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Institutional Barriers and Enabling Conditions for Public Sector Adaptation to Climate Change in Europe

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Abstract:

Background: It has been well established that the institutional context within which actors take decisions is one of the decisive determinants for adaptation to climate change. A fast growing body of empirical literature has revealed a vast number of institutional attributes that either impede or foster the process of climate adaptation, most often dependent upon the biophysical and socio-economic context of the situation. However, synthesis of this diversity is timely needed not only for an academic interest in building generalisable theories of climate adaptation, but also for enabling cross-case learning. Moreover, adaptation policies currently developed and implemented at national and international levels involve a very large number of single cases. Policy formulation at these levels requires a knowledge base at an appropriate level of generality which allows for, on the one hand, identifying patterns shared by multiple cases and, on the other hand, for accounting for the particularities of individual cases where needed. Against this background this paper synthesizes empirical evidence on institutional barriers and enabling conditions for adaptation to climate change by public sector agents across a range of economic sectors in Europe. These insights provide theoretical foundations about institutional design properties for effective and balanced public climate change adaptation.

Methods and concepts: The paper conducts a model-centered meta-analysis. Based on a systematic search and selection of published literature it identifies 12 empirical case-studies comprising 25 cases on the institutional dimensions of public sector adaptation to climate change in Europe. A structured coding scheme is developed to extract the models that have been empirically supported in these case-studies. A qualitative analysis of this data set reveals converging and diverging empirical evidence about institutional barriers and enabling conditions for climate adaptation. The conceptual and theoretical groundwork is a diagnostic, multi-tier framework of climate adaptation based on Ostrom's IAD framework.

Results and Conclusions: The study finds 17 distinct functions and properties of institutions that shape the processes and outcomes of climate change adaptation where public sector agents are operators of adaptation. The paper presents how specific manifestations of these institutional attributes interact with each other and with biophysical and socio-economic variables to form adaptation barriers, and how institutional designs enable actors to overcome adaptation barriers. By doing so the paper

identifies empirically revealed institutional design properties for effective and balanced public sector adaptation in Europe. In the final step, a typology of revealed institutional barriers is given.

Keywords: Barriers to climate adaptation; Qualitative meta-analysis; Institutional design properties; Public sector adaptation; Europe.

1. Introduction

The established literature on adaptation to climate change leaves no doubt: institutions, i.e. the rules and norms which frame human actions, are one of the decisive factors for enabling, impeding and shaping adaptation (Yohe/Tol 2002; Adger et al. 2005; Adger et al. 2007; Gupta et al. 2010; Eakin et al. 2011). Conceptually, there is an array of ways how institutions shape adaptive actions. Institutions prohibit, prescribe or allow certain actions or outcomes and define positions, procedures, rights and duties. They are sources of constraints, rewards, or punishment. By framing mental models of a situation, institutions influence what counts as rational and which values and notions of justice find application in that situation. By providing predictability and defining procedures they mitigate or regulate conflicts and enable cooperation. By assigning rights and positions they distribute power and authority (March/Olsen 1989; North 1990; Ostrom 2005; Paavola/Adger 2005; Vatn 2005; Young et al. 2008). Thus, whether or not actors take effective, efficient, and legitimate action in response to or expectation of climatic changes crucially depends on the presence of an appropriate institutional framework.

While this abstract conclusion seems to be widely accepted, one of the major challenges to research in this area is to gain a substantially more detailed understanding of the institutional characteristics that foster, respectively impair, adaptation processes in different social, economic and biophysical contexts. The literature has generally taken two strategies to tackle this question. One strategy is to develop a general framework of institutional characteristics that are theorized to have an impact on adaptation. Taking this road, Agrawal (2008; 2010) and Agrawal/ Perrin (2009) use the literature on common-pool resources and decentralization to derive 20 factors that they assume to affect the performance of local institutions for adaptation of the rural poor. In a similar manner, Gupta et al. (2010) present six dimensions with 22 criteria to assess the adaptive capacity of institutions based on climate adaptation literature. These kind of studies present comprehensive lists of variables. They indicate institutional dimensions with assumed relevance for adaptatoin and might serve as heuristic tools for future studies. However, these frameworks need further empirical verification to assess their validity, the relative importance and the interrelatedness between the variables. A second strategy to tackle the above question is to perform in-depth case-studies in one or a couple of settings. This research strategy uncovers how institutions affect adaptation processes in a highly specific context. They attempt to identify complex interrelations between institutional and non-institutional variables based on empirical data. However, a recognized weakness of the case-study approach is that its low external validity meaning its results cannot easily be extrapolated to other cases (van Laerhoven 2010). Therefore, synthesis of the diversity of singular case studies is timely needed not only for an academic interest in building generalisable theories of climate adaptation, but also for enabling cross-case learning. Moreover, adaptation policies currently developed and implemented at national and international levels involve a large number of single cases. Policy formulation at these levels requires a knowledge base at an appropriate level of generality which allows for identifying patterns shared by multiple cases while accounting for the particularities of individual cases where needed.

This article integrates both research strategies. It builds upon a diagnostic framework of climate adaptation and performs a meta-analysis of case-study evidence about the role of institutions for climate adaptation. By doing so it investigates design properties of institutional systems that are likely to characterize self-organizing social systems which enable actors to adapt effectively to climatic change.

The paper focuses on a particular "arena of adaptation", that of public sector adaptation. The regional focus is on Europe. Conceptually, the distinctive feature of this arena is that governmental or public administration agents serve as operators of adaptation, i.e. they exercise anticipatory or reactive responses to climatic change by taking political and administrative decisions. Other important "arenas of adaptation" seem to be private adaptation by households, business and non-governmental organizations, the public sector as facilitator of private adaptation, community-based adaptation, and international adaptation. It is argued here that the concept of "arenas of adaptation" supports investigations at an intermediate level of generality by clustering cases that share relevant patterns in one arena while clustering cases with other patterns into other arenas. By doing so it supports efforts to reveal generalisable patterns while minimizing the risk of invalid panaceas (Ostrom 2007).

The paper conducts a model-centred meta-analysis (MCMA) of empirical case-studies. A MCMA is a structured, qualitative method that synthesizes diverse findings from case studies in order to provide a comprehensive picture and generalisable conclusions about the research questions while remaining sensitive for the particularities of the diverse social, resource, and biophysical contexts of cases. It allows to integrate both qualitative and quantitative studies. Based on Rudel (2008) this article refines and develops the MCMA method to study the role of institutions for adaptation to climate change. The basic idea of MCMA is to gather the empirical findings of case studies, to apply a standardized coding scheme of model types, and finally to analyse the meta-dataset. By using an appropriate coding scheme the MCMA reduces the complexities involved in a structured, controlled and comprehensible manner in order to derive generalisable and context-sensitive conclusions.

The article contributes in four ways to scholarship about adaptation to climate change: First, it develops a comprehensive picture of the crucial institutional dimensions in the arena of public sector adaptation based on empirical evidence. Second, by means of the MCMA method it builds explanatory, generalising, and refutable models that explain how these functions and properties of the system of institutions impede or foster adaptation processes and reveals relevant interactions between institutional and social, economic or biophysical variables. Third, it develops these insights at an intermediate level of generality and closes the gap in the literature which so far mostly focuses on single cases or generalizing conceptual maps. Fourth, it proposes and develops the method of model-centered meta-analysis as a powerful, systematic and transparent tool for meta-analyses of literatures that are predominantly of qualitative nature.

The article is organized as follows. Section 2 presents methods and concepts. Section 3 gives an overview over the revealed institutional dimensions of public sector adaptation in Europe and the frequencies of models in the case studies. Section 4 discusses these empirically supported models that explain how institutional systems shape climate adaptation. Section 5 concludes.

2. Methods and Concepts

2.1. The Diagnostic Framework of Climate Adaptation

For the purposes of this article we define adaptation as action or adjustment of behaviour undertaken by individual or collective actors in response to, or in anticipation of, climate-related changes of

environmental conditions. A barrier is defined as an impediment in the process of adaptation that either limits the actors' set of available means for adaptation (i.e. adaptive capacity) or restricts actors from realising their adaptive capacity (Oberlack/Eisenack forthc.). Institutions are defined as the "prescriptions that humans use to organize all forms of repetitive and structured interactions" (Ostrom 2005:3).

The question what determines the processes and outcomes of adaptation to climate change has been approached with methods and perspectives from many disciplinary and interdisciplinary research programs. Consequently, the literature uses a broad range of concepts and provides many findings which are specific to a certain context and/or scale. In order to make this complexity more tractable while minimizing the risk to lose relevant information this study adopts the idea of a *multi-tier conceptual map* (Ostrom 2005, 2007, 2009). This is a classificatory framework that organises variables which were found to influence adaptation processes and outcomes. It partitions these variables into classes and subclasses on multiple conceptual tiers such that the lower-tier variables are subcomponents of the higher-tier variables. It helps identify single factors or combinations of them that may impact on adaptation in one type of situation and not in others. The development of this framework was guided by the conceptual groundwork of the Institutional Analysis and Development framework (Ostrom 1990, Ostrom et al. 1994, Ostrom 2005) and used an open coding procedure drawing on several hundreds of publications in the field of climate change adaptation, vulnerability and reslience. It adopts the IAD framework and the SES framework (Ostrom 2009) to particularities of climate adaptation. (for details on the development see Oberlack/Neumärker forthc.).

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): properties of the climatic and non-climatic stresses [CS], attributes of the governance system [GS], available resources [R], and attributes of the involved actors [AA]. The CS-, R-, GS- and AA-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. maximizing utility, using heuristics) and modes of acquiring and using information (e.g. using mental models) (Ostrom 2005).

Table 1 unpacks the first-tier variables into the second-tier, and partly third-tier variables

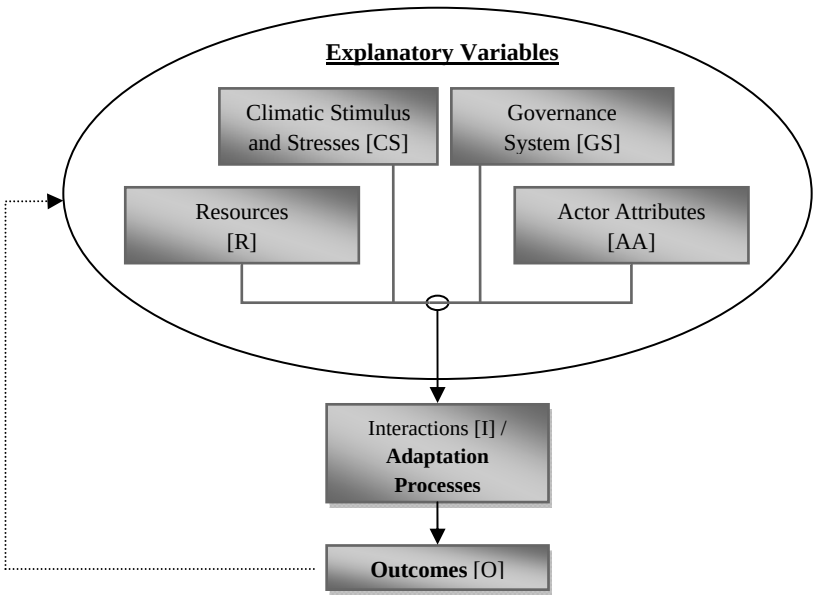

Figure 1: First-tier variables of the diagnostic framework of climate change adaptation (source: Oberlack/Neumärker forthc.)

Table 1:

	Climatic Stimulus and Stresses to the exposed unit [CS]	*References (example)*
CS1	Climatic stimulus/ change in ecological parameters (type, intensity, duration, frequency, regularity, predictability)	*Parry et al. 2007*
CS2	Exposure to climatic stimulus	*Parry et al. 2007*
CS3	Sensitivity against climatic stimulus	*Parry et al. 2007*
CS4	Concurrent non-climatic goals and stresses (e.g. market price pressures, demographic change, competing claims)	*O'Brien/Leichenko 2004*

	Resources [R]	*References (example)*
R1	Physical Infrastructure and Technology	*Yohe/Tol 2002*
R2	Assets, Financial Resources and Credit	*Yohe/Tol 2002*
R3	Insurance	*Yohe/Tol 2002*
R4	Information	*Di Falco et al. in press*
R5	Natural Resources	*Arnell/Delaney 2006*
R6	Other Resources (e.g. labor)	*Tucker et al. 2010*

	Governance System [GS]	*References (example)*
GS1	Attributes of the Rule System (for structuring action situations)	*Gupta et al. 2010*
GS2	Attributes of the Rule System itself (e.g. institutional inertia)	*Gupta et al. 2010*
GS3	Interplay of Governance Levels (vertical/ horizontal)	*Keskitalo et al. 2010*
GS4	Attributes of Organisations	*Tompkins et al. 2008*
GS5	Modes of Organisation (e.g. market, hierarchy, network)	*Mendelsohn 2006*

	Attributes of the Involved Human Actors [AA]	*References (example)*
AA1	Socio-economic Attributes (e.g. health, age)	*Brooks et al. 2005*
AA2	Number of Actors	*Barnett 2008*
AA3	Relationship between Actors	
	a. Social Capital	*Pelling/High 2005*
	b. Distribution of Power	*Engle/Lemos 2010*
	c. Characteristics of Leaders	*Ivey et al. 2004*
	d. Communication	*Ivey et al. 2004*
	e. Conflicts	
AA4	Behavioural Variables	*Grothmann/Patt 2005*
	a. Preferences and Values	*Ivey et al. 2004*
	b. Mental Models and Knowledge	*Alessa et al. 2008*
	c. Awareness and Concern	*Amundsen et al. 2010*

	Interactions [I]
I1	Vulnerability to climatic and non-climatic stresses
I2	Barriers to Adaptation
I3	Drivers of Adaptation
I4	Adaptation Activities and Processes (e.g. types, timing, duration, extent)

	Outcomes [O]
O1	Impacts on CS-, R-, GS- and AA-Variables
O2	Effects on Other Processes (e.g. climate mitigation)
O3	Evaluative Criteria (e.g. efficiency, effectiveness, fairness)

Table 1: Second-tier and partly third-tier variables of the diagnostic framework (source: authors' compilation).

It is important to note that in a particular case typically only a subset of these variables are examined and only a subset may matter for the adaptive capacity in that case. “The choice of relevant second or deeper levels of variables for analysis (from the large set of variables at multiple levels) depends on the particular questions under study, the type of social-ecological system, and the spatial and temporal scales of analysis.” (Ostrom 2009:420) Furthermore, the possible manifestations of the variables may differ from case to case. For example, establishing an early-warning system against storm surges will require quite different information and knowledge than the adoption of agricultural production to changing soil quality. Thus, this framework helps to identify the niche of a specific case and helps to avoid panaceas (Ostrom 2007). In this sense, it is highly useful for the meta-analysis of a highly disordered literature, because it helps to understand relationships between the concepts and variables in single (case) studies and provides the ground for results that go beyond the primary studies.

Based on this diagnostic framework the purpose of the subsequent meta-analysis is twofold: First, it identifies the institutional dimensions that have been empirically found of particular relevance for climate adaptation by public sector agents. Second, it develops empirically supported models that explain how functions and attributes of the institutional system impede or foster climate adaptation. Thus, in terms of the diagnostic framework the meta-analysis analyses in-depth the variables GS1, GS2 and GS3. The R-, CS- and AA-variables are indirectly relevant to the meta-analysis in the sense that they are potential sources of interaction effects between institutional variable [GS1-3] and barriers to adaptation.

2.2. The Model-Centered Meta-Analysis

The diagnostic framework of climate adaptation serves as the heuristics for the subsequent meta-analysis of case study evidence. Meta-analyses most often examine the statistical evidence of the primary literature on the effect of some variable(s) X on another variable Y (Cooper et al. 2009). Usual steps are to pool the effect sizes (e.g., regression coefficients, correlation coefficients, t-statistics) of the primary studies, to compile an overall effect size and to perform a moderator analysis. This presupposes that the primary literature uses statistical tests for a shared research question with fairly homogenous indicators for the variables in question. However, the climate change adaptation literature provides a different research landscape. The majority of adaptation studies uses qualitative methods for empirical studies. The few studies that report statistical effect sizes (e.g. Tol/Yohe 2007, Bryan et al. 2009, Posey 2009, Coleman 2011) differ largely in the type of effects that they quantify. Rudel (2008) suggests for this type of primary literature to pool the “models” that have been derived from the original data rather than pooling the data or effect sizes themselves. The next step is to look for systematic patterns across the models. A model in this terminology is a statement about the relationship between variables X and Y that has been empirically supported in the primary research. Such an approach is taken, e.g., by Geist/Lambin (2001) for tropical deforestation and Misselhorn (2005) for food insecurity. Appropriate to the heterogeneous and often qualitative body of primary literature in the field of climate change adaptation and appropriate to its purposes, this study conducts a model-centered meta-analysis of case study evidence using a similar procedure. The approach takes five steps as shown in table 2.

(1) The guiding question of this meta-analysis is: Which design properties of institutional systems characterize self-organizing social systems which enable actors to adapt effectively to climatic change and which design properties are likely to contribute to persistent barriers to adaptation? Thus, the purpose of this research effort is to reveal underlying design attributes of institutional systems that characterise adaptive social systems and design attributes in cases with persistant barriers to adaptation.

Steps of the meta-analysis:	
1	Giving a clear organizing research question
2	Identifying the relevant literature
3	Selecting the studies
4	Coding the study results
5	Analyzing the meta-data set and presenting the results

Table 2: Steps of a model-centered meta-analysis.
(Source: Adapted from Rudel 2008 and Cooper et al. 2009).

(2) The search strategy for primary literature comprised the use of the Web of Science database and cross-references. The following searchterms were use to identify relevant literature that was published up to January 2012: "adaptation AND (climat* OR extreme* OR environmental change OR global change OR natural hazard* OR hazard* OR Resil* OR Vulnerab* OR Risk*)", "(adaptive capacity OR adaptability) AND (climat* OR extreme* OR environmental change OR global change OR natural hazard* OR hazard* OR Institution* OR Regime* OR Governance OR Determinant* OR Indicator* OR Assessment* OR Eval* OR Barrier* OR Driver* OR Resil* OR Vulnerab* OR Risk* OR Case study)", "(cope OR coping) AND (climat* OR extreme* OR environmental change OR global change OR natural hazard* OR hazard*)", "(resilienc* OR vulnerab*) AND (climat* OR extreme* OR environmental change OR global change OR natural hazard* OR hazard*)", "disaster risk reduction", and "natural hazard*". This procedure yielded an initial sample of 27.672 publications most of which could be excluded as "off-topic" by manual screening of the title. This step provided the primary sample.

(3) The primary sample is subject to several filters to be fulfilled in order to be included into the meta-analysis. First, the research must show sufficient methodological quality in terms of transparency as well as internal and construct validity (based on Miles/Huberman 1994, Mayring 2002, Yin 2003). Table 3 shows the criteria used to evaluate the methodological quality of the primary studies. Second, the primary study must use systematically empirical data or evidence and this evidence must support its findings. This implies that results from reviews or from a theoretical model unexposed to systematic empirical observations are not included into the meta-analysis. Third, the topic and research questions of the primary study must fit the question of this meta-analysis, i.e. investigate the relation between institutions (rules) and adaptation to climatic change. For instance, studies that only *describe* existing governance arrangements in the field without investigating their relations with adaptation are not included; the same applies to studies which assess existing institutions against a pre-defined theoretical framework. As a heuristics, it is necessary that the resulting "models" of the primary study must be refutable (or identified differently) by the collected empirical evidence. Fourth, the studies must be written in English.

Finally, from this sample 12 primary studies were chosen for inclusion into the present conference paper. Further studies will be included in the next steps of this paper. A case is defined as a distinct time and place specific action arena (Ostrom 2005). These 12 studies, authored by 35 researchers and published in 10 different journals or books and one policy report, contain research on 25 cases. Table 4 gives descriptive details on the included sample of case studies.

Criterion	Operationalized Criterion
Transparency	- Clear documentation of the whole research process - Use of case study protocol or database
Internal and construct validity	- Adequate and clearly stated theoretical preconceptions - Clear analysis of the empirical material - Alternative explanations are examined - Use of different interpreters - Validation of interpretations, e.g. key informants review draft of case study report - Use of multiple sources of evidence - Coherent interpretations
Other	- No apparent methodological bias

Table 3: Criteria of the methodological quality of the primary studies.
(Source: Author's compilation based on Miles/Huberman 1994, Mayring 2002, Yin 2003).

(4) Results of the selected studies of the final sample were coded. A coding scheme was developed. It makes a detailed, eight-fold distinction as to which types of models between an institutional function or attribute and adaptation barriers have been found in the case study: direct effect, relevance, insignificance, differential effect, moderator effect, conjoint effect, mediator effect, or internal effect. Figure 2 illustrates the different model types of this meta-analysis. Combinations of these types are possible within, e.g., in cases where two mediation effects lead to an undetermined change in the outcome.

To capture the diversity of effects reported in the case studies the coding scheme also distinguishes between different process parameters P_k. Starting with the four-fold classification of Eisenack and Stecker (2012), who distinguish the barriers of missing operators, missing means, unemployed means and complex actor relations, it was found in the course of coding that additional elements were needed to adequately capture the diversity of reported process parameters. Table 5 presents the resulting nine process parameters P_k.

Hazards		Countries		Data Sources	
Flood	7	Netherlands	6	Interviews	9
Multiple	6	Norway	3	Policy and planning documents	6
Coastal Erosion	2	Sweden	2	Workshops, focus groups, roundtable discussions	3
Drought	1	UK	1	First-hand experience	2
		Germany	1	Stakeholder consultations	1
		Ireland	1	Scientific literature	1
				Questionnaire	1

Table 4: Descriptive characteristics of the case studies (n = 12 studies; multiple items possible).

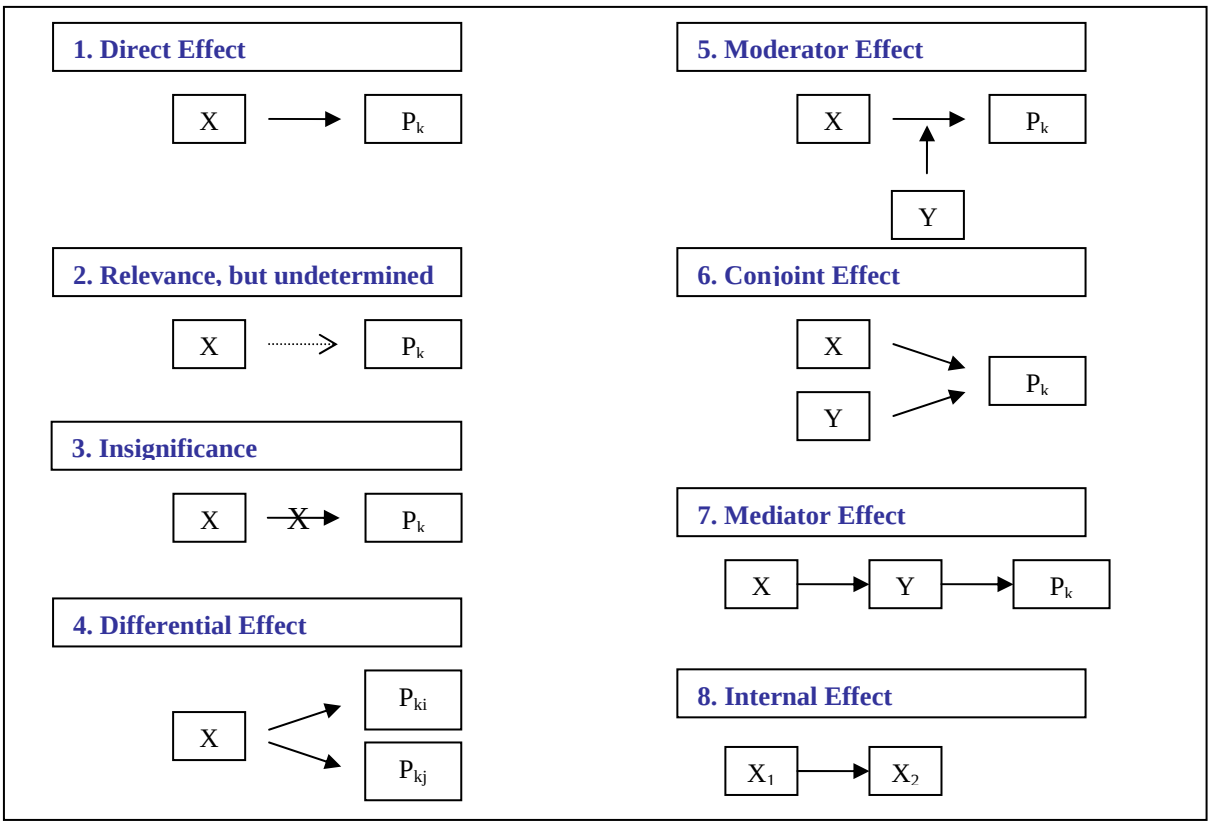

Figure 2: Effect types investigated in the meta-analysis (author's compilation).
X: Institutional Characteristic; Y: Other Variable; P_k: process parameter *k*; i/j: Index for actor i/j.

(5) The final step is to analyze the obtained meta-data set. This step first presents the frequency distribution of effects. It captures a picture of how often direct effects of institutions for shaping adaptation barriers or enabling conditions have been found, and how often more complex interactions seem to characterize the relation of institutions and adaptation. The models obtained for each institutional characteristic are then reported and discussed.

	Possible values of P_k	
Hampering effect	m	Missing means (including unaccessible information)
	o	Missing or unclear operator
	c	Increased costs of adaptation (including increased transaction costs of decision-making)
	di	disincentive for adaptive action (including lack of side-benefits of adaptation)
	ma	incentives for maladaptive action
Fostering effect	e	increased effectiveness
	i	increased incentive for adaptive action
	b	balanced decision-making
	u	increased understanding (i.e. developing appropriate mental models)
	a	increased awareness

Table 5: Codes for process parameters P_k.

3. Results

3.1. Institutional Dimensions of Adaptation by Public Sector Operators

Table 6 depicts the functions and attributes of the institutional system which the meta-analysis has found to impact on adaptation processes in at one or more of the empirical case-studies. It is useful to distinguish governance functions of the institutional system, institutional characteristics of nested governance systems and inherent properties of the institutional system itself.

Institutional Characteristics	Description
Governance functions of the institutional system	
Allocation of roles and responsibilities in collective decision making (clearness and transparency of allocation; completeness; perceived responsibility; leadership)	Attributes of choice rules that define the permitted, required and prohibited set of actions that actors may, must or must not take.
Inclusiveness	Attributes of boundary and position rules that define the set of actors who are eligible to participate in different position in decision-making.
Fair distribution of risks, costs, and benefits	Attributes of rules that impact the distribution of risks, costs, and benefits of adaptation.
Conflict prevention and resolution	Rules and mechanisms for the prevention and resolution of conflicts.
Social Learning	Rules and mechanisms that enable actors to create and use new information, refine routines and to change fundamental mental models and assumptions.
Climate proofing established structures, policies, and practices	Rules and mechanisms to incorporate climate change considerations into established structures, policies, and practices.
Robust process	Attribute of a process to work properly in the presence of biophysical or socioeconomic shocks.
Flexible process	Attribute of a process to allow adjustments of practices.
Trust	Trust among involved actors as an attribute of the adaptation process.
Institutional properties of nested governance systems	
Hierarchical public governance	Guidance by national governments for sub-national and implementing authorities.
Decentralized collective decision-making	Presence of authority at low levels of governance.
Cross-boundary coordination and cooperation	Interaction of agents across the boundaries of established organizations.
External resources	Participants of an arena have access to resources from other levels of decision-making.
Properties of the institutional system itself	
Fit of institutional system with ecological change	The boundaries of the institutional system and the ecological change coincide.
Adaptiveness of institutions	Institutions can be changed at low transaction costs.
Legitimacy of rules and practices	Rules and practices receive public support.
Formality of rules, statutory character, programmatic approach	Formal: Rules are in written form; Statutory: rules are embedded in laws or other formal regulations; programmatic approach: long-term, solid undertaking of broad spectrum.

Table 6: Institutional Dimensions of Public Sector Adaptation to Climate Change.

3.2. Model frequencies

Table 7 presents the frequencies of empirically found model types for each institutional variable X. The numbers state how often X impacted on process parameters P_k or on another variable of the diagnostic framework in a conducive (green), hampering (red), differential (black), or relevant resp. insignificant (blue) way.

There can be three reasons for the parallel presences of conducive, hampering, differential or relevance/insignificance type of effects of institutional variable X on adaptation processes. It can be due to contradictory evidence, due to different effects of distinct sub-variables of X, or due to different effects of X on distinct manifestations of B_k.

Institutional Characteristic	Direct Effect	Rele-vance	Insignifi-cance	Differential Effect	Moderator Effect	Conjoint Effect	Mediator Effect	Internal Effect	Total
Governance functions of the institutional system									
Allocation of roles and responsibilities	1 / 1	1	-	1	1	2 / 1	1 / 2	-	10
Inclusiveness and participation	2 / 1	-	-	2	2 / 1 / 1	1	1 / 1	2	14
Fair distribution	-	-	-	-	-	-	-	-	0*
Conflict prevention and resolution	2	-	-	-	-	2	-	-	4
Social Learning	1	-	-	-	1	1	1	1	5
Climate proofing established structures, policies and practices	2	-	1	-	1	2	1	-	7
Robust process	-	-	-	1	-	1	2	-	4
Flexible process	3	-	-	-	-	-	-	-	3
Trust	1	-	-	-	-	-	-	1	2
Institutional properties of nested governance systems									
Hierarchical public governance	2		2	2	1 / 1 / 1	4	1 / 1	2	17
Decentralized collective decision-making	-	-	-	-	-	1	-	-	1
Cross-boundary coordination and cooperation	1	-	-	1	1	1	3	-	7
External resources	-	-	-	-	-	3 / 1	-	-	4
Properties of the institutional system itself									
Fit	1	-	-	-	-	-	-	-	1
Adaptiveness	1	-	-	-	-	-	-	-	1
Legitimacy	-	-	-	-	-	-	-	-	0*
Formality and statutory character	-	-	1	1	-	3 / 2 / 1	1	-	9

Table 7: Frequencies for institutional function/attribute and effect type.
Notation: Green [red] [black] [blue] numbers indicate how frequent the institutional variable X had a conducive [hampering] [differential] [relevance/insignificant] effect on adaptation processes.
* Trust and legitimacy were found as important outcome variables in internal models.

It is important to note that the numbers do not indicate the relative importance of the variables. For instance, enabling social learning and building trust might be equally important for adaptation although there are five revealed models on social learning compared to two models on trust. To rigorously clarify the relative importance of each factor would require a different study design, could be very case-specific and is left for future studies. Instead of this, the numbers in table 7 present the variety of models that the sample of 12 case-studies revealed building on 25 cases of public sector adaptation. This is in line with the main purpose of this meta-analysis which is to reveal "if X, then Y"-types of models about the working properties of institutions for climate adaptation.

4. Discussion

This section analyses the obtained meta-dataset of empirically supported models. It discusses converging (subsection 4.1) and diverging (4.2) evidence about institutional working properties for effective and balanced climate adaptation in the public sector in Europe.

4.1. Converging Evidence on Institutional Dimensions of Public Sector Adaptation

The meta-analysis reveals instances of converging evidence of case-studies. Converging evidence suggests that there are uncontroversial institutional design properties that contribute to effective and/or balanced public sector adaptation. This subsection presents a synthesis of evidence about these institutional design principles and explains how they shape processes of climate adaptation.

Mechanisms for conflict prevention and resolution:

Conflict prevention and resolution can take many forms such as transparency mechanisms (e.g. monitoring and reporting), managing expectations of stakeholders, involving stakeholders and reframing problems to reconcile initially conflicting interests. This meta-analysis finds effective conflict prevention and resolution mechanisms to support adaptation processes by increasing trust among involved actors (or at least avoid erosion of trust) and contributing to the legitimacy of decision-making, thereby supporting compliance. In one case conflict prevention during policy development was be more cost- and time-efficient than conflict resolution (e.g. lawsuit) during policy implementation.

Climate-proofing established structures, policies, and practices:

Established organizational structures, policies and practices usually emerged under present or past climatic conditions. Climate change will challenge the adaptedness of such achievements in many sectors such as coastal management, health, water, and energy. To incorporate climate change considerations into established policies, structures and practices improves adaptedness of social systems by reducing the risk of unforeseen negative side-effects and maladaptative trends. In addition, it offers the opportunity to resolve conflicts between climatic and non-climatic goals and address antagnostic policy interplays. Concerning the appropriate level of climate-proofing activities, it was shown that missing links to climate change in national-level policies are not too relevant, as long as sub-national agencies can build these links and as long as climatic and non-climatic goals are not overly antagonistic.

Social Learning:

In the context of changing biophysical environments, uncertainty and complexity the presence of mechanisms that enable actors to create and use new information, refine routines and to change basic mental models and assumptions becomes crucial. Institutional arrangements that facilitate such social learning are, for instance, systems of monitoring, reporting and evaluation and integration of lessons into policy processes; participatory processes that integrate dispersed knowledge, explore uncertainties, deliberate alternatives and reframe problems and solutions; science-policy interactions; capacity-building workshops; sharing and transfer of risks for experimentation and innovation; and consistent systems of data management and information support.

Such mechanisms facilitate adaptation processes by improving access to practically relevant and scientifically sound information, improving expertise and understanding among involved agents and reduce transaction costs for individually searching for relevant information. Through facilitating awareness such mechanisms may motivate agents to adapt and through developing sound mental models they may increase the ability of agents to adjust the course of action.

The effectiveness of investments into personalised human capacities depends upon continuity of staff, as high turn-over of staff diminishes their return. In addition, resources (e.g. financial, labour time) crucially determine the extent to which social learning mechanisms are feasible. The mechanisms can also have positive side-effects, for instance, if systematic monitoring, reporting and evaluation increase transparency and legitimacy, thus supporting balanced decision-making.

Robust and flexible process and adaptive institutions:

Robust processes are characterized by their resilience against social and physical shocks. Rules may support robust processes, for instance, by committing public agents to long-term financial support of adaptation processes and ongoing monitoring and reporting. This in turn may improve the prospects for continued and cumulative learning, thereby developing awareness and understanding among agents about locally relevant climatic challenges and adaptations.

Flexibility of processes proved important for adaptation in a couple of meanings. The ability to integrate new information into decision-making processes was important to enable overall social learning. Moreover, the option to create new initiatives and projects within a given adaptation process reduced transaction costs through avoided delays in decision-making. Finally, tailor-made solutions that fit the context of biophysical, economic, social and institutional settings of a social system exposed to climatic change increase the probability of effective adaptation. Two institutional mechanisms that are conducive for the flexibility of processes are nested governance systems for complex, large-scale ecological challenges, and flexible boundary and position rules.

Concerning adaptiveness of institutions the meta-analysis found that the ability of social systems to adjust existing rules through a legitimate procedure enhances the capacity to adapt by lifting regulatory and financial constraints.

While robustness and flexibility of processes seem crucial, trade-offs between both have been reported. For instance, a formalized top-level master plan was found to lead operative work of sub-national public agents and to guide interaction with critical stakeholders enhancing the robustness of the process. At the same time its rigour incurred extra costs as it could not be adjusted to local physical and institutional particularities. Currently more evidence is required to achieve generalisable conclusions about different manifestations of such robustness-flexibility-trade-offs and institutional attributes that are able to avoid or cope with them.

Trust:

Trust among involved actors has been shown to be a facilitator for adaptation by reducing transaction costs of decision-making and by enhancing robustness of adaptation processes. Transparency mechanisms, expectation management by process owners and involvement of inhabitants of the affected area were seed-beds of trust.

4.2. Diverging Evidence on Institutional Dimensions of Public Sector Adaptation

Diverging evidence can be due to three reasons. First, it can point to the existence of trade-offs concerning the design of institutional attributes. Second, different sub-classes of the institutional variable X may impact adaptation in different manners (i.e. different effect types). Third, it may be that different manifestations of X are are appropriate for different settings, pathways, modes or tasks of public adaptation.

This section presents the instances of diverging evidence. It discusses reasons for these differences as well as conditions and institutional mechanisms that conciliate the prima facie contradictory models.

Inclusiveness:

Boundary and position rules ex- or implicitly define the set of actors who are eligible to participate in decision-making processes (Ostrom 2005). Through defining who has access (voice, rights, power) to the process they impact on the allocation of public resources to competing policy agendas and shape the distribution of risks, benefits and costs of adaptation. Diverging evidence exists about whether inclusion of a larger or smaller set of actors supports processes of adaptation decision-making.

One group of evidence suggests that involvement of most or all of the actors who are concerned of and about climatic changes supports adaptiveness and balanced decision-making of social systems. A high degree of inclusiveness implies higher probabilities that changing conditions and needs are recognized, understanding of the climatic challenges more comprehensive, and decisions more responsive to the preferences and needs of the stakeholders; can enable the reframing of problems (e.g. reflection on goals, assumption about ways to achieve goals, about attributes of the considered systems) to prevent or overcome conflicting interests; increases the probability that collective decision-making is perceived as balanced and fair by stakeholders; improves prospects of motivation and commitment for, and compliance with, collective decisions and, thus, long-term effectiveness.

However, other evidence reports increased transaction costs of processes and decreased effectiveness, at least in the short-term. Slower pace of participatory decision-making can manifest in a serious temporal scale mismatch, if the climatic stimulus comes at high pace as in the case of flash floods. Additionally, participatory processes give rise to NIMBY-kind of strategic problems of public good provision ("not in my backyard"), where actors aim for the non-exclusive benefits of adaptations (e.g. reduced flood risks in a region) while resisting to accept high costs of contributing to the public good (e.g. accepting relocation of single villages to build a new canal to cope with increased flood risks). In participatory processes these kinds of strategic problems may result in underprovision of public adaptations or to decisions to the detriment of less well-organized groups.

Taken together, a positive net effect of participatory adaptation processes is likely, if

- they deal with adaptative responses to medium- and long-term changes or have well-functioning organizational arrangemens to deal with short-term changes;
- stakeholders are concerned about the agenda-items;

- interdependence of stakeholders is high, i.e. they depend upon each other to reach their goals;
- knowledge is incomplete and dispersed among actors;
- there is little agreement about a problem and stakeholders hold conflicting interests, but have incentives to change ideas and attitudes (e.g., perceived interdependence).

The most appropriate set of participation rules for a given setting is not only a question of how many actors participate, but is interrelated with the set of choice rules that define the roles and responsibilities of involved actors.

Clear, transparent, and (in-)complete roles and responsibilities:

Explicit or implicit choice rules define the permitted, required and prohibited set of actions that actors may, must or must not take (Ostrom 2005). Clear and transparent allocation of roles and responsibilities, mandates and tasks has been repeatedly set out by empirical evidence as an important driver of adaptation. This factor assigns identifable operators to required tasks. For the responsible agent it promises benefits for performing an action or sanctions for failing this. In addition, clear and transparent mandates prevent potential conflicts between agents about reaping benefits of actions and about responsibilities for failures. In a similar vein, actors have clear incentives to place adaptation initiatives on the political agenda, if they perceive it to be their responsibility, are aware of climatic risks and have sufficient resources to do so.

However, it was also found essential to retain the ability to re-negotiate and adjust roles and responsibilities in order to cope with complexity and uncertainty of future climate impacts. Moreover, some roles and responsibilities in developing national- and subnational-level adaptation strategies were deliberately left incomplete to provide stakeholders with the option to find their appropriate position during the process and allow initiatives from the local level to represent important stakeholders.

Taken together, for this institutional dimension there seems to be a trade-off between clarity and transparency of operators, means and responsibilities on the one side, and the ability to incorporate new actors and perspectives into adaptation processes. The optimal position in this trade-off seems to depend from the degree of complexity, uncertainty and dynamics involved.

Leadership:

Leadership as the centralization of authority within organizations and public arenas plays an ambiguous role for climate adaptation. On the one side, it reduces transactions costs of negotiating decisions. Further, a leader can be a key driving force for developing public adaptation strategies and plans reducing the risk of maladaptation and increasing adaptiveness. The extent to which this is possible was found dependent upon the individual abilities and attitudes of the leader. Additionally, the presence of organizational learning processes may support the leader's activities. On the other side, however, social systems that rely on leadership by single strong actors can face barriers to climate adaptation in a couple of ways. First, to allow for leadership implies a concentration of power implying an inherent threat of power mis-usage and unbalanced decision-making to the detriment of marginal groups. Secondly, systems relying on leadership and strong personal learning by the leader are susceptible to stalled social learning (limiting awareness, understanding, and information about the climatic challenges) in the broader set of stakeholders as long as new information is filtered and discretionarily used by the leading persons. Additionally, in the case that the particular climatic challenge is of cross-boundary nature (i.e. crossing the boundaries of existing organizations), overall

adaptive performance tends to be reduced as long as leaders do not succeed in building mutual, cross-sectoral ownership and integration, human and resource capacities.

To sum up, the presence of individual leaders in public arenas such as municipalities, who are aware, concerned and knowledgeable about climatic change and who are accepted by stakeholders to show direction and motivate others is one of a few distinct conditions which facilitate endogeneous emergence of adaptation strategies within public arenas without imposed external, higher-level prescriptions. This is in line with empirical evidence from municipalities in developing countries which explored influencial climate change champions as drivers for adaptive change (Ziervogel et al. 2010; Carmin et al. 2012). However, to insure against susceptibility to power-misuage, unbalanced decision-making, stalled social learning and individual underperformance, accompanying institutional mechanisms for transparency, balanced power distribution, organizational learning and – if necessary – cross-boundary integration can enhance overall adaptive and balanced performance of social systems. These are analyzed in the respective parts of this section.

Nested governance systems I: Hierarchical top-down governance in public sector adaptation

In the case studies a core issue about multi-tiered, nested levels of governance concerns the role of national governments for adaptation processes in implementing agencies and at sub-national governance levels (e.g. in municipalitites). Evidence on this role is diverging.

One set of evidence suggests that national-level top-down governance supported sub-national and implementing adaptation ...

- by *defining clear roles and responsibilities for sub-national agencies* as well as providing *legal and financial measures*, e.g. through guidelines for spatial planning and flood protection. In terms of adaptation barriers and enabling conditions this provides identifiable operators and available means.
- by *defining and prioritising items on policy agendas* that need to be considered or implemented at sub-national levels. This incentivizes adaptation at sub-national levels and contributes to perceived transparency of the issue, supporting trust by public agents and citizens in the process.
- by *legislative edict* that commits local actors to undertake local level adaptation strategies, signals priorities and contributes to greater stability of the process. This 'hard' form of governance was also found to contribute to the perceived seriousness and acceptance of climate change as a relevant issue in standard operations of sub-national public agencies.
- by *defining policy goal, but leaving operational responsibility to sub-national actors*. This facilitates locally adjusted plans expected to show higher effectiveness in coping with local-scale climatic changes.
- through *ensuring a transparent process and implementing benefit-transfer-schemes* that work towards a balanced distribution of risk, costs and benefits of adaptation.
- by *enabling mutual knowledge exchange* in networks which contributes to social learning and supports endogenous dynamics in resource-rich municipalities.

However, another set of evidence found serious difficulties to integrate knowledge about local needs and preferences into national-level policy making. In the presence of this caveat national-level guidance risks to reduce the effectiveness of addressing the challenges that local agents perceive. IN addition, if integration of local knowledge into national-level decision-making is low and prescriptions by national authorities detailed, overall social learning in the governance system was found to face substantial obstacles.

A third kind of evidence exists about the situation, where guidance by national authorities is missing. Evidence suggests, that some sub-national authorities lacked legal instruments to enforce adaptations, for instance in the case of climate-proofing buildings. Additionally, awareness and external incentives for addressing climate issues were missing. This formed serious barriers to adaptation for small municipalities and for those who put low priority on climate issues. However, a lack of national-level guidance was rather insignificant for pro-active municipalities ("autonomous operators"), in which endogeneous adaptation dynamics emerged before national-level adaptation strategies were developed. It seems that there are distinct sets of conditions under which endogeneous dynamics of adaptation processes can emerge within municipalities. The presence of individual concerned and capable leaders is one of them as explained in the respective paragraph in this section. A second one (distinct, but potentially overlapping) is the combination of high risk awareness, available resources and perceived responsibility among public agents.

Taken together, the evidence on hierarchical top-down governance by national governments for sub-national and implementing adaptation is diverse. National authorities may clarify the roles and responsibilities in public sector adaptation and provide sub-national authorities with required means. However, mechanisms to include local knowledge seem crucial. Endogenous dynamics at sub-national levels can partly substitute for a lack of national-level guidance.

Nested governance systems II: Decentralized collective decision-making

Given that the particular impacts of climate change and the distribution of adaptive capacity are often specific to a particular local arena, several authors have assumed that a high degree of decentralized decision-making would be conducive for climate adaptation (e.g. Pahl-Wostl 2009; Tanner et al. 2009). This meta-analysis, however, finds a different model for a particular setting. In the presence of an unbalanced power distribution at local levels a high degree of decentralized decision-making over allocating external disaster relief actually enforced an unbalanced distribution of measures for adaptation and reinforced local power inequalities. Thus, the question how decentralization of collective decision-making affects climate adaptation needs to be answered more specifically for particular social-economic settings. The distribution of power at the local level has been identified as an important moderator variable for the supposed beneficial effect of decentralization.

Nested governance systems III: Cross-boundary coordination and cooperation and institutional fit:

The meta-analysis confirms the general view that a fit between the institutional boundaries and the ecological challenge is conducive for effective adaptation. In the case that climatic stimuli (e.g. floods) cross established organizational boundaries (e.g. sectoral, spatial, temporal boundaries) coordinating and cooperating across organizational boundaries could – prima facie – increase adaptiveness of social systems. This apparent effect is substantiated by evidence that suggests cross-boundary coordination and cooperation incentivizes cross-sectoral policy integration and climate-proofing and eases prevention and resolution of conflicts. Additionally, the involvement of key actors in different arenas of decision-making facilitates coherence and consistency in policy-making.

However, evidence was also found that cross-boundary interaction also detects differences in professional interests and priorities as well as administrative cultures and goals. This in turn can encourage isolationism and rivalry between involved agencies increasing the transactions costs of cross-boundary interaction and, if situations have a prisoner dilemma type of incentive structure, leading to collective mal-adaptation. The extent to which these hampering effects reduce the effectiveness of cross-boundary interaction for climate adaptation was found to depend upon the

attitudes of the involved individuals rather than the organizational boarders or cultures per se. In addition, resources (e.g. finances, labour) were shown to constrain the ability for organizations to maintain a network for cross-boundary interaction.

Formality of rules, statutory character and programmatic approach

Diverging evidence exists on the question how a formal and statutory character of rules affects public sector adaptation.

On the one side, a statutory character of national adaptation-related rules was found to have a signaling and committing effect for sub-national authorities to set their priorities accordingly. It also supported legitimacy and trust in the national-level ambitions and promised stability to the process.

On the other side, in some cases formalized plans had low adaptiveness to new conditions implying increased costs and reduced effectiveness at local levels. Other evidence suggests that the *in*formal and inclusive character of an adaptation process in a contested policy field helped overcome barriers to developing a public adaptation strategy. Having no formal mandate informal interactions gave participants the opportunity to address sensitive problems and explore new solutions. By reframing problems actors were able to leave entrenched positions. As a side-benefit participants gained access to new networks that had not been possible before in established, formalized procedures. As this informal process had no formal mandate, mobilization of substitutionary financial, political, legal and procedural support was supportive for implementation of new solutions.

5. Conclusion

This article investigated institutional barriers and triggers of adaptation to climate change by means of a model-centered meta-analysis. It focuses on public sector adaptation in Europe. 12 case-studies provided empirical evidence from 25 distinct cases. The study developed and applied a standardized, but multi-faceted coding scheme that captures the diversity of diagnosed models as well as the diversity of institutional dimensions of climate adaptation in the public sector. By analysing the obtained meta-data set the article revealed institutional design properties for balanced and effective adaptation ("triggers") as well as institutional barriers to adaptation.

The insights of this study streamline the institutional dimensions of climate adaptation in the public sector in Europe. As we have seen, there is not a simple institutional blueprint that can be copy-pasted for any kind of setting. Instead of this, the meta-analysis identified 17 distinct functions and attributes of institutional systems whose manifestations were shown to make a difference for climate adaptation. The most appropriate institutional design also depends upon the manifestations of socio-economic and biophysical variables in a particular setting, such as the prevailing distribution of power in a social system or the pace of the particular climatic stimulus.

Instead of blueprints, the insights of this meta-analysis provide diagnostic tools, i.e. when applied to new cases of failures or successes of climate adaptation, they can be used as initial heuristics to look for reasons of the particular adaptation pathway (Ostrom 2007). It is likely that they can partly explain the course of this pathway, another part of the explanation will likely be particularities of the case and perhaps also some institutional variables that may have been omitted in the case studies, and therefore in this meta-analysis.

The article offers methodical innovations. Calls for more rigourous syntheses of research to advance sustainability sciences are frequent (e.g. Poteete/Ostrom 2008; Ford et al. 2011). This article suggests

that model-centered meta-analyses (MCMA) are one way of doing this. Based on Rudel (2008) this study refines and further develops the MCMA method to study the role of institutions for adaptation to climate change: it adds a typology of eight models (see figure 2) and a typology of effects that barriers have on adaptation processes (see table 5). A couple of features of the MCMA method shall allow to characterize it as a systematic, rigorous, qualitative method of research synthesis (cf. Ford et al. 2011): a clearly formulated organizing research question; transparent identification and selection of primary literature; standardized and multi-faceted coding scheme and conceptual framework; inclusion of both quantitative and qualitative empirical studies.

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