experts from Lima and Santiago (L08, L09, L10, L11, S01, S02, S06, S07). In Lima, for example, potential solutions of the most dominant concerns, public safety and traffic congestion, provide few co-benefits in terms of adaptation. In turn, the existence of co-benefits was an important driver for measures taken in Berlin, where many elements of the city's climate action plan had in fact already been in place before its adoption, e.g. to address demographic change (B01, B05), or are no-regret options which produce multiple benefits (B01, B02, B04).

5 Discussion of the empirical results

Table 6 provides an overview of the empirical results. Certainly, our empirical findings are not representative but rather of anecdotal character. Nevertheless, there are several overarching findings we consider worth highlighting.

First, with regard to the differences between industrialized countries and developing and emerging economies, our analysis suggests that the relevance or importance of the variables influencing the progress in municipal adaptation planning is rather insensitive to the level of economic development. The major differences can be rather explained by the varying *characteristics* of these variables across the cities analyzed. For example, the availability of resources and institutional capacity are decisive in both developed and developing countries. However, the lack of resources and the insufficiency of institutions are typically more severe in less-developed countries. Our empirical results would therefore support Biesbroek et al.'s (2013) statement that barriers may be shared across contexts, at least at aggregate levels.

Second, our study has confirmed the importance of several institutional factors which are discussed in the literature. These aspects are particularly relevant as they typically constitute the starting point for policy recommendations.

- Mainstreaming of adaptation is an important challenge in all cities. Many interviewees confirmed that adaptation planning is not primarily an environmental issue and should

Table 6 Overview of empirical results

	Information	Resources	Incentives
Actor-specific characteristics	<p>Barriers</p> <ul style="list-style-type: none"> • Lack of individual awareness (L,SGH) • High individual awareness (L,B,SGH), e.g. due to personal contact to scientists (B) or NGO background (L) <p>Opportunities</p> <ul style="list-style-type: none"> • Lack of institutionalized information exchange at the city level (L,S) • Lack of guidance from national organizations (L,S) • Lack of institutional memory (L,S) 	<ul style="list-style-type: none"> • Market-oriented national governance approach (S) • Poorly developed fiscal federalism (S) • Overlapping and competing competencies of different governance levels (L,S) • Insufficient institutional embeddedness of adaptation needs (L,S,SGH) • Coordination by environmental department (L) 	<ul style="list-style-type: none"> • Insufficient willingness to take responsibility (S) • High personal priority of adaptation (L,B), e.g. due to NGO background (L) • Market-oriented national governance approach (S) • Overall lacking political mandate for adaptation assigned by higher administrative levels (S,SGH) • Insufficient diffusion and enforcement of adaptation-oriented norms (SGH) • Lacking coordination between urban and rural areas (L,S) • Organizational routines within administration (L,S,SGH)
Institutional environment	<p>Opportunities</p> <ul style="list-style-type: none"> • Departments and committees dedicated to information exchange at the city level (B,SGH) • Information provision by State authorities (B,SGH) 	<ul style="list-style-type: none"> • Well-renown coordinating unit established (B) • Financial support from development cooperation (L) and European funds (B) • Participation of science (L) and business sectors (B) • General budget constraints (L,S,B,SGH) 	<ul style="list-style-type: none"> • Initial steps to require adaptation legally, e.g. national law on climate strategies (L) and German Building Code (B,S,SGH) • Financial assistance programs contingent on adoption of climate policies (L,S,B,SGH)
Natural and socio-economic environment	<p>Barriers</p> <ul style="list-style-type: none"> • Complexity of the climate system (L,S,B,SGH) <p>Opportunities</p>	<ul style="list-style-type: none"> • High priority of other public concerns (L,S,SGH) 	<ul style="list-style-type: none"> • Irregular observability of climate impacts (L,S,SGH) • Time scales of impacts (L,SGH) • High priority of other public concerns (L,S) • Co-benefits with other public concerns (B)

The acronyms provided in brackets (*L* Lima, *S* Santiago, *B* Berlin, *SGH* Sangerhausen) specify for which city a specific barrier or opportunity was mentioned by one or more of the interviewed experts

Blank boxes only illustrate that no specific barriers or opportunities were identified in the interviews. This does not imply the absence of any such barrier or opportunity in the case study cities

be embedded into existing sectoral procedures, just as pointed out in the literature (Füssel and Klein 2004; Füssel 2007; Adger et al. 2009; Measham et al. 2011; UNDP/UNEP 2011). However, it was also frequently argued that mainstreaming is not yet sufficiently taking place. In addition, cross-sectoral coordination, which is usually understood as a prerequisite for effective mainstreaming (Hunt and Watkiss 2011), remains deficient. In this context, the Lima example confirms that allocating the lead to the environment department may hinder mainstreaming as it may result in adaptation being understood as a primarily environmental problem (Measham et al. 2011; UNDP/UNEP 2011).

- With regard to multi-level governance, our results suggest that national and state-level guidance (to improve information), financial support (to overcome resource constraints), and mandate and regulation (to set appropriate incentives) are often essential for urban adaptation planning. This is in line with the widespread observation that the absence of such mandate is an important barrier to proper adaptation planning (Betsill 2001; Næss et al. 2005; Bulkeley and Kern 2006; Koch et al. 2007; Amundsen et al. 2010; Burch 2010b; Corfee-Morlot et al. 2011; Measham et al. 2011).
- Participation is gradually gaining importance in all cities and may help to overcome restrictions regarding information and resources (see also, Adger et al. 2009; Corfee-Morlot et al. 2011; Hunt and Watkiss 2011). Experience shows that some initial steps have been taken in this context, e.g. via the collaboration with science and NGOs, but that a permanent and institutionalized participation of the civil society is still pending.
- Finally, existing bureaucratic routines and procedures have been found to be an important barrier.

Third, our analysis also confirms that there are several barriers and opportunities, which distinguish adaptation planning from other decision-making problems:

- The complexity of the natural environment (including the climate and environmental system) brings about large uncertainties regarding the local impacts of climate change. Objectives are hard to specify – and the effectiveness of adaptation measures to address these objectives is difficult to measure. This difficulty clearly impairs the incentives to invest in adaptation planning (see also, Biesbroek et al. 2013).
- There is a clear mismatch between the long time horizons of climate change impacts and the effects of adaptation measures (characteristic of the natural environment) on the one hand and the rather short-term, election-driven time horizons for municipal decision-making on adaptation planning (characteristics of the institutions) on the other hand. This mismatch causes another important barrier to effective adaptation planning: the incentives for urban planners to act are often limited as the costs of adaptation planning tend to arise in the short term while benefits often only materialize in the long run (see also, Biesbroek et al. 2013).
- Adaptation is a crosscutting planning issue. This implies that co-benefits and co-costs with other political objectives are decisive for urban planners' incentives to act and the availability of resources.

Fourth, we would argue that some of the barriers and opportunities we identified are specific to decision-making problems at the local level as compared to adaptation planning at the regional or national level:

- Local decisions on adaptation planning are framed by the institutional environment of higher administrative levels. In this context, an explicit national mandate to adopt local

adaptation strategies and the transfer of resources to develop these strategies may enhance opportunities for adaptation planning in municipalities substantially (see also above where multi-level governance is discussed).

- Cities are also vulnerable to climate impacts occurring in their hinterland, e.g. concerning water supply. Institutionally, adaptation to such impacts is beyond the scope of municipal adaptation planning. Thus, there may be a spatial mismatch between the natural and the institutional environment (for a more comprehensive discussion on this issue, see Moss 2004). A proper governance framework would require coordination mechanisms between urban and rural areas (see also Moser and Ekstrom 2010, p. 22028). The absence or difficulty to set up such mechanisms can be regarded as another important barrier to effective adaptation planning at the local level. This is exactly a situation to which Eisenack and Stecker (2012) refer when arguing that complex actor relations may impede adaptation action.

6 Conclusion

Our paper has examined barriers and opportunities for adaptation planning by municipal decision-makers in cities. The particular focus of our analysis has been on the process of preparing and adopting urban adaptation strategies and action plans. For this purpose we have proposed a two-tier framework of variables whose characteristics may constitute barriers or opportunities for adaptation planning. The primary novelty of this framework is to explicitly point out interactions between commonly discussed categories of barriers (or opportunities). Thus, we contribute to understanding how barriers come about, rather than only proposing a one-dimensional typology of barriers. We have used the framework to provide and organize empirical evidence for the existence and relevance of different barriers and opportunities in four selected case study cities: Lima (Peru), Santiago (Chile), Berlin and Sangerhausen (both Germany).

Our empirical analysis has revealed that the framework we propose is quite suitable to understand the (lack of) progress in urban adaptation planning in varying contexts. Despite differences in spatial and demographical characteristics, level of economic development and current stage of the adaptation planning process, we have been able to attribute all barriers and opportunities mentioned by decision-makers of different organizations in these cities to the different variables pointed out in the framework. Therefore, we would argue that this framework can be applied to explain the (lack of) progress in adaptation planning in a wide range of cities worldwide, characterized by different sizes, demographic trends and natural framework conditions.

More importantly, we would argue that our framework provides a useful starting point for deriving policy recommendations to overcome barriers to adaptation planning – which would be the analytical step subsequent to our barrier analysis. The framework helps to disentangle to what extent characteristics of the first-tier variables (information, resources, incentives) depend on one or more of the underlying factors (actor-specific characteristics, institutional environment, natural and socio-economic environment). Policy invention is by definition meant to modify the institutional environment for adaptation action. In contrast, barriers associated with actor-specific characteristics (preferences, perceptions, etc.) and the natural and socio-economic environment (patterns of climate change, economic development) can at best be addressed indirectly – and usually only in the long run – via changes in the institutional environment. Of course, we are aware that changing the institutional context is often far from being an easy task – but it is usually more tangible than targeting the other

sources of barriers to adaptation planning. For example, when it comes to an urban decision-maker's incentive to adopt an adaptation strategy, a clear-cut policy recommendation could be to establish a corresponding national mandate. In turn, addressing relevant characteristics of the actor (e.g., lacking personal preferences for environmental concerns) or the natural and socio-economic environment (e.g., the minor importance of adaptation as compared to other public concerns, such as poverty alleviation) may be difficult if not impossible.

There certainly are several open research questions remaining regarding barriers to adaptation to climate change. First, it has to be learned more about the origins of barriers and opportunities, inter alia by employing existing disciplinary approaches to understanding human behavior (one example is the economic contribution by Gawel et al. 2012). Second, more insight is needed on the relevance of different categories of barriers and their sources. In both respects, it would be useful to depart from anecdotal evidence (which is provided in numerous studies including ours) and move, where possible, towards more quantitatively based approaches. Finally, as Biesbroek et al. (2013) point out, it would be useful to shift priorities from analyzing barriers to analyzing solutions, whereby the former is certainly a precondition for the latter.

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