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Integrative governance processes towards sustainable spatial development – solving conflicts between urban infill development and climate change adaptation

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Due to the high concentration of people and infrastructures in European cities, the possible impacts of climate change are particularly high (cities’ social, economic and technical vulnerabilities). Adaptation measures to reduce the sensitivity of a city to climate risks are therefore of particular importance. Nevertheless, it is also common to develop compact and dense urban areas to reduce urban sprawl. Urban infill development and sustainable spatial climate policies are thus in apparent conflict with each other. This article examines how German cities deal with the tensions between these two policy fields. Using six case studies, a new heuristic analysis method is applied. This study identifies three key governance aspects that are essential for promoting the joint implementation: instruments, organisation and interaction. Based on our case studies, we conclude that successful implementation can only be achieved through integrative governance including all three domains.

Keywords: urban infill development; climate change adaptation; governance; social innovation; heuristic analysis

1. Introduction

Europe is strongly characterised by urbanised regions. Today, nearly 75% of the European population lives in cities. Projections and forecasts predict that this share will continue to increase (European Commission [EC] 2019). Due to the high concentrations of people and infrastructure, the potential impacts of climate change in cities are particularly high. The implementation of adaptation measures to reduce the sensitivity of a city to climate risks is therefore of particular importance for Europe. It has been argued, for example, that inner-city open spaces must be kept free of buildings in the future to avoid negative effects of climate change such as heat islands (Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety [BMUB] 2018; Sturiale and Scuderi 2019). Nevertheless, it is also common to develop

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compact and dense urban areas to reduce urban sprawl (BMUB 2007; United Nations [UN] 2015, 2016). A focus on compact and dense development, especially in growing cities, serves to reduce traffic and thus increase climate protection; however, this type of development can also increase vulnerability to climate impacts. Urban infill development and sustainable spatial climate policies are thus in apparent conflict with each other.

This article examines how German cities deal with the tensions between urban infill development and climate change adaptation. Using the five North Rhine-Westphalian cities of Soest, Neuss, Cologne, Bochum and Bonn, as well as the federal capital Berlin, this article shows how synergies and conflicts of climate change adaptation and urban infill development are countered and negotiated. The aim of this article is to show how to resolve the potential spatial and environmental conflicts between these policy fields by pointing out practical options for action. The complexity of the problem (content-related and political-communicative challenges) is addressed. The approaches to be presented for future action reflect the current state of scientific knowledge. In addition to this scientific value, there is a particular benefit for the practice of spatial development. On the basis of our qualitative analysis of case studies, conclusions can be drawn that can be transferred to the policy discussion in comparable cities and municipalities.

This article is divided into six sections. First, [Section 2](#) introduces the background to urban infill development and climate change adaptation. The research design is introduced in [Section 3](#), which presents the analytical framework to evaluate the joint governance of the policy fields and the case studies. Based on this, [Section 4](#) presents the key findings of the study. [Section 5](#) is dedicated to the discussion of the presented results. [Section 6](#) closes with a conclusion and a description of further research needs.

2. Background

The literature highlights the importance of climate change adaptation for sustainable urban development (Lobell *et al.* 2008; Ensor and Berger 2009; IPCC/SCNAT/UBA 2019). It is now assumed that the occurrence of negative consequences of climate change can no longer be completely prevented (tipping points) if greenhouse gas emissions remain the same or increase (Stock 2013). Cities are the drivers of this development. Producing a share of approximately 75% of global CO₂ emissions for transport and buildings, cities significantly contribute to climate change. At the same time, cities, as agglomerations of social and technical infrastructures as well as of people, are particularly vulnerable to the negative effects of climate change (Sturm *et al.* 2009; Cortekar *et al.* 2016; Scheuer, Haase, and Volk 2017; Heaphy 2018). In Europe, approximately 75% of the population currently lives in cities, and this trend is increasing. From a broad literature review, Gasper, Blohm, and Ruth (2011) identified and discussed the potential impacts of climate change on urban areas in broad fields such as industry, health effects, food and water scarcity, and livelihood impacts and the distributional impacts within and among cities. These impacts included consequences such as deaths caused by heat and cold and rising risks from extreme weather events, such as heavy rain and floods.

It is therefore not surprising that the issue of climate change adaptation has increasingly moved to the political agenda in recent years (BMUB 2007; EC 2009, 2013; UN 2015, 2016). Both the EU and individual EU member states have developed climate adaptation strategies (Heidrich *et al.* 2016). To date, 25 EU member states and

three other EEA member states have introduced climate change adaptation strategies. In addition, 15 EU member states and two other EEA member states have adopted climate adaptation plans. At the sub-national level, the issue has also gained importance. In Germany, for example, climate change adaptation strategies and action plans have been developed by all federal states (Bundesländer). At the local level, the issue has been taken up in particular by large cities, but medium-sized municipalities are also concerned with this issue (Reckien *et al.* 2018; Otto 2019). The central fields of action are water, energy, agriculture and forestry, transport and logistics, soil, nature conservation, and health care as well as urban, regional and state-level planning. Providing, maintaining and qualifying inner-city open and green spaces as well as open-air corridors to prevent heat islands and other negative effects of climate change (Gstach and Berding 2016) are central components of climate change adaptation in urban areas (Anguelovski and Carmin 2011). In addition, retrofitting of buildings and technical infrastructures is conducted, which includes the orientation of buildings and building structures, the planting of south-facing building facades, the vertical greening of buildings, the use of water in public spaces and the arrangement of living spaces in buildings (Gstach and Berding 2016; Amer *et al.* 2017).

In recent years, these aspects have been integrated into urban research and increasingly expanded by analyses regarding the institutional framework for implementing adaptation to climate change. In particular, the focus has been on the identification and assessment of strategies and concepts on different administrative and political levels (Heidrich *et al.* 2016; Reckien *et al.* 2018, 2019; Araos *et al.* 2016; Ellison 2010; Remling 2018) as well as the tension between climate mitigation and adaptation (Clar 2019; Nguyen, Davidson, and Gleeson 2018; Göpfert, Wamsler, and Lang 2019a; Grafakos *et al.* 2019; Pietrapertosa *et al.* 2019).

Implementation deficits can be traced back to thematic priorities, rules and regulations at higher levels (Landauer, Juhola, and Klein 2019); institutional “silos” (Measham *et al.* 2011); and the lack of integration of the private sector and other actors (Klein *et al.* 2018). The institutionalisation of climate policy (Anguelovski and Carmin 2011) and simultaneous capacity building at different administrative levels (Pilato, Sallu, and Gaworek-Michalczenia 2018) are seen as key elements in strengthening the adaptation to climate change. In addition, both Measham *et al.* (2011) and Patterson and Huitema (2019) assume that institutional innovations and cross-sectoral integration can strengthen the implementation of climate adaptation.

At the same time, progressive urban sprawl can be observed in Europe (Fina and Siedentop 2008; Siedentop and Fina 2010, 2012). Urban sprawl refers to the increasing fragmentation of natural habitats by urban areas, such as roads and housing (European Environment Agency [EEA] 2016). The conversion of land into urban areas has been uninterrupted for years. In Europe, from 2000 to 2018, the average annual land take was 780 km² (EEA 2020). Even regions affected by population losses continue to occupy land and thus contribute to urban sprawl (Fertner *et al.* 2016).

Against the backdrop of maintaining open spaces, one of the most important strategies for reducing land take and landscape fragmentation is the concentration of urban development in inner urban areas (BMUB 2007; EC 2011). The aim is to direct the demand for urban land use to already developed areas to reduce the consumption of new land, avoid land use conflicts at the outskirts and protect the remaining open spaces, e.g. for food and energy production, recreation and biodiversity protection (Steinhäüßer *et al.* 2015). There are different approaches to promoting or advancing

urban infill development. In both the scientific literature and the literature published by the ministries responsible for urban and environmental planning, measures such as the development of unused inner-city areas (e.g. conversion), densification of large underused plots, closing of building gaps, rebuilding of roofs (e.g. saddle roofs into flat roofs) and extension of existing buildings are discussed. Moreover, instruments to systematically identify, record and prioritise potential areas for urban infill development are in use (Hanke 2006; BMVBS/BBSR 2009; Geschäftsstelle der KBU - Kommission Bodenschutz des Umweltbundesamtes (KBU) 2009; Bundesamt für Bauwesen und Raumordnung (BBSR) 2016; Gstach and Berding 2016; Amer *et al.* 2017; Rebmann and Philipp 2018).

In dynamically growing urban areas, however, the potential to employ urban infill measures is decreasing. Medium to large inner-city conversion areas have largely been developed. Therefore, the number of plots for residential construction projects to develop many dwellings at once is limited. Additionally, the mobilisation and development of small-scale inner-city areas are usually time-consuming and often face a variety of location-related challenges, such as difficult ownership structures or outdated building regulations that no longer fit the current structural requirements (Rebmann and Philipp 2018). Increasing densities also face social limits that are concerned with the subjective perception of too high densities, the increase in traffic volume or the loss of the established identity of neighbourhoods (Haaland and van den Bosch 2015). In growing urban areas, therefore, growth pressure can also cause a partial shift in urban infill measures to higher quality urban green spaces, which contributes to satisfying housing demand but also leads to a reduction of important open and green spaces.

Against this background, Table 1 shows an overview of some illustrative examples of the advantages and disadvantages of the implementation of urban infill and climate change adaptation measures. The table clearly shows that both approaches have specific advantages and disadvantages that must be taken into account in the planning process.

As shown, there is a rich body of literature that focuses on the analysis of climate change adaptation and urban infill development. Nevertheless, only a few studies deal specifically with the joint governance of both policy fields. To meet the challenges of successfully linking these two policy fields, in these studies, the roles of relevant actors (combining the object-related and actor-related perspective), the use of specific planning instruments (e.g. orientation values, strategic concepts) and the organisation within the administration and the relevance of scales were highlighted (Haaland and van den Bosch 2015; Gstach and Berding 2016; Thorne *et al.* 2017; Landauer, Juhola, and Klein 2019).

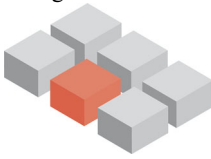

Our study builds upon and contributes to this body of literature by explicitly evaluating the joint implementation of both policy fields. The main interest of our study was in identifying governance settings that enable conflict-minimising implementation of planning approaches (Mann and Jeanneaux 2009; Hersperger *et al.* 2015). To achieve this aim, a heuristic analysis was developed and applied to six case studies in Germany.

3. Research design

3.1. Analytical focus to evaluate the joint governance of urban infill development and climate change adaptation

Planning is quite often highly specialised and characterised by a strong sectoral division of tasks. By splitting the complexity of the real world into partial aspects, it provides efficient solutions to specific urban challenges (Leiren and Jacobsen 2018). With

Table 1. Illustrative examples of the interrelationships between climate change adaptation and urban infill development.

Urban infill development (construction of buildings and infrastructure)		Climate change adaptation (preservation and creation of open spaces)	
			
Advantages	Disadvantages	Advantages	Disadvantages
<ul style="list-style-type: none"> • More efficient (e.g. compact, mixed-use) settlement structures (Amer <i>et al.</i> 2017) • Cost efficiency of social and technical infrastructures (Siedentop <i>et al.</i> 2006) • Increase in the number of trips made on foot, by bicycle or public transportation (Krehl <i>et al.</i> 2016) • Decreasing land-use conflicts in the outskirts (Steinhäüßer <i>et al.</i> 2015) 	<ul style="list-style-type: none"> • Increase in vulnerability due to an increasing number of buildings and infrastructure in a given area (Koopmans <i>et al.</i> 2018) • Increase in inner-city land-use conflicts due to space limitations (Gstach and Berding 2016) • Social challenges such as gentrification and segregation (Haaland and van den Bosch 2015) • Reduction in open and green areas suitable for natural flood protection measures (Gstach and Berding 2016) • Increase in traffic volume and in exposure to noise, nitrogen oxides and particulate matter (Salomons and Berghauser Pont 2012) 	<ul style="list-style-type: none"> • Prevention of heat islands (Sturiale and Scuderi 2019) • Promotion of rainwater runoff (Meyer and Overbeck 2009) • Access to inner-city public green spaces for recreational purposes (Haaland and van den Bosch 2015) 	<ul style="list-style-type: none"> • Promotion of construction activity in the outskirts, which fosters the loss of ecosystem services (ESS) and productive land (Maes <i>et al.</i> 2015) • Increase in traffic flow towards the city centre (Salomons and Berghauser Pont 2012)

regard to long-term and complex challenges such as climate change that transcend organisational boundaries and administrative levels, however, planning is also limited by its own thematic narrowness when issues are only considered separately (Innes and Booher 2010; Pasquini and Shearing 2014). To date, contemporary governance systems are characterised by gaps, mismatches, or other dysfunctionalities. Usually, solutions fail to address the variety of interrelationships, conflicting aims and demands, distributed capacities (Hummelbrunner and Jones 2013) and actor-based knowledge stocks (Salet 2014).

In contrast, more integrative approaches aim to address the whole complexity of a problem (Yigitcanlar and Teriman 2015). This requires integrative knowledge, objectives, instruments and processes, raising new questions about the responsibilities, power, resources, actor orientation, knowledge integration and implementation, which in city administrations are usually answered within departmental units (Zscheischler and Rogga 2015; Moser 2016; Mauser *et al.* 2013; Blomkamp 2018). Integrative approaches thus often counteract established administrative practices.

To solve these problems, social institutional innovations and change processes are seen as important factors (Patterson and Huitema 2019). Social innovations especially offer the potential to generate better solutions to (new) challenges within an established institutional framework. Therefore, social innovations originate from actors or groups of actors who implement social practices in certain fields of action in new ways to solve problems and conflicts (Howaldt and Jacobsen 2010), reflecting fundamental framing concepts for the analysis of political and planning processes, such as actor-centred institutionalism (Scharpf 2018; Ostrom 2011; Mayntz 2010). This is continued in analyses of adaptive and transformative governance (Chaffin *et al.* 2016). In this article, social innovations are defined as innovative approaches to better solve problems and conflicts resulting from the joint implementation of urban infill development and adaptation to climate change. Our study did not focus on technical implementation but on how governance structures changed and adapted in terms of organisation, planning procedures, actors and participation.

Following Burch (2010), Chu (2018) and Aylett (2013, 2015) as well as the body of literature presented in Section 2, three aspects of governance were identified to be integrated in a heuristic analysis to examine the governance of both policy fields: (1) organisation, (2) instruments and (3) interaction. Specifically, those three aspects were derived from the theoretical discussion on which aspects of urban governance mattered most in the context of climate policies and densification. Details on the three aspects are discussed below to show their relevance, especially for the empirical approach.

1. The first governance aspect addresses the instruments used to implement both policy fields together. Particularly in these fields, various measures overlap from a content perspective, and a broad spectrum of instruments and tools is required to adequately support planning decisions. For instance, the development and use of integrated concepts for the implementation of urban planning measures is an important, repeatedly discussed element (Burch 2010; Chu 2018).
2. The second governance aspect addresses the organisation of urban infill development and climate change adaptation within the administration. Here, the central question is how the implementation is actually organised. Issues of urban infill development and climate change adaptation are often interdepartmental and therefore require a high level of cooperation. Are new organisational structures

created to address the topics or are they taken over by existing organisational units? What is the organisational positioning of urban infill development and climate change adaptation (Burch 2010)?

3. The third governance aspect addresses the modes of interaction between relevant actors. Since a multitude of external actors are affected by the development and implementation of climate adaptation and urban infill measures, the participation of actors is decisive. How are these actors involved, and how is the participation and communication of planned measures organised (Burch 2010; Aylett 2013, 2015)?

Moreover, the heuristic analysis considers enabling factors that support policy implementation beyond the three main governance aspects. In addition to endogenous factors that can be specifically influenced by the administration and other actors, there are also exogenous factors that can have an effect on implementation (e.g. new laws, unforeseeable socio-demographic or economic shocks).

To be able to consider and supplement other important governance aspects in the analysis that did not arise from the literature review, the analysis was designed as an iterative process (Srivastava and Hopwood 2009). The predefined governance aspects can thus be refined and concretised based on the data analysed.

3.2. Case studies

For our methodological approach, we used a case study approach (Farthing 2016; Yin 2018). Case studies allow for an in-depth analysis of complex interactions by analysing a variety of positions and influencing factors in real-world situations similar to planning. The choice of relevant case studies was guided by a set of criteria. The main focus of the selection of regions was to work with administrations that are experienced in dealing with both policy fields. To meet this goal, relevant cities need to have appropriate planning documents that guide administrative actions. In addition to this politically based criterion, we looked for a variation in the geographical location of cities and aimed to include both large and small cities. Moreover, these cities should cover the range of shrinking, stagnating and growing populations to gather information on the pressure of population growth on the conflicts between the policy fields.

Finally, we added the German capital Berlin as a potentially contrasting example. The city is far larger than the others but is also fast growing. More importantly, Berlin is a federal state on its own, giving the city a decisively different influence on planning conditions. The results will show whether size and planning capacity alone will have a positive impact on solving new planning challenges.

The resulting set of case studies is listed in Table 2, together with basic statistics. The population ranges from almost 50,000 people in Soest to over 3.5 million people in Berlin. The urban density ranges from 20 people per hectare of settlement and traffic area in Soest to 57 in Berlin. With the exception of Soest and Bochum, all cities recorded population growth. The population development ranges from -4.4% (Bochum) to +8.1% (Cologne). In all case studies, the built-up area grew, ranging from 0.4% (Cologne and Bochum) to 2.9% (Neuss). In combination with the decrease in population, the cities of Bochum, Neuss and Soest have experienced slight declines in population density. Figure 1 shows a map indicating the specific locations of our case studies.

Table 2. Case study selection (in alphabetical order).

Indicators	Berlin	Bochum	Bonn	Cologne	Neuss	Soest
Area (in hectares)	89,112	14,566	14,106	40,501	9,952	8,581
Population in 2016 (2007)	3,574,830 (3,416,255) 4.6%	364,920 (381,542) -4.4%	322,125 (316,416) 1.8%	1,075,935 (995,397) 8.1%	152,882 (151,449) 0.9%	47,436 (48,526) -2.2%
Population growth 2007–2016 [in percent]						
Area for settlement and transportation in 2015 (2007) [in hectares]	62,632 (62,322)*	10,250 (10,211)	7,150 (7,101)	24,757 (24,668)	5,087 (4,945)	2,382 (2,327)
Change in area for settlement and transportation from 2007–2015 [in percent]	0.5%	0.4%	0.7%	0.4%	2.9%	2.4%
Urban density in 2015 (2007) [population/settlement and transportation area]	57 (57)	35 (37)	45 (44)	43 (40)	30 (31)	20 (21)

Note: *Data for Berlin for only 2008.

Source: state database NRW (Bochum, Bonn, Cologne, Neuss, Soest) and regional database (Berlin).

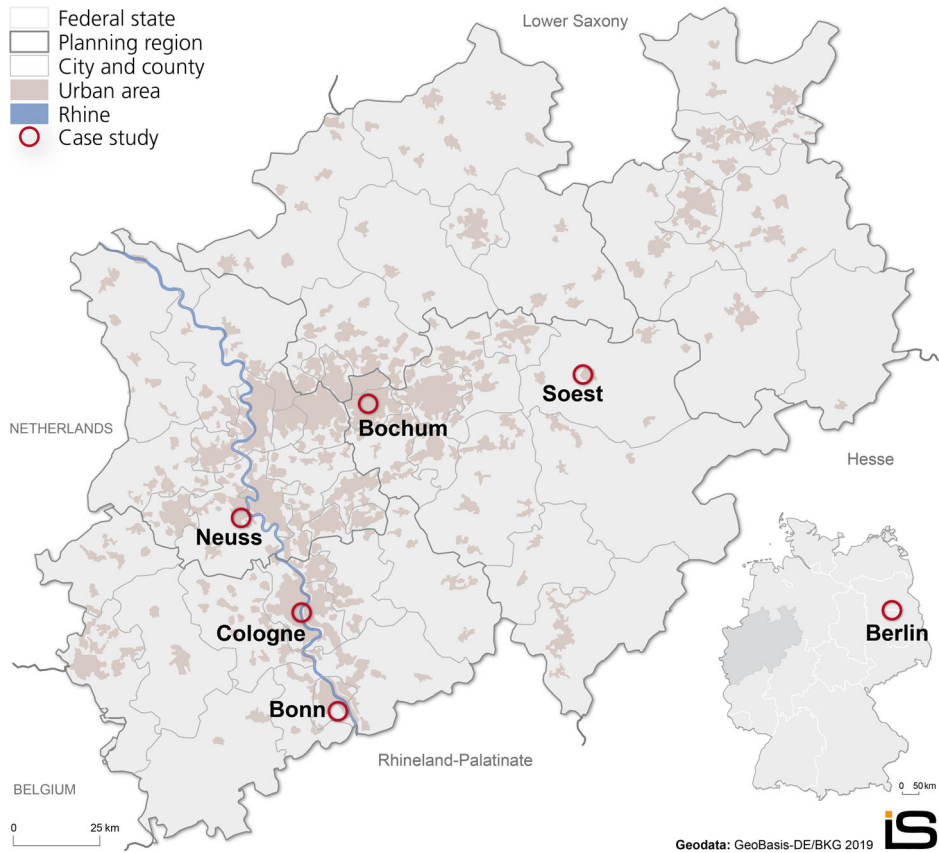


Figure 1. Map of case study cities.

Table 3 lists the specific projects that were analysed in more detail within our case studies. Hereby, we chose a variety of project aims and scopes, based on the range of projects in each city available at the time we conducted our study. To extract relevant factors that improve the implementation of policy measures, our selection included different types of concepts/projects, which differed in their spatial focuses. In three cities, the development and application of city-wide concepts were analysed. Concrete projects were examined in Bochum, Bonn and Berlin. Table 3 also includes information about the initiative actor, the central cooperation partners and affiliation of the interviewees.

From an analytical perspective, we conducted a two-way approach. First, we performed extensive desktop research that collected all relevant documents that were available concerning urban development and the studied projects. This initial step provided the relevant basic information for understanding the aims and scope of urban development and the specific projects.

Based on this basic understanding of how urban infill development and climate change adaptation planning are interlinked in our case studies, we contacted the main person in charge of each project to conduct in-depth expert interviews. As actors are of central importance for social innovations, this methodological approach was particularly appropriate for the present study. Moreover, it offered us the opportunity to let

Table 3. Overview of the case studies (in alphabetical order).

Case study	Object of study	Spatial focus	Initiative actor/cooperation partners	Interviewee
Berlin	Berlin: KiezKlima (engl. Berlin: KiezKlima)	Neighbourhood level	L.I.S.T. Stadtentwicklungs mbH Eimer Projekt Consulting (EPC) degewo Central District Office Senate Department for Urban Development and Environment	Employee of L.I.S.T. Stadtentwicklungs mbH
Bochum	Bochum Ostpark (engl. Bochum East Park)	Neighbourhood level	City of Bochum Ruhr-University Bochum German Institute of Urban Affairs (Difu) Eimer Projekt Consulting (EPC)	Project management of the city of Bochum
Bonn	Natur in graue Zonen (engl. Nature in grey zones)	Parcel level	Wissenschaftsladen Bonn Companies Community foundations Garden and landscape planners	Project management of the Wissenschaftsladen Bonn
Cologne	Klimawandelgerechte Metropole Köln (engl. Climate change friendly metropolis Cologne)	City level	Ministry for Environment, Agriculture, Conservation and Consumer Protection of the State of North Rhine-Westphalia (LANUV) City of Cologne German Meteorological Service (DWD) Municipal drainage companies Cologne AöR	Employee of the Environmental Office of the City of Cologne
Neuss	Klimaanpassungskonzept Neuss (engl. Climate adaptation concept of the city of Neuss)	City level	City of Neuss Ruhr-University Bochum Eimer Projekt Consulting (EPC)	Employee of the Climate Protection and Adaptation Unit of the City of Neuss
Soest	Klimaanpassungskonzept Stadt Soest (engl. Climate adaptation concept of the city of Soest)	City level	City of Soest Ruhr-University Bochum Eimer Projekt Consulting (EPC)	Employee of the Department of Urban Development and Building Regulations of the City of Soest

the interviewees themselves explain what can be described as new, innovative and promising regarding the joint implementation. In sum, for each of the six projects we conducted one expert interview of about 90 min length. Each of the interviews followed a structured approach around an interview guideline to ensure that all relevant aspects of the levels of instruments, organisation, interaction and enabling factors were discussed (Farthing 2016). For this step, the interview was divided into three main parts, which asked about the main challenges, central stakeholders and their roles and the solutions that were suggested within the cities and projects to address the respective challenges. The analysis of the interviews was guided by the content analysis according to Meuser and Nagel (2009). Based on the interview material, typical and common contents of the interviews were identified. To reduce the amount of data, text sections were structured and thematically ordered by means of headings and keywords. Subsequently, the text passages of different interviews were compared with each other and headings were standardised. The aim was to identify and form thematic categories.

4. Results

In the following, the results of our interviews are summarised. Framed by the heuristic analysis, relevant elements will be sorted and presented within our presented governance aspects. Based on our structured analysis of interview contents, common factors for the successful implementation of integrated planning of dense and adaptive urban areas will be extracted and structured.

As a first overview, Table 4 lists the results in a comprehensive way and showcases the cities whose governance aspects played a crucial role in following the cities' goals for infill-oriented, sustainable development policies. As shown in Table 4, the iterative analysis process of the interviews has led to a further subdivision of our pre-defined governance aspects (see Section 3.1). Hereby, a more specific description of the social innovations identified in our case studies was possible. The new sub-categories are described in the following text sections. Importantly, the difference between the governance aspects and the subcategories is that the former are derived from the theoretical discussion and the latter are summarising items to give the wealth of information we got from the interviews a comprehensive inner structure.

In general, results show a high variety of innovative activities and solutions. Nevertheless, none of the examples comprise a comprehensive approach. The results vary from case to case. Details of the measures taken and their relevance for supporting conflict-minimising outcomes are discussed by looking at the three pillars of our heuristic analysis.

4.1. Instruments

The governance aspect *instruments* looks at measures that have been taken to implement both policy fields together. In our case studies, it became obvious that under this pillar, there are two branches of relevant aspects. On the one hand, municipalities implement a variety of analytical (technical) tools to measure, map and assess the impacts of development plans on urban climate issues. On the other hand, experts highlighted a number of policy and planning instruments to support a synergetic implementation of policy fields.

Table 4. Governance aspects used in the case study cities based on expert interviews.

Municipality	Instruments		Organisation		Interaction	
	Analytical tools	Policy and planning instruments	Internal	External	Communication	Participation
Berlin	✓				✓	
Bochum	✓		✓	✓		✓
Bonn			✓	✓		
Cologne	✓	✓	✓		✓	✓
Neuss	✓	✓	✓		✓	
Soest	✓		✓			✓

4.1.1. Analytical tools

On the level of *analytical tools*, interviewees stressed that for a thorough understanding of the impacts of climate change on the urban realm, a detailed database is necessary. These databases should be able to map small-scale impacts of changes in the built environment as well as project future stress due to heavy rain events or long heat periods. For this purpose, the cities of Cologne, Neuss, Soest and Berlin established climate models for their administered regions where current climate effects are monitored (e.g. by mobile sensors), and the relationship of these effects to the housing stock are modelled. This basic research provides important information for city planning and is provided for the whole administration via georeferenced climate databases. For example, in Bonn, local climate data could not be used for the selection of plots for adaptation and infill measures, which, according to the interviewee, impaired the implementation of the most effective measures possible and limited the subsequent impact measurement.

Another important aspect of the capacities of climate databases is that they need to be able to integrate climate models that project future scenarios of changes in frequency of heat days and stormwater flow so that the effects of climate change and changes in built-up land can be projected. In the cities of Soest, Berlin and Bochum, this feature was used to locate climate-sensitive areas. Detailed maps were constructed that highlight neighbourhoods where the need for action in terms of adaptation is high – and further urban infill activities should be located in contrasting spaces. In Soest, for example, further local climate assessments could be carried out on the basis of climate maps to check, adjust or prevent projects that were located in climatically critical locations.

In summary, analytical tools can be seen as a “*conditio sine qua non*” for planning approaches to deal with planning goals that might be contradictory. These tools are important to support decision-making processes and inform and foster discussions.

4.1.2. Policy and planning instruments

The second element in the governance aspect of instruments are *policy and planning instruments*. In part, these instruments build upon the climate databases previously discussed and are partially inspired by the necessary means to influence urban development in certain directions, which are guided by the goals of both policy fields.

For the first part, Cologne can be considered a city that provides blueprint approaches for policy instruments. Here, the climate database is used to locate areas with a high need for action. Based on the profiles of those areas, visions for joint actions of different departments of administration are developed. A list of possible actions is developed and discussed internally, reflecting the policy goals for the city. In addition, for all actions, an analysis of strengths, weaknesses, opportunities and threats is conducted to fully assess possible risks and the existing interlinkages between individual actions. Concepts for action thus offer content-thematic frameworks for more efficient site developments (e.g. pre-selection of sites and content-related specifications). In the absence of higher-level guidelines, the interviews also show that the synergetic linking of individual measures is hampered and the visibility of each individual measure is reduced, as was the case in Berlin and Bonn. In contrast, Cologne and Neuss managed to increase the visibility of their measures by developing, bundling and coordinating them jointly in advance.

For the second part, Neuss is considered a good example. Here, urban framework assessments (*Städtebauliche Verträge*) are used to influence how alterations in the built environment can fulfil policy goals. For this purpose, developers are legally bound to specific restrictions on spaces that are designated for development. Those restrictions are grounded in the climate database projections – high-risk areas for stormwater are pinpointed with more open retention spaces, and spaces with less risk are allowed denser development.

Furthermore, the city gives financial incentives to companies and citizens. When landowners decide to leave a high share of their plots open and highly permeable, the water treatment payments are lowered. This incentive is a means to incentivise the building of more resilient neighbourhoods.

4.2. Organization

The aspect of *organisation* looks at how policy implementation is actually organized. This aspect refers to specific organisational innovations and amendments that have been established to increase the efficiency of policy measures. For our cases, a main organisational challenge was managing the interdisciplinary and transdisciplinary aspects of both policy fields. For each field, several departments have specific responsibilities and disciplinary views, including ecological, engineering and planning aspects. In the interviews, it became obvious that the organisational measures taken can be divided into internal and external aspects, i.e. focusing on the administration itself or on using the knowledge of external experts.

4.2.1. Internal

Related to the central problem of overcoming disciplinary boundaries, many of our cities intensified the *cooperation between departments*. In Bochum, bilateral coordination between planning and environmental departments was pinpointed to discuss the needs for actions and the measures that need to be implemented in planning documents. The organisational changes in Cologne and Neuss have been even stronger than those in Bochum. In the former, departments worked together to interpret the climate database, and in the latter, integrated plans were developed that were the results of a consensus between departments. Other case studies, namely, Soest and Bochum, task forces for

climate adaptation and city development were introduced, and each department sent an expert so that these task forces could work on focused approaches on the planning measures they finally agreed upon. In addition, the city of Soest merged two committees (Ausschüsse) that have been working on strategic city development and nature issues. Committees should not be mixed with working groups, which are often temporary and consist mainly of experts. Committees are regularly fully institutionalised and serve to prepare political decisions. For the internal reorganisations, the cities of Neuss and Bonn assigned central individuals to coordinate actions. Here, these “care takers” were responsible for organising meetings and reporting results, and they served as central contacts for the members of the task forces.

4.2.2. *External*

Some of the cities saw the need to implement regular *exchanges with external experts and stakeholders* to improve their decision-making processes. In Bochum, the city administration worked closely with the local university to evaluate the climate projections and discuss the consequences for city development. Therefore, hearings for university experts were included in their task force meetings.

Another approach that was followed by the city of Bonn was to build strategic alliances with public and private stakeholders that would have been affected by actions within the city plan. By doing so, general responsibilities were fixed in contracts, and stakeholders became part of the process of developing on-the-ground solutions for adaptation of densification measures.

4.3. *Interaction*

As already clarified in the organisational aspect, integrating all affected stakeholders into the process is of crucial importance for its success – which leads to the aspect of governance of *interaction*. Here, the focus of our analyses is to determine how external stakeholders are involved and to what extent. This information can somewhat be seen as an extension and a link to the aspect of external organisation. In that case, we are interested in the communication and integration of external knowledge. When discussing governance of participation, the analytical extension is to look at the integration of external information and opinions to improve the planning process. The aspects that have been named by experts can further be distinguished into pure communication measures on the one hand, which aim at raising awareness of planning topics and making the public understand the interrelatedness of topics and measures. On the other hand, there is a more bi-directional level of participation, which also aims at exchanging with stakeholders but wants to learn from external inputs.

4.3.1. *Communication*

In terms of informing stakeholders, our case studies used a wide range of methods. Generally, experts stressed the importance of raising awareness of stakeholders by intensive *communication* (e.g. Berlin). In this effort of sensitisation, the city of Cologne regularly informs practitioners that are affected by planning measures as well as the population within the radius of particular plans. Here, it is important to show-case how long the investments in specific plans will affect the city and why the

interlinkage between open spaces, adaptation and densification needs to be discussed and reflected in current plans. For this purpose, the city of Neuss has a specific approach that experts rated as being very effective: more than only planning documents are used for external communication. Moreover, maps and results of analyses (i.e. climate database) are used as central argumentation when discussing the reasoning of plans. This strategy strongly supports the arguments of planners and helps to convince external stakeholders of specific ideas and concepts.

4.3.2. Participation

In extension to the communication of needs and actions, cities work together with the public to enrich their approaches with local information – by establishing classic and more modern *participation* steps. For this, all case studies followed a regular approach of participation, as is foreseen in German planning laws. More importantly, experts highlighted the importance of going beyond the standard approaches, especially when working with issues of sustainability. For example, the city of Soest is keen to interact with local citizens and stakeholders before legally binding participation takes place. This process ensures a more detailed mutual understanding of what will be done and what is needed on the ground. Additionally, stakeholders feel more integrated in the process and develop a deeper level of ownership on particular projects compared to the standard results seen by other participation approaches.

Other cities, namely, Bochum, the opinions of citizens, students and experts are integrated by inviting them to take part in innovative participation methods (for example, the Charette) to use open approaches to more easily access people's perceptions and understandings. By doing so, the overall planning process is better understood, and implementation is less opposed.

4.4. Enabling factors

Throughout the interview phase, it became obvious that experts named a number of relevant factors that enforced the implementation of policy measures beyond belonging to the three aspects of instruments, organisation and interaction. Moreover, those *enabling elements* are the pushing factors for the successful and efficient governance, stressing the social aspects of innovation. These factors can be divided into favourable framework conditions and push factors for implementation.

4.4.1. Framework conditions

In Berlin, for example, experts stressed that collaboration with neighbourhoods is especially fruitful in areas where there is already a well-functioning neighbourhood. In some cases, there have already been existing (social) networks that supported the management of neighbourhood-level planning. In other cases, there have been a variety of local NGOs that supported the sustainability idea and acted as moderators between different interests.

In contrast, it is more than only the social flair within neighbourhoods that is crucial for successful innovations. Equally, a strong political will to act needs to be present. For instance, the city of Cologne was only able to fulfil its ambitious plans for dense, sustainable urban development because there was political consensus to do so.

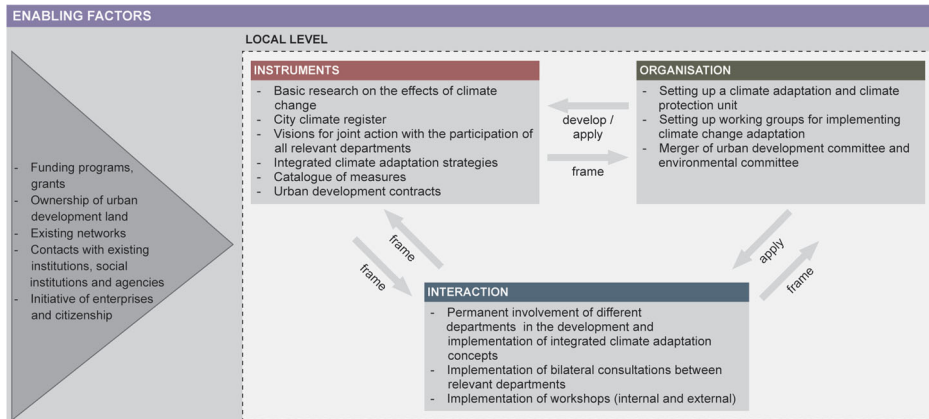


Figure 2. Central results of the analysis of the case studies.

For other cities, such as Neuss, it was especially important to obtain external funding from federal or national sources. This funding was even more relevant in times of austerity, but even after that, policy makers were easy to convince to support specific projects if they obtained the full benefits by paying only a fraction of the costs. Similar arguments have been put forward in the city of Soest.

4.4.2. Push factors for implementation

In addition to those favourable framework conditions, there have been a number of other relevant push factors that have explicitly been stated by experts as being important. In Neuss, there is a quite important policy document that is derived from the national adaptation strategy (DAS) – a climate adaptation strategy. This document was very important, as it functions as a common ground for all decision makers to build upon. This situation directly links to the idea of having political will to act – which in this case is fixed in a city-wide document.

Another relevant push factor is the effect of pioneering. In some cities, for example Bochum, city planning started to implement pioneer projects that could only be implemented because the city itself owned the spaces. This situation helped to strongly lower the scepticism of citizens and private landowners. In a second step, early adopting private investors can again be seen as pioneers. In Bonn, this condition helped to convince a second stage of companies to invest in greening and opening up their plots.

Figure 2 shows an overview of the aspects we have identified and discussed so far. This summary indicates a circular relationship between the governance aspects and a crucial underlying influence of enabling factors. Generally, all three aspects of governance influence each other. Due to these circular dependencies, there is no real starting point to initiate social innovations. One exemplary way of explaining relations would be to start with looking at organisational changes. We have discussed several important aspects that can help change attitudes and the efficiency of the administration of trans-disciplinary, synergetic policy goals. Such an organisation would then be enabled to use specific modes of participation and communication to interact with the public. This result would provide important lessons for policy implementation. Next, it leads to the field of policy instruments that can be designed to support implementation based

on experiences in the modes of interaction. Innovation in such cases would be even more effective and hindered by fewer obstacles if the right enabling factors are set in place.

Interestingly, two aspects showed a lower impact on social innovation than we expected. At first, the spatial focus of the respective project did not alter the importance of specific success factors. Neither city-wide nor primary local initiatives favoured a specific aspect of governance. Second, the results for the case of the federal capital of Berlin are in line with experts' opinions in the cities of North Rhine-Westphalia – independent of their size and planning capacity. Despite our future expectations, there seems to be a general understanding of the positive and negative aspects of policy implementation.

5. Discussion

The results show that there is no standard procedure for combining urban infill development and climate change adaptation (see [Section 4](#)). Based on our results, rather, specific components are needed that must be linked together depending on the challenges and previous experiences of each individual municipality. From our case studies, relevant aspects for successful governance could be derived. In the following, our results will be linked to results of previous studies to check whether similar or different results have been identified.

Göpfert, Wamsler, and Lang (2019b) came to the conclusion that climate change adaptation – as measured by committees dealing with this issue – has so far been institutionalised in very few German cities. Our case studies can also confirm this finding for the joint implementation of urban infill development and climate change adaptation. Our case studies show that there are selective and efficient forms of work, but institutionalised, consistent and continuous processes are the exception here as well. In general, the joint consideration of both policy fields is case-dependent and primarily addressed in concrete project contexts. From the experts' perspective, a continuous exchange between actors can be achieved, especially with the help of high-level strategies and concepts.

Driessen *et al.* (2018) and Jim, van den Bosch, and Chen (2018) emphasised the existence of adequate formal rules that provide a balance between legal certainty and flexibility as well as the adoption of normative spatial, temporal and institutional visions. Our interviews have also shown that joint visions, guidelines and objectives are of particular importance for the effective coordination of measures. Here, all relevant stakeholders, such as climate actors, the housing industry and owners, should be considered. As shown by our case studies, we argue that the application of a guiding framework within high-level strategies support the harmonisation of a joint implementation.

Taking into account different actors and different points of view, we assume that the weighing of measures should be based on clear criteria to allow for a technically correct balancing. In the field of urban development, for example, these measures include target values for the demand for residential and commercial building land or the demand for social and technical infrastructure. In the field of adaptation, aspects such as social needs and ecological objectives should be taken into account. Here, visions and plans should present both the advantages and disadvantages of partial aspects of planning and implementation in a transparent manner. This information

includes the consequences of possible (re-)densification, keeping inner-city open and green spaces free as well as open spaces at the outskirts (see Table 1).

Financial resources are essential for the implementation of measures. Municipalities often pursue innovative approaches, but due to tight finances, they are often dependent on financial support from higher levels (Kim and Grafakos 2019; Landauer, Juhola, and Klein 2019). Our case studies confirmed the importance of funding programmes and financial incentives. Although all cities benefit from financial assistance, the smaller cities are often dependent on external support due to scarce personnel and financial capacities. Moreover, the content of national funding programmes is an important element for encouraging or inhibiting integrative actions by municipalities. Against this background, sectorally oriented funding programmes should be avoided.

Patterson and Huitema (2019) show that the institutional link between individual administrative disciplines/units is an important direction. From their perspective, it is of particular importance for municipalities to find ways to enhance institutional connectivity to avoid silo mentality. The same can be said from the perspective of our study. Institutionalised formats of exchange, such as working groups, teams or committees, were highlighted by the interviewees. In most of our case studies, positive experiences with interdisciplinary working formats have already occurred. However, it should be noted that employees can also be overburdened by too many non-standard working formats. The establishment of these kinds of formats should be accompanied by the provision of sufficient financial and personnel capacities (relevance and inter-linkage to appropriated funding programmes). In this context, mutual support via bi- or multilateral networks between and within municipalities and city regions was also mentioned as a valuable resource.

From the perspective of Chu (2018), a successful implementation of climate change adaptation is neither a top-down nor a bottom-up process. This coincides with findings by Klein *et al.* (2018) and Brink and Wamsler (2018), who examined the importance of cooperation between the city, citizens and the private sector. Our case studies have shown that, in particular, well-tested contacts to NGOs, citizens and the involvement and initiation of measures by companies can be used for an integrated implementation. In addition, we conclude that a central contact point is essential for the implementation.

6. Conclusions

The results show that there is currently no comprehensive approach to solving conflicts between urban infill development and climate change adaptation. Nevertheless, a number of modules were identified to create applicable solutions. Clear common visions and objectives are seen as a good starting point by a number of cities. These objectives included the development of scenarios for urban development and adaptation that are linked with positive and negative effects of interconnected solutions.

To date, sectoral solutions are still in use in many cities and regions, leading to insufficient and unsuccessful governance methods related to the interdisciplinary issues described above. Obviously, there is a need to negotiate solutions that combine organisational, institutional, interacting and enabling factors. One of the main future tasks is to find new creative solutions for assumed contrary societal demands, e.g. for dealing with the increased demand for housing while simultaneously adapting to climate change. The use of an adequate spatial level, i.e. the regional context, will play an important role. Moreover, additional knowledge will be necessary to generate a

broader overview of local and regional solutions for minimising conflicts and developing innovative activities, e.g. by generating new databases. The case studies showed that social innovations contribute to overcoming institutional barriers, taking into account that these innovations often involve complex actor constellations and processes and therefore have long development times before they are institutionalised and translated into established and continuous action (Christmann *et al.* 2018). For instance, implementing a strategic framework for a common understanding of city-wide goals support a synergetic combination of single measures and an efficient discussion of project steps (like in the cases of Berlin and Bonn). Furthermore, linking single projects to common strategic goals is very important to improve the visibility and impact of partial projects, as they can be showcased as being stepstones to a bigger common goal (as in the cases of Cologne and Neuss). These positive, self-enforcing features of projects need to have a sound evidence base to support the whole decision-making process. Using analytical tools that help to identify relevant facts and to discuss with stakeholders proved to be a major supporting element for successful implementation.

While this study was limited to six German cities, we consider that the analytical framework could also be applied to examine a larger sample of cities. An analysis based on a larger variety of cities could reveal more differences between cities and allow meaningful comparisons to be made between cities that are significantly different. International comparative case studies will show how much national and regional framework conditions will influence regional and local governance approaches. For this article, our heuristic analysis was suitable for capturing important aspects of the joint governance of climate change adaptation and urban infill development. We found that the combination of interviews and policy document analysis was helpful for identifying the relevant interactions between the governance aspects considered.

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