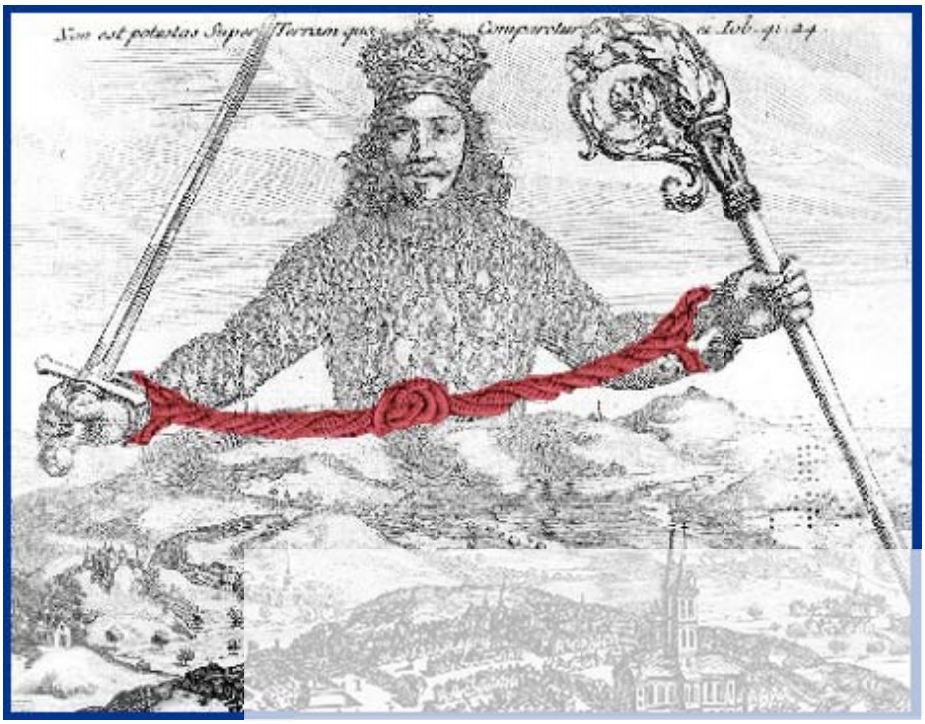

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Overcoming Barriers to Urban Adaptation through International Cooperation? Modes and Design Properties under the UNFCCC

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Abstract

This study examines by which design properties international cooperation can effectively facilitate specific climate adaptation processes at the local level. First, a qualitative meta-analysis of empirical evidence from 23 cases is conducted to identify archetypal patterns of barriers and change factors for climate adaptation in urban squatter settlements and in municipal public sectors in low- and middle-income countries. Second, five modes of international cooperation for climate adaptation are characterized based on UNFCCC documents, process observation and literature review. Third, these results are combined to derive testable propositions about how selected design properties of international cooperation can facilitate local efforts to overcome barriers to urban adaptation in low- and middle-income countries. Findings indicate, first, that a major step to tackle adaptation barriers in squatter settlements is improvements of the status of urban poor in the public sector. Second, national or regional centres of competence are means to foster endogenous dynamics in municipal public sectors. Third, national adaptation policies are arrangements to enable and incentivise municipal adaptation. Fourth, flexible indicators of adaptation benefits are instruments to target international decision making and monitoring systems to local needs. It is finally discussed how these insights and methods can be used to advance the study of international cooperation, barriers and success factors for climate change adaptation.

Keywords: Barriers to Climate Adaptation; International Cooperation; Design Properties; Archetypes.

1. Introduction

Most impacts of climate change manifest at the local level. This may suggest to take adaptive action at comparatively local scales to ensure that social responses fit the climatic impact (see, e.g., Füssel/Klein 2006; Adger et al. 2007; Young et al. 2008). However, at the same time adaptation to climate change has become a major agenda item in international climate policy, in particular under the UN Framework Convention on Climate Change (UNFCCC). This paper links the global to the local perspective by investigating how international cooperation might address specific barriers to and change factors of urban adaptation.

In general, at least three perspectives provide a rationale for cooperation on climate change adaptation at the international level. First, support by the global north for adaptation in the global south can be considered as a moral obligation arising from three inequalities of impact risks, adaptive capacity and responsibility: While the exposure and sensitivity to climate change is particularly high in low- and middle-income countries (LMIC), their capacity to adapt is frequently limited. Additionally, the bulk of historic greenhouse gas emissions originated from industrialized countries and completes the triptych of climate change inequalities (Roberts 2009). Second, developed country parties might use adaptation support in international negotiations as a confidence building negotiation strategy and an incentive for developing country parties to join a global climate agreement (Rübbelke 2011; Buob/Siegenthaler 2011; Eisenack 2012a). Third, international cooperation on climate adaptation may pave the way to provide a range of international public goods. This includes models and information about changes in climate and impacts, control of climate-sensitive infectious diseases, protected biodiversity, avoided international migration and conflicts, and smoothed price volatility of climate-sensitive agricultural products (Aakre/Rübbelke 2010; Persson 2011; Rübbelke 2011; Schenker/Stephan 2012).

Consequently, adaptation has become officially recognized as one of the UNFCCC regime's key building blocks in 2007. A number of arrangements for finance, technology development and transfer, institutional development and learning have been institutionalised (Schipper 2006; Levina 2007; UNFCCC documents at www.unfccc.int). Currently, major ongoing work under the Convention includes the evolving climate finance architecture, the work programme on loss and damage in particularly vulnerable developing countries, the emerging technology mechanism, the evolving architecture on National Adaptation Plans and National Adaptation Programmes of Action, the reform of the Nairobi Work Programme on impacts, vulnerability and adaptation, and the emerging Adaptation Committee that serves as the overall advisory body to the Conference of Parties on adaptation. One of the multiple challenges in this process is the design of channels for facilitating adaptation at local, national and regional governance levels.

The literature on international arrangements for climate adaptation focuses on means to raise adaptation finance (e.g. Müller 2008; Bowen 2011; Eisenack 2012a), and to govern and monitor funds (e.g. Müller 2010). It investigates guidelines for spending adaptation funds based on normative premises (e.g. Grasso 2010) and based on general characteristics of the adaptation challenge such as deep uncertainty (e.g. Burton et al. 2006; Fankhauser/Burton 2011). Tompkins/Amundsen (2008) and Stecker et al. (2012) examine effects of international arrangements on national and regional adaptation policy. Other contributions trace the conceptual history and framing of adaptation in the UNFCCC process (e.g. Schipper 2006; Horstmann 2008), describe the legal framework (e.g. Mace 2006), investigate the interaction of adaptation and development (e.g. Smith et al. 2011) and the interplay of adaptation and mitigation in the negotiations (e.g. Rübbelke 2011).

This literature is mostly de-linked from research on adaptation at the local level. Here, research has predominantly been conducted in the form of contextualised case-studies of adaptation in specific economic sectors (e.g. fisheries: Kalikoski et al. 2010), regions, geographical areas (e.g. dryland: Eriksen/Lind 2009) or by particular actors (e.g. local public administration: Roberts 2008). In this context, barriers or constraints to adaptation are increasingly observed and examined as impediments to adaptation (e.g. Adger et al. 2009; Moser/Ekstrom 2010; Heinrichs et al. 2011). Most of this research presents insights for one or a few cases without examining repeating patterns across cases. In addition, to the best of our knowledge there is no study yet that systematically assesses which kind of international cooperation fits to which local impediments to adaptation. In sum, there is a clear lack of multi-level studies which model processes of climate adaptation at lower governance levels to analyse how international cooperation may alter these processes. As a consequence, it remains largely unclear by which design properties international cooperation may effectively facilitate adaptation at the local level, where most of the adaptation challenges manifest.

This article explicitly addresses this gap. It utilizes the concept of barriers to climate adaptation to investigate design properties of international arrangements that are capable to address specific impediments to adaptation. To provide focus, the paper is restricted to two important settings in urban areas in low- and middle-income countries: adaptation in urban squatter settlements and adaptation by municipal governments and public administration. The first setting covers a particularly vulnerable group (urban poor), while the latter considers a potentially important operator of adaptation (municipal governments and public administration).

The applied methods and core concepts are described in section 2. Subsequently, three sections present the results. Section 3 provides a qualitative meta-analysis of empirical evidence of 23 cases about climate adaptation in urban squatter settlements and formal public sectors in low- and middle-income

countries. This part identifies archetypal patterns of barriers and change factors for adaptation in both settings. Section 4 systematises and analyses modes of international cooperation on climate adaptation based on policy documents, process observation and scientific literature. Section 5 combines the archetypes of barriers and change factors from section 3 and the conceptual structure from section 4 to provide an institutional-economic analysis of selected design parameters of international arrangements that are likely to support local adaptation processes. Conclusions are drawn in section 6.

2. Methods and concepts

For the purposes of this article we define adaptation as action undertaken by individual or collective actors in response to, or in anticipation of, climate-related changes of environmental conditions (Eisenack/ Stecker 2012). A barrier is an impediment in the process of adaptation that either limits the actors' set of available means for adaptation or restricts actors from realising their adaptive capacity. A change factor is a condition, strategy or process that alters barriers and fosters adaptation processes. The effectiveness of international cooperation for adaptation is defined as the suitability of the international arrangement to alter adaptation problems (Young 2011). The research process of this study comprises three interrelated parts.

In part I (section 3) we conduct a meta-analysis of empirical evidence to model empirically supported archetypal barriers and change factors of climate adaptation in urban areas in low and middle income countries (LMIC). This part requires an appropriate notion of generality, a conceptual framework, and a strategy to search and select the literature. The large diversity of local adaptation contexts is a clear challenge in the endeavours to build empirically validated theories of how international arrangements work for local adaptation as well as designing effective international institutions for adaptation. Both tasks require a comprehensive and flexible notion of climate adaptation to adequately capture the diversity of adaptation. There seems to be a trade-off between the generality of concepts and theories on the one side and their case-specific applicability on the other side (Young et al. 2006, Romero Lankao/Qin 2011). The notion of archetypes has been suggested as a heuristics to solve this apparent trade-off (Eisenack 2012b). Archetypes of adaptation are patterns that describe or explain climate adaptation in more than one, but not necessarily in all cases. The explanation of one case, in turn, can include more than one archetype and potentially a set of case specific attributes. In other words, the heuristics of archetypes directs attention towards conceptual and functional similarities across cases at an intermediate level of generality while allowing, first, that an explanation of one case may require multiple archetypes as well as a set of case-specific assumptions and, second, that one archetype usually does not appear in all cases. The underlying hypothesis is that transferring insights from one case to another is valid, if these cases share archetypes. Thus, the notion of archetypes provides this

study with a heuristics to tailor concepts and models of adaptation barriers and change factors at an intermediate level of generality.

We use the diagnostic framework of climate adaptation (Oberlack/Neumärker subm.) as a conceptual basis for comparing and translating different case study results. This multi-tiered framework adopts Ostrom's IAD (Ostrom 2005) and SES framework (Ostrom 2009) to particularities of climate adaptation. It explains manifestations of climate adaptation processes (e.g. timing, extent, types of adaptation) and outcomes (e.g. altered exposure, altered sensitivity, altered adaptive capacity) as a result of the interplay of variables that fall into four broad categories (cf. figure 1): the properties of the climatic and non-climatic stresses, attributes of the governance system, resources, and attributes of the involved actors. These variables determine the actors' action space for adaptation (adaptive capacity). Actors choose their adaptations from this set of options given their preferences and values, modes of choosing (e.g. using heuristics) and modes of acquiring and using information (e.g. using mental models) (Ostrom 2005).

To identify the relevant empirical literature we used keyword search [(adapt* OR vulnerab*) AND (urban* OR cit*)] in the Web of Knowledge/Web of Science database as well as cross-references in articles. An article must fulfil the following criteria to be included in the meta-analysis: it provides

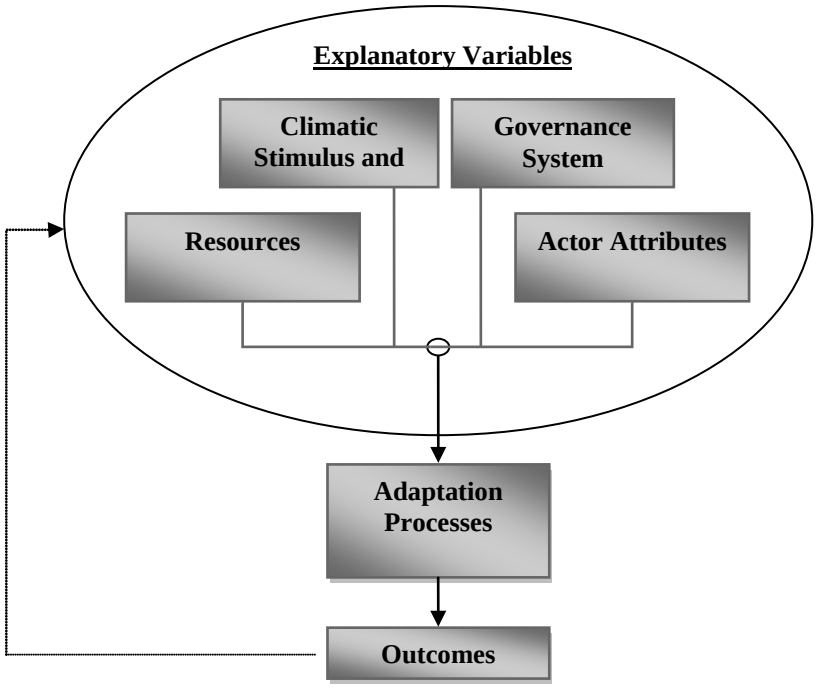

Figure 1: First-tier variables of the diagnostic framework of climate change adaptation (source: Oberlack/Neumärker subm.)

empirical evidence on climate change adaptation barriers and/or change factors; it investigates adaptation to climate change or climate-related environmental hazards in urban areas in low- and middle-income countries; the research process has been coherently and clearly documented; theoretical preconceptions and the sources of empirical evidence are adequate and clearly stated. A final selection was made to obtain a set of 13 studies covering 23 distinct cases and spanning across countries in all continents with LMIC and across a range of economic sectors (e.g. water, health) and types of hazards (e.g. floods, landslides). From each case study we extracted the revealed adaptation barriers. For this purpose we formulated the empirical findings in the language of the diagnostic framework as second- and third-tier variables which cause an impediment in the adaptation process in the respective case. It proved useful to distinguish exactly five ways in which a barrier impedes the adaptation process: (1) by constraining the available means for adaptation; (2) by hampering the use of available means; (3) by increasing the costs of adaptation including transaction costs; (4) by reducing the incentives for adaptation; and (5) by increasing the incentives for mal-adaptation. Through increasing the number of included case studies a typology of adaptation barriers emerged. If a change in this typology occurred, the earlier analysed case studies were re-read and if necessary re-coded to ensure accordance of the typology with all case studies. This method was equally applied to extract the empirically revealed change factors from the case studies. This iterative process yielded a typology of adaptation barriers and change factors as well as models how these factors impede or foster adaptation processes in urban squatter settlements and in municipal public sectors. They are presented in section 3.

Part II of this study (section 4) develops a typology of modes of international cooperation for climate adaptation. We need to abstract from the historically contingent, time-dependent real-world institutions such as those under the current UNFCCC regime to develop a more generic understanding of international arrangements for climate adaptation. This approach allows to reduce the complexity of real-world institutions for analytical purposes to develop sound theoretical and testable propositions about the properties of international agreements. Moreover, insights are expected to be transferable between the particular contexts, if the contexts share relevant properties. We use two criteria to distinguish the modes. First, a mode comprises distinct design parameters, i.e. issues that can be decided about in an international arrangement. Second, a mode affects distinct elements of lower-level climate adaptation processes and outcomes. This typology of modes is developed by drawing on UNFCCC documents (www.unfccc.int), participation as scientific observer at UNFCCC conferences between 2009 and 2012 and by reviewing literature about international adaptation cooperation (see below in table 3 for references). The modes provide us with a conceptual structure for the study of international arrangements, whereas the specific real-world UNFCCC arrangements on adaptation are interpreted as particular manifestations of these modes.

Part III (section 5) combines the results of the previous parts to examine the effectiveness of selected configurations of design parameters of international arrangements on adaptation. This is based on a classification of the effects of barriers and change factors (identified in part I), which is also used to characterize the effects of the design parameters of international cooperation (established in part II). The focus is on four configurations for which particularly meaningful insights emerge from the meta-analysis of urban adaptation barriers and change factors. For each configuration we describe the problem of social organisation and develop propositions how this configuration alters the archetypes of urban adaptation barriers and change factors from part I. Thus, part III is an explorative study that provides testable and refutable models.

3. Archetypal barriers and change factors for climate adaptation in urban areas

3.1. Adaptation barriers and change factors in urban squatter settlements

The results of the urban-level meta-analysis show that climate adaptation in squatter settlements is hampered by a set of barriers that can be summarized as severely limited resources, ill-defined rights, weaknesses in municipal planning and regulation, constrained human skills, and non-climatic stressors and goals. Figure 2 illustrates the twelve barriers revealed by the meta-analysis and how they impede adaptation processes. The text below describes the interconnections. Conceptually, the distinctive feature of this setting is that the urban squatter settlement is the exposed unit.

Severely limited resources of different sorts are a first important class of adaptation barriers in urban squatter settlements. Precarious income and a lack of assets (RE1) frequently restrict dwellers to use no- or low-cost adaptations. In addition, limited access to basic infrastructure for water, energy, drainage, waste, sanitation and transport (RE2), public education and health (RE4) as well as low-quality housing and dense settlement (RE3) do not only increase the risks of flooding, diseases, interrupted economic activities, and other climate impacts, but also imply additional constraints on the means and increased costs for adaptation.

Ill-defined rights of dwellers exacerbate and reinforce the precarious resource endowments. Dwellers that lack the formal status of citizens (RG1), e.g. for living in illegal settlements, often experience exclusion from formal public programs, development plans and lack access to the formal education and public health systems. This reduces their options to be receptor of municipal adaptations. Apart from this, insecure land tenure (RG2) is a frequent concern in the investigated settlements. From a dwellers perspective, disputes about land rights confront them with the permanent risk of eviction and

Barriers to climate adaptation in urban squatter settlements			
Barrier	**Effect**	**Barrier**	**Effect**
Severely limited resources		**Impairments in municipal planning and regulation**	
RE1 Precarious income and limited assets.[2,3,4,6,7,8,9]	m↓	MP1 Limited accountability of public officials to slum dwellers.[3,4]	i↓
RE2 Limited availability of/ access to basic infrastructure, e.g. for water, energy, sanitation, transport.[3,4,5,6]	m↓; c↑	MP2 Maladaptive municipal planning and regulation.[1,3,4,6,7,8]	ma↑
RE3 Low quality of housing; dense settlement.[6,7,8]	m↓	MP3 Missing connection between the formal structure for disaster preparedness and the most vulnerable groups. [1]	m↓
RE4 Limited access to formal public education and health.[6]	m↓		
Ill-defined rights		**Non-climatic stressors and goals**	
RG1 Lack of formal citizen status for dwellers.[3,6]	m↓	NC1 Conflicting development goals; ongoing urbanization pressure.[4,5,6,7,8,9]	c↑; ma↑
RG2 Insecure land tenure.[5,6,7,8]	i↓	NC2 Prevailing social conflicts among dwellers and between dwellers and public authorities.[7,8]	m↓; um↓
Constrained human skills			
HS1 Illiteracy, low formal education and skills.[2,3,6]	m↓ um↓		

Figure 2: Barriers to climate change adaptation in urban squatter settlements and their effects on adaptation processes (source: authors' compilation).
Symbols for effects on adaptation processes: [m↓]: Constrained availability of means for adaptation through reduced options to act as an operator of adaptation or reduced options to be receptor of other agents' adaptations (e.g., financial, legal, organisational, technical, infrastructural means, knowledge and skills etc.); [um↓]: technically and economically available means are less effectively used; [c↑]: increased costs of adaptation; [i↓]: Reduced incentives for adaptation; [ma↑]: Enhanced maladaptive activities.
References: 1) Ahammad 2011; 2) Braun/Aßheuer 2011; 3) Chatterjee 2010; 4) Douglas et al. 2008; 5) Jabeen et al. 2010; 6) Porio 2011; 7) Wamsler 2007; 8) Wamsler/Lawson 2012; 9) Wilhelm 2011.

increase the potential for conflicts between them and public authorities. This increases uncertainty about the benefits of risk reduction lowering the incentives for anticipatory adaptation. It also adds another stressor to livelihoods.

Impairments in municipal planning and regulation have repeatedly hampered adaptations that would benefit squatter settlers. Partly as a result of the informal status the mechanisms through which municipal officials are held accountable to squatter settlers are weak or absent (MP1). As a consequence, the incentives for public officials to provide adaptation measures to informal inhabitants tend to be low. Moreover, municipal planning and regulation has even be maladaptive for slum dwellers in some cases (MP2). Instances include unregulated urban development as well as externalities between formal and informal inhabitants that are regulated to the disadvantage of squatters. Apart from this, with regard to the implementation of municipal decisions a couple of

deficits have been found to reduce the available means for adaptation in urban squatter settlements, including weak abilities to enforce regulations and missing connections between formal structures for disaster preparedness and the most vulnerable groups (MP3).

Constrained human skills such as illiteracy and lack of technical knowledge and skills (HS1) reduce the set of available means for adaptation and the ability to use otherwise available adaptation options.

The fifth set of barriers is non-climatic stressors and goals. Individual and municipal development goals and pressures can be in conflict with the reduction of vulnerability to climate change (NC1). An example is a flood-prone area in which commercial and industrial development could take place at the expense of higher climatic risks. In terms of climate adaptation processes these competing goals and pressures increase the opportunity costs of adaptation and thus increase the incentives for maladaptive activities. Apart from this, prevailing conflicts among squatter dwellers or between dwellers and public authorities (NC2) can reduce resources (e.g. energy and time) for adaptations and available means might not be used due to other priorities.

Taken together these barriers have the potential to severely impede climate adaptation in urban squatter settlements by constraining the available means, leaving available means unused, increasing the costs of adaptation, reducing incentives for risk reduction and adding incentives for maladaptive actions. The archetype in figure 2 depicts patterns that have been empirically revealed in case studies. As these barriers are archetypes, a particular time- and place-specific case of an urban squatter settlement does not necessarily include all of these elements and interactions. It is likely, however, that figure 2 contains major barriers prevalent in that case.

The meta-analysis also investigated change factors for this archetype. Despite the hardships and adaptation barriers associated with livelihoods in urban squatter settlements a considerable range of such change factors can facilitate adaptation to climatic hazards in urban squatter settlement. Table 1 describes the change factors and illustrates how they affect processes of climate adaptation.

Dwellers self-organise to adapt to climatic hazards in numerous cases. At the individual or household level they are able to use no- or low-cost options for private adaptation, gradually accumulate assets or diversify livelihood options with the effect of increased means and reduced costs for adaptation. In community networks and organisations (CNO) dwellers arrange informal security systems such as collective saving schemes or informal assistance. They also engage in CNOs to provide small-scale infrastructure-related services, to interact with external parties and to learn within the community.

Level of decision making	Change factor		Description	Effect
Individual/ Household	HH1	**No-/ low cost private adaptation** [3,4,5,6,7,8]	Household activity to use available options for private adaptation with low or no financial costs, such as putting valuables upon the top of furniture against flooding, manual removal of flood water from houses, acceptance of risks, reduction of expenses.	*m*↑; *c*↓
	HH2	**Private savings** [2,5,7,8]	Household activity to gradually accumulate assets, e.g. building materials, assets that may be used or sold in case of disaster or serve as collateral for credit.	*m*↑
	HH3	**Diversification of household incomes and livelihood options** [5,7,8]	Household activity to increase the number of potential or actual sources of income and to enhance livelihood options (e.g. raising the potential alternatives for work places and housing).	*m*↑
Community networks and organisations	CN1	**Informal security system** [2,4,5,6,7,8]	Self-organised community security systems. Types include collective saving schemes which can be approach in times of hardship (e.g. for micro-credit) and assistance for relatives, friends, and community members, such as food sharing, informal credit, part-time shelter during extreme events, and emotional support.	*m*↑; *c*↓
	CN2	**Community-based infrastructure or service provision** [3,7,8,9]	Self-organised community activity to provide infrastructure and services, e.g. waste removal, small drainage systems, and cooperative early warning system.	*m*↑
	CN3	**Interaction with external parties** [9]	Organised community activity to interact with external parties such as municipal authorities.	*m*↑; *c*↓
	CN4	**Community-based learning** [7,8]	Developing mental models and accessing information by interacting with friends, neighbours and other community members.	*m*↑; *um*↑; *c*↓
Public administration (e.g., municipal, district, national level)	PA1	**Governmental infrastructure or service provision** [6]	Activity by governments and public administration providing infrastructure or services, e.g. drainage/ water diversion pumps, energy, education, provision of relocation areas and housing for informal settlers.	*m*↑
	PA2	**Governmental post-disaster relief** [3,7,8]	Post-disaster relief from domestic governmental organisations.	*m*↑
	PA3	**Access to international adaptation support and post-disaster relief** [1]	Governmental provision of a modality through which adaptation (pre-/post-disaster) is internationally supported.	*m*↑
Markets	MA1	**Access to markets, e.g. for formal insurance and credit, assets, food, services, labour** [1,2,3,7,8]	Option for households to access markets for labour, insurance, credit, goods and services with low transaction costs, e.g. to trade goods and assets in case of disasters or find new employment.	*m*↑
Non-governmental, international and other organisations	NG1	**Infrastructure or service provision** [1]	Activity by non-governmental, international and other organisations to provide infrastructure (e.g. water, energy, housing) and services (e.g. community awareness raising).	*m*↑; *um*↑
	NG2	**Access to domestic and international support** [3,7,8]	Provision of direct support by non-governmental, international and other organisations resp. provision of access to international support by these organisations.	*m*↑

Table 1: Change factors for the archetype of adaptation barriers in urban squatter settlements in LMIC (authors' compilation).
Symbols: [m↑]: increases in the means for adaptation; [c↓]: reduction of the costs of adaptation; [um↑]: technically and economically available means are more effectively used.

References: 1) Ahammad 2011; 2) Braun/Aßheuer 2011; 3) Chatterjee 2010; 4) Douglas et al. 2008; 5) Jabeen et al. 2010; 6) Porio 2011; 7) Wamsler 2007; 8) Wamsler/Lawson 2012; 9) Wilhelm 2011.

Access to markets for formal insurance and credit, assets, food, services and labour enables dwellers to approach a wider range of goods and services, find employment, or sell assets and services increases the potential means they have for adaptation.

Moreover, public agencies and non-governmental organisations from various levels assist dwellers in some cases by providing infrastructure-related services and access to domestic or international adaptation support and post-disaster relief.

3.2. Adaptation by municipal governments and public administrations

Municipal governments may play an important role in climate change adaptation as there are numerous local public goods such as infrastructure (e.g. freshwater, drainage, local energy supply, public transport), information about local climate impacts and vulnerability, and urban land use planning with high relevance for adaptation. However, persistent barriers to municipal decision making can leave an urban area in a state of high vulnerability. Therefore, this second archetype of our meta-analysis investigates the provision of adaptation-related goods by municipal governments and administrations. Conceptually, the distinctive feature of this archetype is that the operators of adaptation are municipal governments and administrations, while there can be multiple exposure units and receptors such as the urban population, infrastructure, and ecological or economic systems. We find twelve barriers for adaptation by municipal agents (cf. figure 3).

Institutional deficits can impede public decision making on urban climate adaptation in several ways. Cases are documented in which political and administrative competences are ill-defined or dysfunctionally distributed among public agencies (ID1). In a similar vein a lack of coordination between different public agencies can impede adaptation (ID2). Both factors increase the transaction costs of adaptation decision making and raise the probability that technically available means for adaptation are not used, e.g. due to conflicts or coordination failures. In addition, adequate communication among public officials and urban stakeholder, e.g. about local needs and technical details of adaptations, is found to be supportive for effective adaptation. A lack of this (ID3) may evoke maladaptive activities and unused opportunities of technically available means. Apart from this, public municipal decision making frequently depends on national policy and regulatory frameworks. If missing national guidance (ID4) is not compensated, e.g. through strong awareness and capacities of local officials, inactivity at the municipal level is likely due to a lack of means and incentives or unused means for adaptation.

Barriers to climate adaptation by municipal governments and public administrations			
Barrier		**Effect**	**Barrier**		**Effect**
Institutional deficits			**Limited awareness and understanding**		
ID1	Dysfunctional definition or distribution of political and administrative competences and responsibilities. [1,12]	c↑; um↓	AU1	Limited awareness and understanding of local vulnerabilities and adaptation options among public officials. [1,10,11,12]	um↓; ma↑
ID2	Lack of coordination between public agencies. [1]	c↑; um↓	AU2	Limited awareness and understanding of local vulnerabilities and adaptation options among urban stakeholders. [10,11,12]	um↓; ma↑
ID3	Deficient communication between policy makers, municipal agencies, scientists and practitioners; deficient integration of local knowledge into municipal decision making. [1]	um↓; ma↑	**Constrained resources**		
ID4	Reliance and/or dependence upon national policies and regulations[12]	m↓; um↓; i↓	CR1	Constrained financial resources. [1,10,11]	m↓
ID5	Scale Mismatch I: Long-term challenge vs. short-terminism of decision making [12]	c↑; ma↑	CR2	Lack of reliable data and information about local climate change impacts and vulnerabilities. [10,11]	m↓
ID6	Scale Mismatch II: Rapid environmental dynamics vs. slow reaction [12]	m↓	CR3	Constraints on trained labour. [1]	m↓
			Non-climatic stressors and goals		
			NC1	Conflicting development goals and urbanisation pressure.[1,10,11,12]	c↑; ma↑

Figure 3: Barriers to climate change adaptation in the provision of adaptation-related public goods by municipal governments and their effects on adaptation processes (source: authors' compilation).
Symbols for effects on adaptation processes: [m↓]: Constrained availability of means for public adaptation (e.g., financial, legal, organisational, technical, infrastructural means, knowledge and skills etc.); [um↓]: technically and economically available means are less effectively used; [c↑]: Increased costs of adaptation including transaction costs of public decision making; [i↓]: Reduced incentives for public adaptation; [ma↑]: Enhanced incentives for maladaptive activities.
References: 1) Ahammad 2011; 10) Carmin et al. 2012; 11) Roberts 2008; 12) Heinrichs et al. 2011; 13) Ziervogel et al. 2010.

Scale mismatches between the institutional system and environmental conditions can hamper public adaptation in two ways. First, if the time preference of municipal officials is high, e.g. due to political election cycles, decisions are likely to put low value to distant adaptation benefits. Given the long-term character of climate change, this first type of temporal scale mismatch (ID5) can easily become costly or maladaptive for decisions with a long-term effect such as in cases of long-term investments, long lead times and expensive retrofitting (Fankhauser et al. 1999). In contrast, if changes in the environment are rapid such as in the case of extreme weather events, the reaction time for public decision making can be too short (ID6) to allow for meaningful and effective means of adaptation.

Severe constraints of financial resources (CR1), of reliable data and information about local climate change impacts and vulnerabilities (CR2), and of trained labour (CR3) are a repeated barrier to

municipal adaptation decision making by limiting the available means for adaptation. This situation of resource scarcity is aggravated, if non-climatic stressors and goals, such as development goals or urbanisation pressures, are in conflict with vulnerability reduction (NC1). As in the first set of archetypes, this factor increases the opportunity costs of adaptations and the incentives for maladaptive activities.

Awareness and understanding shape priorities. If the public officials' and urban stakeholders' awareness and understanding of local vulnerabilities are low (low AU1; AU2), municipal decision makers are tempted to assign low priorities to climate change. This implies unused means for adaptation or even maladaptive decisions.

Apart from these twelve barriers the meta-analysis also revealed change factors for this archetype. Table 2 describes the change factors and illustrates how they influence adaptation processes.

Endogenous dynamics within municipal politics and administration can be driven by six conditions. Committed individual members of municipal staff (UP1) or municipal leaders (UP2) have been driving forces for urban adaptation strategies in some cases. On a broader basis, a tradition of foresighted planning and/or experience with former extreme events in the urban area (UP3) are triggers for anticipatory public adaptations. This is particularly likely, if they are supported by sound information about expected local impacts of climate change. Opportunity costs of adaptation are reduced, if the goals and the means of reducing climate vulnerabilities were compatible with the pre-existing urban agenda, programmes and organisational structure (UP4). A robust process of adaptation is supported by anchoring climate change in the urban agenda, e.g. through creating dedicated working groups, resources or strategic plans to climate change (UP5). Local networks of public agencies, local NGOs, research organisations, and residents can be means to recognize local vulnerabilities and to devise adaptive responses (UP6).

Apart from such endogenous dynamics, external drivers can foster urban adaptation. One instance is national and provincial policies, laws and regulations. These can incentivise or prescribe municipal adaptations and enhance available legal, financial and other means for municipalities (NP1). A second instance is interaction in national or transnational networks of municipalities which can support urban adaptation by raising awareness, exchanging information and know-how and by creating incentives to be perceived as leaders (MN1).

Level of decision making	Change factor		Description	Effects
Urban politics and public administration	UP1	**Influential climate change champions** [10,11,13]	Individual members of municipal political or administrative staff recognize climate vulnerability to be relevant in their locality and subsequently gain support from other influential elected officials, municipal staff and stakeholders to create an adaptation strategy. A core facilitating factor is if climate adaptation is compatible with, or even advances, the urban agenda. Supportive is also a tradition of forward looking planning in the city.	*m↑; um↑; i↑; ma↓*
	UP2	**Commitment of municipal leaders** [10,11,12]	Municipal leaders are legally, politically, or personally committed to advance urban adaptation.	*m↑; um↑; i↑*
	UP3	**Long-term planning, experience and sound information** [10,11,12]	A tradition of foresighted, long-term urban planning, experience with former extreme events, supported by accessible, sound information about expected local climate impacts and vulnerabilities facilitate a high degree climate-related awareness among public urban officials and the broader population.	*m↑; um↑; i↑; ma↓*
	UP4	**Compatibility with the existing urban agenda** [10,11,12,13]	Compatibility of local climate vulnerability and existing urban programmes and priorities yields incentives for public officials to foster adaptation strategies and facilitates the use of the existing institutional and organisational structure for climate adaptation.	*m↑; c↓*
	UP5	**Anchoring climate change in the urban agenda** [10,11,12]	The creation of dedicated climate teams (e.g. committees, working groups) or the allocation of dedicated resources to climate change anchor this item as a long-lasting element in urban public agendas. A strategic plan/priority on climate adaptation supports a process which facilitates coordination, communication and learning among different parts of municipal public administration.	*m↑; c↓; um↑; i↑; ma↓*
	UP6	**Local networks** [10,11]	Networks with local NGOs, research organisations and residents are means to recognize local vulnerabilities and to develop and implement specific adaptations, e.g. by involving stakeholders in monitoring and reporting local climate variations, and improve water management.	*m↑; c↓*
National/ provincial level	NP1	**National and provincial policies, laws and regulations** [12]	National and provincial policies, laws and regulations are used to incentivise or prescribe the development and implementation of urban adaptation strategies, e.g. through national sustainability strategies.	*m↑; um↑; i↑*
Municipal networks	MN1	**Interaction in national/ transnational networks of municipalities** [12]	Interaction in national and transnational municipal networks leads to the development of urban adaptation strategies, e.g. if urban officials desire their city to be visible as leader on sustainability issues and in cases in which networks enabled learning about climate change and best practices for adaptation. Municipal networks can serve as platforms for adaptation-related ideas and information, confidence in priorities and reputation.	*m↑; c↓; um↑; i↑; ma↓*

Table 2: Change factors for the archetype of barriers in the provision of adaptation-related public goods by municipal authorities (source: authors' compilation).
Symbols: [m↑]: Available and/or used means of adaptation are enhanced; [um↑]: Technically and economically available means are more effectively used; [c↓]: Opportunity costs of adaptation are reduced; [i↑]: The incentives for, and perceived benefits of, adaptation increase; [ma↓]: Maladaptive trends avoided/reversed.
References: 1) Ahammad 2011; 10) Carmin et al. 2012; 11) Roberts 2008; 12) Heinrichs et al. 2011; 13) Ziervogel et al. 2010.

Taken together the two archetypes of adaptation in urban squatter settlements and in municipal public sectors describe an important set of adaptation problems in urban areas in low- and middle-income countries. They capture a particularly vulnerable population group (dwellers of squatter settlements) as well as an important potential operator of local adaptations (municipal governments and administration). Interventions from national and international levels may facilitate or impede a change in these archetypal patterns of adaptation barriers, depending on their design. Therefore, both archetypes provide models to study the local effects of higher level interventions. This will be subject of the fifth section. As a foundation for this we provide a conceptual structure of international cooperation on climate adaptation in the next section.

4. Modes of international cooperation for climate adaptation

Table 3 depicts the five modes of international cooperation for climate adaptation identified from the literature, UNFCCC documents and process observation: finance, technology, learning, insurance and institutional development and organisation. The table provides a short description, identifies core design parameters as well as manifestations in the current UNFCCC regime and gives references. In addition to the modes, four dimensions are of cross-cutting nature, i.e. relevant in all five modes: the framing of adaptation; the relation with existing institutions; monitoring and evaluation; and the organisation of international decision-making.

The modes are conceptually distinct as they have distinct design parameters as well as distinct potential effects on local climate adaptation. Nevertheless, they can overlap, for instance in a programme of financially supported technology transfer and learning. Moreover, the overall effect of an international arrangement depends on the interplay of these modes.

As table 3 suggests there is potential to support climate adaptation in low- and middle-income countries through international cooperation, for instance by relaxing resource constraints, facilitating conducive institutional environments and learning, and sharing risks. However, the precise design of international arrangements will crucially shape their effectiveness in local arenas. This is subject of section 5.

Modes of international cooperation on adaptation to climate change				
Mode	**Stylised description**	**Core Design Parameters**	**Manifestation in the UNFCCC regime (examples)**	**References**
Finance	Description: Transfers of financial resources (grant or loan) to an operator as a means for adaptation. Possible direct effect at local levels: enhanced resource opportunities for operators of adaptation.	▪ Funding sources (e.g. bilateral/multilateral, private) ▪ Operation of the funds - Eligibility rules and access modalities. - Disbursement channels and implementation. - Monitoring, reporting, verification. ▪ Allocation of the funds - Prioritisation rules (e.g. criteria, indicators). - Cost measures (e.g. incremental/additional/full costs).	Adaptation Fund, LDC Fund, SCC Fund, Green Climate Fund.	Bouwers/Aerts 2006; Ayers 2009; Fankhauser/Burton 2011
Technology Development, Transfer and Diffusion (TDTD)	Description: International cooperation to develop, transfer or diffuse technologies for adaptation. Possible direct effect at local levels: improved technological capacities for operators of adaptation.	▪ Funding of TDTD. ▪ Scope of the term "technology" (e.g. "hard", physical technologies such as drainage systems or seeds; "soft" technologies such as crop rotation patterns; related technical information and human skills). ▪ Organisational arrangements at global, regional, and national levels. ▪ Arrangements for the implementation of projects and measures, e.g. adoption of technologies to local contexts, effective use and maintenance of available technologies. ▪ Measures to strengthen domestic R&D capacities in developing countries and south-south cooperation. ▪ Design of intellectual property rights.	Technology Mechanism (Climate Technology Center and Network; Technology Executive Committee), Nairobi Work Programme.	UNFCCC 2006; Christiansen et al. 2011; Lybert/Sumner 2012
Learning	Description: Development of understanding and access to information among potentialactual operators of adaptation. Possible direct effect at local levels: - Improved availability and access to data and information. - Improved mental models.	▪ Matching mechanism for actors (e.g. providers of data and information, knowledge intermediaries, and end-users), e.g. participation rules, accepted types of knowledge, thematic areas, knowledge products. ▪ Resources for provision of data and information. ▪ Capacity-building measures for using information.	Nairobi Work Programme, National Adaptation Programmes of Action (NAPA), National Communications, IPCC.	Lu 2011

Insurance and Risk Reduction	Description: Instruments to share and transfer climate-related financial risks. Possible direct effect at local levels: - Controlling financial risks and improving incentives to invest. - Incentives for preventive risk reduction. - Increasing post-disaster relief capacity.	▪ Objects of international financial support (e.g. start-up costs for insurance markets, premium subsidies). ▪ Incentives for preventive risk reduction (e.g. deductibles, reduced premium rates, required minimum risk reduction measures, focus on extreme layer of risk funding). ▪ Eligibility and access modalities for participation in the scheme. ▪ Index (e.g. weather related parameters) and coverage (e.g. public and private assets). ▪ Operational rules of the insurance facility.	Climate Risk Insurance Facility under the Work Programme on Loss and Damage (being negotiated).	Bals et al. 2006; Linneroth-Bayer/ Mechler 2007; Collier et al. 2009
Institutional Development and Organisation	Description: Establishing or changing rules, decision-making procedures, and rights at regional, national and sub-national levels Possible direct effect at local levels: Improved systems of decision making	▪ Incentives , resource mobilisation and/or commitments for designing/reforming institutional arrangements and policies at regional, national and subnational levels.	National Adaptation Plans (NAP), Nataional Adaptation Programmes of Action (NAPA), National adaptation strategies, Regional Adapation Centres.	Harmeling et al. 2011

Cross-cutting issues (relevant in each of the five modes)		
Issue	**Description and design parameter**	**References**
Framing	Explicit or implicit definition of adaptation to climate change.	Horstmann 2008
Relation to existing institutions and practices	Creation of new institutions or adjustments of existing institutions and practices; shaping the interplay with other international arrangements.	Harmeling et al. 2011
Monitoring and evaluation	Arrangements to observe and review adaptation activities and their results.	Spearman/ McGray 2011; Lamhauge et al. 2012
Organisation of international decision making	Procedures, rules and decision-making bodies for international level decision making.	

Table 3: Modes and cross-cutting issues of international cooperation on adaptation to climate change (authors' compilation).

5. Design properties of international arrangements for climate adaptation

Based on the previous results this section investigates conditions under which international cooperation is likely to facilitate urban climate adaptation in low- and middle-income countries. For this purpose, we use the models of adaptation barriers and change factors from section 3 and the conceptual structure from section 4 to develop testable propositions about the effects of selected configurations of international arrangements on urban adaptation barriers, change factors and processes. In order to provide focus we concentrate on four configurations of design parameters, for which particularly meaningful insights emerge from the meta-analysis of urban adaptation barriers and change factors (section 3).

Table 4 summarises the investigated design parameter configurations and their expected effects on adaptation barriers, change factors and processes using the notation of section 3 (see table 1 and 2; figure 2 and 3).

5.1. The Problem of Municipal Commitment and Coordination: National and Subnational Adaptation Policies

There is a range of regulatory measures for adaptation at the municipal level including adjustments of building codes, infrastructure standards and land-use management. They often require commitment, prioritisation, or institutional development rather than large budgets of adaptation finance (Satterthwaite 2011). Such regulatory adaptations can be driven by endogenous dynamics at the municipal level. The change factors for municipal adaptation in section 3.2 above illustrate this. However, institutional deficits, constrained resources, concurrent development goals and limited awareness and understanding of local vulnerabilities can impede such endogenous dynamics (see "barriers" in section 3.2). External factors from outside the municipality may partly compensate the lack of endogenous drivers. Carefully developed adaptation policies at national and provincial/district levels may initiate and guide municipal adaptations (Heinrichs et al. 2011). They have the potential to address an array of adaptation barriers and change factors. In particular, the process of developing, implementing and complying with such adaptation policy frameworks may disclose institutional deficits in municipal adaptation and induce responses (ID1-6). Climate vulnerability and adaptation as an emerging item in urban agendas may raise awareness about local vulnerabilities among municipal officials or stakeholders (AU1/AU2/UP2). It may change frames of reference and priorities they assign to development goals and strategies (NC1). Additionally, national policy frameworks can be an instrument to anchor climate change in the municipal agenda (UP4) and commit municipal leaders to advance urban adaptation (UP5). International cooperation in turn can play an important role for

Configurations of selected design parameters and their expected effect on urban climate adaptation			
Configuration of design parameters	**Involved modes and design parameters**	**Expected effect on urban adaptation barriers and change factors**	**Expected effect**
National and subnational adaptation policy	▪ Institutional Development: incentives, resources, commitment	Altered Barriers ID1 ID6 ID2 NC1 ID3 AU1 ID4 AU2 ID5 Addressed Change Factors NP1 UP2 UP4 UP5	m↑; c↓; um↑; i↑; ma↓
Regional and national centres of competence	▪ Institutional Development: resources ▪ Learning: matching mechanism, resources	Altered Barriers CR2 AU1 Addressed Change Factors UP2	m↑; c↓; um↑; i↑; ma↓
Reform of access of urban poor to the formal public sector	▪ Institutional Development: incentives, resources, commitment	Altered Barriers RG1 MP1 RG2 MP2 RE2 MP3 RE4 Addressed Change Factors PA1 PA3	m↑; c↓; i↑; ma↓
Flexible indicators of adaptation benefits	▪ Finance: monitoring and evaluation ▪ Finance: prioritisation ▪ Finance: methodologies/ procedures for developing and applying indicators	Increased probability of addressing locally relevant barriers and change factors by tailoring international-level decision making and monitoring/ evaluation systems to diverse adaptation contexts. Altered Barriers RE2; RE3; HS1; AU1; AU2; CR2; ID1-6 Addressed Change Factors HH3; PA1-3; NG1; NG2; UP1; UP2; UP6; NP1	m↑; c↓; um↑; i↑; ma↓

Table 4: Configurations of selected design parameters and their effects on barriers, change factors and processes of urban climate adaptation (authors' compilation). Symbols: see table 1 and 2, resp. figure 2 and 3.

initiating national adaptation policy frameworks by creating incentives and commitments for national-level decision makers. This might also improve the institutional setting for channelling international resources through different administrative levels. A major supportive factor for the effectiveness of national and subnational adaptation policies is the stimulation of endogenous dynamics in local arenas, e.g. through developing awareness and skills or by building linkages between adaptation and local development priorities.

5.2. The Problem of Municipal Learning: Regional and National Centres of Competence

In a similar vein, international cooperation may support national and subnational endogenous adaptation dynamics by (co-)financing regional and national centres of competence. These are platforms with missions ranging from research, knowledge sharing, knowledge services, the

transmission of good practices, facilitation of networks, to the development, transfer and diffusion of adaptation technologies (McGray 2009). These services have the properties of a club good, i.e. users can be excluded at low costs, but the consumption of one actor does not reduce the options for use by other actors. Economically, larger-scale centres of competence are particularly useful for climate services that are provided at high fixed costs, and benefit a larger number ("club") of service users with similar needs. The centres change the models of adaptation barriers and change factors, if they support adaptation-relevant awareness and knowledge (AU1, AU2, RE3, UP2), including for potential local climate change champions (UP1), provide reliable and accessible data and information (CR2), facilitate adaptation networks (MN1), and relax technological constraints (PA1, NG1).

5.3. The Problem of Exclusion of Urban Poor: Institutional Reforms for the Inclusion of Urban Poor in the Formal Public Sector

Many of the adaptation barriers in urban squatter settlements (cf. section 3.1) are related to a precarious status of urban poor within the formal public system. An illegal status or a hostile relation between public agencies and urban poor limits the extent to which adaptation of urban poor can be effectively facilitated through international cooperation. This is due to several effects. First, the illegal status limits the access that dwellers have to international support through public agencies. It also prohibits any mechanisms through which public official agencies are hold accountable to these dwellers. Second, partly a result of this, squatter settlers often lack the access to public education, health and basic infrastructure services leaving them with low formal education and with limited infrastructure-related means to adapt to hazards. Community-based provision of infrastructure services such as self-organised waste collection may alleviate some risks, but often depends on larger scale infrastructure systems. Third, insecure land tenure and the risk of eviction add a further disincentive for taking costly risk reducing investments in housing. Fourth, a lack of public security services can sustain and aggravate violent social conflicts among slum dwellers exacerbating climate vulnerabilities. Finally, the options and benefits of non-governmental organisations' involvement largely depend on the legal and political context in which they operate (Ayers 2009; Satterthwaite et al. 2009; Jabeen et al. 2010). In summary, these effects clearly suggest that a precarious status of squatter dwellers in the public system is a major bottleneck for international adaptation support to be effective for them. If international adaptation support is supposed to assist the most vulnerable groups of societies, reforms for the inclusion of urban poor seems both a precondition and a means for effective international adaptation arrangements. There is a plethora of effects that such reforms can have on the models of adaptation barriers and change factors in urban squatter settlements. They may improve the formal citizen status of dwellers (RG1), access to formal education and public health (RG2) and work towards tackling the problem of contested land tenure (RG3). Additionally, they may increase accountability of public officials for dwellers (MP1) and thereby improve access to governmental

provision of infrastructure and services (PA1; RE2) and access to international adaptation support (PA3). They may also prevent maladaptive municipal planning and regulation (MP2), and connect urban poor to formal institutions for disaster preparedness (MP3). Overall, these changes would increase the available means for adaptation by urban poor, improve incentives for adaptive actions and reduce incentives for maladaptation.

5.4. The Problem of Measuring Benefits of Adaptation Interventions in Heterogeneous Cases: Flexible Indicators

The provision of adaptation finance evidently eases constraints of financial resources for the receptors of the funds. Depending on its use adaptation finance may indirectly address an array of other barriers and change factors for adaptation. This includes, but is not limited to, interventions which target a lack of basic infrastructure (RE2) and low quality housing (RE3), investments to address limited skills and formal education (HS1), vulnerability assessments to enhance awareness and understanding of vulnerability and adaptation (AU1/AU2), infrastructure for the provision of locally relevant data (CR2), programmes that support institutions building (ID1-6) and the diversification of livelihood options (HH3).

However, the configuration of design parameters crucially shapes the likelihood that international financial adaptation support targets locally relevant adaptation barriers and change factors in an effective manner. In this context, this subsection examines the role of indicators for monitoring, reporting, verification as well as for prioritisation of funds.

Indicators are widely seen as important instruments to operationalise and measure unobservable concepts such as vulnerability and the effects of adaptation interventions. Indicators consist of observable variables and functions that relate these variables to the latent concepts of interest (Hinkel 2011). They are expected to serve multiple purposes (ibid.). By synthesizing dense information in simple numbers, they are supposed to ease communication about complex issues. In vulnerability or harm indices they are used to identify particularly vulnerable groups, regions or sectors (e.g. Harmeling 2009). As assessments of adaptation effectiveness they can be meant to inform the prioritisation of adaptation funds (Stadelmann et al. 2011). In arrangements for monitoring and evaluating adaptation interventions they are supposed to contribute to social learning about good practices, to holding agents accountable for their decisions, and to communicating outcomes (Lamhauge et al. 2012).

However, one of the severe difficulties with indicators of the benefits of adaptation interventions at the UNFCCC level is the large diversity of adaptation at lower levels. A broad range of climatic stimuli,

exposed entities, operators, levels of decision making, and normative backgrounds impede the quest for universally applicable indicators of adaptation benefits. As a consequence, we currently have a wealth of contextualised information and models about the course of climate adaptation in particular cases. We also have frameworks of repeated determinants of vulnerability and adaptive capacity (e.g. Adger et al. 2007). But we rarely see generalised, empirically validated theories and models. These would explain in more detail how variables interact and shape climate adaptation processes. This generic knowledge about the interactions and effects of indicating variables on adaptation processes would be necessary to relate generic indicating variables to the latent concept of adaptation benefits (Hinkel 2011). In short, the diversity of adaptation and the lack of general theories and models impede the quest for generic, scientifically sound and meaningful indicators of adaptation benefits. There seems to be a trade-off between the generality of indicators (enabling systematic validation of indicators; improving the comparability of cases) and their applicability (improving the fit with particularities of cases). For addressing local adaptation barriers through international cooperation this trade-off implies that overly general indicator frameworks would not allow to target interventions to the locally relevant adaptation barriers. International support may underperform or even be counterproductive in addressing barriers. Thus, at what level of generality are indicators of adaptation benefits appropriate?

The meta-analysis of urban adaptation in developing countries (section 3) suggests that there are repeated patterns of adaptation barriers and change factors. But these are context-dependent in two meanings: First, there are major variations of barriers between different archetypes, e.g. between adaptation in urban squatter settlements and adaptation by municipal authorities. Second, there are additional minor variations within an archetype concerning the case-specific relevance of specific barriers, their manifestations and their precise interrelation and effect on processes. Developing a set of indicators for adaptation benefits in urban settings is beyond the scope of this article. But given the patterns of barriers just described and assuming that indicators shall be used in international cooperation for adaptation it seems a worthwhile strategy to develop flexible indicators of adaptation benefits to ensure that international mechanisms are able to support local adaptation processes in an effective manner. These indicators would be flexible in two ways: First, there are different sets of indicators for different archetypes of adaptation. This captures the major differences between archetypes. Second, standard indicators of one archetype could be combined with additional idiosyncratic data. This captures the minor idiosyncracy of cases within an archetype.

The procedure of developing and applying flexible indicators of adaptation benefits for UNFCCC adaptation arrangements has implications. Importantly, it is expected that the indicators would yield non-commensurable data. While incommensurability may exist within an archetype, e.g. in data about how different barriers have been addressed, incommensurability is very probable for data of different

archetypes, e.g. when comparing adaptation in an urban squatter settlement with the protection of marine ecosystems. Thus, flexible indicators can only inform, but not pre-determine, allocation decisions for international adaptation funds. As Klein (2009) and Hinkel (2011) outline, funding decisions at this level are still a political problem of negotiating and agreeing on the procedures, methods and final decisions. Indicators can be an informative instrument, but no "allocation algorithm" (Hinkel 2011:205).

Flexible indicators in this sense are a promising instrument to ensure that indicator-based international support effectively targets local barriers to adaptation. Both flexibility elements – distinction of archetypes and option of idiosyncratic data – enhance the fit of indicators with particularities of cases while allowing to reap the benefits that indicator frameworks offer for public choices.

6. Conclusions and future research

The paper combines a bottom-up analysis of empirically revealed barriers and change factors for climate adaptation in urban squatter settlements and in municipal public sectors in developing countries (part I) with the conceptual structure of modes of international cooperation on adaptation (part II) to provide models of design parameters of international arrangements for climate adaptation (part III).

Several lessons emerge. First, there are repeated patterns of barriers for urban adaptation in low- and middle-income countries, but these vary at an intermediate level of generality (see figure 2 and 3). It seems feasible and instructive to cluster these patterns in "archetypes" with minor variations within an archetype (e.g. case-specific relevance and manifestation of barriers/change factors) and major variations between different archetypes (e.g. types of barriers/change factors, exposed systems, and operators). Second, there is an array of potential change factors in urban squatter settlements and public sectors. They alter barriers and/or drive adaptation processes (see table 1 and 2). Third, international agreements such as arrangements under the UNFCCC may facilitate local adaptation in a variety of ways. We discussed four options here. International cooperation may address urban adaptation barriers and change factors by initiating national and subnational adaptation policies; regional and national centres of competence; addressing problems of access of urban poor to the formal public sector; and by flexible indicators of the benefits of adaptation interventions (see table 4).

Methodically, the paper presents and applies a novel modelling framework for barriers to climate adaptation based on the notion of archetypes (Eisenack 2012b) and the diagnostic framework of climate adaptation (Oberlack/Neumärker subm.). It proved helpful to distinguish exactly five ways in

which a barrier may impede the adaptation process: (1) by constraining the available means for adaptation; (2) by hampering the use of available means; (3) by increasing the costs of adaptation including transaction costs; (4) by reducing the incentives for adaptation; and (5) by increasing the incentives for mal-adaptation.

Future research may build upon this article. The framework for adaptation barriers and change factors may be used to study adaptation processes in other settings like adaptation in agricultural or energy systems. Future studies may empirically test the developed models of effectiveness of international cooperation. They may also extend the analysis to other modes and design parameters of international cooperation like insurance schemes and technology arrangements. Apart from this, the results of the present study can be used to assess current international arrangements for climate adaptation, and the typology of modes of international cooperation may be extended through creative design of new mechanisms and instruments.

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