Sustainable Stormwater Management in Existing Settlements—Municipal Strategies and Current Governance Trends in Germany

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Abstract: While a policy of more decentralized stormwater management is increasingly being pursued in areas containing new housing developments, the question arises as to how stormwater management is handled in existing settlements, where restructuring the drainage system is a much more complex affair and often requires the active involvement of property owners. Recognizing that the multidimensional objectives of stormwater management in settlements call for a range of local strategies, this article examines the interaction and strategic contribution of two key municipal institutions for regulating stormwater management, namely, compulsory connection and usage and stormwater charges, in order to examine how they meet these objectives when property owners are involved. The following questions are addressed: How do these two key institutions link the varied objectives of stormwater management with practical options for decentralization? Which institutional designs are capable of integrating property owners into a municipal stormwater strategy in a coherent manner? What is current local government practice? This article begins by analyzing the interactions between different objectives of stormwater management, the interplay of the two key institutions, and options for stormwater management on private properties. On this basis, we then present an empirical study of current practice in 44 medium to large cities in Germany. This shows that while local governments devise very different—and often inconsistent—institutional designs, decentralization is quite commonly pursued in existing settlements.

Keywords: stormwater; governance; compulsory connection and usage; stormwater charges; Germany

1. Introduction

In Germany as well as in many other countries, urban water infrastructure systems are increasingly subject to changing conditions and requirements, such as climate change [1,2], demographic change [3], and a greater need for ecological sustainability in water management generally [4,5]. In order to meet these challenges, it is often considered necessary to transform infrastructure systems [6–8], involving not just far-reaching technical innovations but also significant organizational and institutional changes in the provision of services [9]. In the context of urban water systems, the management of stormwater is crucial [10].

Over the last century, the public drainage system has been the backbone of municipal stormwater management in Germany. This system is run by the public authorities on (and under) public land. However, the system’s role in managing stormwater has come to be questioned over the last few decades in the face of numerous challenges [11]. Climate change, for instance, is expected to...
increase the frequency of heavy rain events, leading in turn to more frequent urban flash floods along with an increase in pollution of the rivers into which this excess water flows [12]. It is therefore becoming increasingly difficult to meet the traditional objectives of stormwater management in terms of flood protection and surface water protection and simultaneously do justice to more demanding environmental requirements, e.g., working towards “good status” as stipulated by the EU Water Framework Directive (WFD). The significance of stormwater management is further heightened when one considers the need to bring the water balance in urban areas closer to a natural state [13] and to deal with heat stress (e.g., via the positive climate effects of green roofs) [14].

Decentralized stormwater management options are becoming increasingly important as a means to address such objectives. These options include local measures such as water retention, the decoupling of sealed surfaces from the mains drainage system as well as water infiltration, evapotranspiration and rainwater use. There may be several benefits to be gained by adding these components to the existing centralized system: the protection of water resources and a decline in emissions by reducing peak flows [15] as well as bringing the water balance of urban areas closer to a natural state by increasing infiltration and evapotranspiration [13,16].

However, those services can also be provided—at least to some extent—by altering centralized systems, for instance by increasing retention capacity or by creating centralized infiltration ponds. In terms of cost-effectiveness, however, decentralization options may be more favorable because they avoid the high costs involved in adapting centralized drainage systems [17]. Additionally, there are certain factors that call either for decentralization or for keeping centralized systems in their original state. Decentralization is expected to provide greater flexibility in the overall system, not least in view of the uncertainties associated with climate change [18]. However, from an economic point of view, the devaluation of previous investments and the risk of increased costs (and, thus, also charges) combined with the loss of economies of scale and higher transaction costs can be considered to be serious arguments against decentralization.

Thus, “decentralized” and “sustainable” are by no means synonyms. “Sustainable” is understood here as achieving the optimum and, in the long term, most viable balance between the ecological, economic and social issues associated with infrastructure development [19–21]. The sustainability challenge faced by municipalities is to find a new balance between centralization and decentralization with respect to local requirements that may differ greatly in spatial terms, e.g., natural landscape conditions, settlement structures, and the state of the place’s infrastructure.

A key issue within this rebalancing process is the extent to which property owners should be entrusted with the task of installing and operating decentralized options in order to utilize the significant portion of urban area in private hands. It has long been the case that property owners are merely the customers of drainage services while municipalities are the providers. Overcoming this traditional understanding of roles is a particular challenge for municipal governance. A large stakeholder group has to be included in planning and implementation, making the outcome of decision-making processes much more complex due to the legal, technical and socioeconomic issues involved. To circumvent this problem, municipalities can build and operate decentralized options on and under public land in order to gain the benefits of decentralization without having the inconvenience of dealing with private landowners.

This is the starting point for the present analysis. The study raises the question as to the direction in which stormwater management is currently being channeled in German municipalities and whether and in what way property owners are becoming involved. Based on numerous studies that have laid the groundwork for designing sustainable stormwater management from a technical perspective [10,14,22–25], this study will focus on institutional aspects of municipal stormwater governance in Germany and their strategic contribution toward integrating property owners.

In line with the New Institutional Economics theory, institutions are understood in the following as a set of formal and informal rules that guide human interaction by defining and limiting actors’ decision space [26]. They are assigned a significant role in the steering of transformation
processes [27,28]. In reference to two fundamental municipal institutions for regulating stormwater management—compulsory connection and usage and stormwater charges—we address the following questions: How do these two key institutions link the varied objectives of stormwater management with the options for decentralization available to property owners? Which institutional designs are capable of integrating property owners into municipal stormwater strategy in a coherent manner? What is current local government practice?

There are numerous other institutions that govern stormwater management in urban areas [29,30]. These include urban land-use planning and local statutes regarding the mandatory use of green roofs as well as local funding programs for decentralization measures, information campaigns, and even restrictions on the use of centralized systems. However, the focus of this study is on compulsory connection and usage and on stormwater charges, because both institutions are found in every municipality and both have an effect on the entire city. They are therefore the institutional foundation for stormwater management. Furthermore, by analyzing the design of institutions and the way they interact (“institutional interplay” see [31]), it is possible to identify current trends in the transformation of stormwater management systems much sooner than would be possible by monitoring the changes made to technical systems, which generally occur more slowly.

In order to explore these questions, this article is organized as follows: first we develop an analytical framework to derive coherent institutional designs of the two key institutions. This framework enables us to analyze the effects of the institutions’ interplay on property owners’ decisions and similarly to establish links between the institutional design options and the municipal objectives of stormwater management as well as strategies to integrate property owners. These coherent institutional designs provide a basis for empirically assessing the current practices of 44 selected large German cities. For the analysis, empirical data were collected at the municipal level in 2019 and compared with a previous assessment from 2012 (see Section 3). In Section 4, we discuss the empirical results against the background of our theoretical considerations.

2. Involving Property Owners in Municipal Stormwater Management—A Key Task for Stormwater Governance

2.1. Challenge of Designing Institutions—Harmonizing Property Owners’ Decisions with the Objectives of Municipal Stormwater Management

In a municipality, institutions play a crucial role in harmonizing the actions of property owners with the objectives of municipal stakeholders regarding stormwater management. A municipality will use institutions to establish decision-making power (who decides?), the permissible alternatives (what can be decided on?) and the decision-making process itself (how will it be decided?). Institutions can also have indirect effects, for instance by setting incentives which promote certain technologies.

For complex tasks such as stormwater management, it is necessary to draw on a range of institutions to coordinate the various measures involved. Here, we analyze two key institutions: compulsory connection and usage and stormwater charges. Ideally, the effects of the different institutions should complement one another. In order to ensure that this occurs, the institutional settings should be designed by the municipality according to two strategic planning steps. First, the municipality must decide on the set of stormwater management objectives it seeks to implement by weighting the various objectives according to local framing conditions and development needs. Second, the municipality must decide whether private property owners are to play an active part in stormwater management at all and, if so, which objectives they should support.

Figure 1 shows these two strategic planning steps preceding the design of institutions. It also shows the mode of operation and conditions for fitting the institutions. Institutions should interact in such a way that (i) by granting/refusing decision-making power, (ii) by approving/discounting options and (iii) by setting incentives, the investment decisions of property owners are ultimately harmonized with the strategic plans.
We argue that while it is possible to distinguish between coherent institutional designs and non-coherent ones, it makes no sense to rank the coherent institutional designs themselves. This is because the municipality’s preferred system as well as its strategies for integrating property owners are (i) geared toward local framing conditions and, thus, may vary tremendously and (ii) may not be reported by municipalities. However, as the institutional design selected by municipalities is evident (i.e., it can be “seen”), this makes it possible to draw conclusions regarding the system to be implemented and the accompanying strategy for integrating property owners.

Figure 1. Conception of institutional design—external influences and effects on private stormwater management.

In the following, we summarize the objectives of stormwater management before introducing the options and reflecting on their varying ability to meet the objectives. We then identify four general strategies for integrating property owners into stormwater management. Finally, we describe the institutions at issue here and specify four coherent institutional designs.
2.2. Sets of Municipal Stormwater Management Objectives

If a municipality wishes to develop a sustainable stormwater management infrastructure, it will need to decide on a certain set of objectives, some of which will inevitably conflict with one another [19]. The main objectives of stormwater management are:

1. Flood protection: One of the main objectives of urban drainage systems is to prevent urban flooding and, thus, to protect people and property from harm. Important measures include ensuring there is sufficient space for floodwater retention in the drainage system or decoupling sealed areas from the system in order to mitigate peak discharges [1,10,11].

2. Surface water protection: The legal requirements regarding the protection of surface water have increased steadily over the last few decades. They include the requirement to reduce peak rainwater outflow and storm drain pollution caused by rainwater discharge or sewer overflows—this can be done by improving retention in the drainage system or by decoupling sealed surfaces at the point of surface runoff [11,13,32].

As both objectives can be met either by improving retention in the drainage system or by decoupling sealed surfaces, they will be conflated in the following discussion.

3. Improving water balance: Stormwater management can partially mitigate the negative effects of sealed surfaces by improving the water balance so that it approaches a natural state. Groundwater recharge should be improved in urban areas by increasing infiltration compared to drainage. Evapotranspiration should also be improved. Further, as a way of adapting to climate change and the reduced availability of fresh water, it may be appropriate and effective to harvest and reuse rainwater as a substitute for fresh water for indoor use or outdoor watering [11,13,16].

In addition to these key objectives of urban drainage (“what has to be done?”), other objectives relate to the matter of implementation (“how is it done?”):

4. Conflict-free refinancing: As the existing public urban drainage systems are capital intensive, it is important to establish a form of refinancing that is as free of potential conflict as possible. Conflicts can arise as a result of prohibitively expensive charges (as in cases when the public drainage system requires major upgrading) or when property owners are presented with a strong incentive to decouple from the public system so that they no longer have to refinance it. In such a case, the remaining users will be faced with a greater financial burden [19].

5. Controllability: As drainage systems are complex networks, they are most easily designed when under the control of as few actors as possible.

6. Cost effectiveness: Water services should be provided at the least cost to the community. Meeting this objective requires that stormwater management be designed in a cost-effective way (static perspective) and that appropriate consideration be given to technological progress and changes in the framework conditions, such as settlement structure, natural landscape conditions and societal objectives (dynamic perspective) [11,17,19].

The question as to which of these objectives are to guide a municipality’s decision-making process will depend on the local framework conditions and the specific design of the system infrastructure. For instance, if an existing municipal drainage system is particularly vulnerable to heavy rainfall, the objectives of flood protection and surface water protection may become particularly important. However, if the systems are already well adapted to the consequences of climate change, the objective of conflict-free refinancing is likely to be more important.

2.3. Practical Options for Stormwater Management on Properties

There are many options that can be applied by property owners and that contribute to one or more objectives of municipal stormwater management (see Table 1). Rainwater can be retained, infiltrated,
evaporated or stored for outdoor or indoor use. Most of the decentralized options contribute to the objectives of flood protection and surface water protection by mitigating surface run-off and providing at least one means of improving the water balance (groundwater recharge, evapotranspiration or water reuse) [32–34]. However, the technologies differ considerably:

- Infiltration systems and the unsealing of surfaces improve groundwater recharge, while cisterns and green roofs contribute very little toward this objective.
- In contrast to green roofs and infiltration measures, cisterns enable drinking water to be substituted by rainwater, thus reducing the need for fresh water abstraction.
- Depending on the choice of technology, the property stays connected to the public sewer (partly decoupled) or becomes completely decoupled.

### Table 1. Contribution of decentralized options to achieving the objectives of stormwater management.

| Option | Flood Protection/Surface Water Protection | Improving Water Balance |
|--------|------------------------------------------|-------------------------|
|        | Retention | Complete Decoupling | Ground-Water-Recharge | Evapotrans-Piration | Fresh Water Substitution |
| Partial unsealing | 0.5 | 0 | 0.5 | 0.5 | 0 |
| Complete unsealing | 0.5 | 0.5 | 0.5 | 0.5 | 0 |
| Green roof with connection to public sewer | 1 | 0 | 0 | 1 | 0 |
| Green roof + infiltration | 1 | 1 | 0.5 | 1 | 0 |
| Cistern with overflow to public sewer | 0.5 | 0 | 0 | 0 | 1 |
| Cistern + infiltration | 1 | 1 | 0.5 | 0 | 1 |
| Infiltration system with overflow to public sewer | 1 | 0 | 1 | 0.5 | 0 |
| Complete infiltration system | 1 | 1 | 1 | 0.5 | 0 |
| Surface infiltration | 0.5 | 1 | 1 | 1 | 0 |
| Infiltration pond | 1 | 1 | 1 | 1 | 0 |

Note: Scores are mainly derived from [34] and represent the contribution of the specific technology to objectives of stormwater management (0 = no contribution, 0.5 = significant contribution, 1 = strong contribution).

2.4. Strategies for Integrating Property Owners

Municipalities must decide whether or not property owners should fulfil some of the tasks of municipal stormwater management and, if so, which of the municipal objectives should be addressed by them. Four strategies can be differentiated:

1. Forced decentralization: Property owners are encouraged as much as possible to adopt decentralized systems of all sorts and to provide the whole range of services that can be provided by decentralized options.
2. Selected decentralization: Property owners are encouraged to adopt those local technologies in particular which help to meet certain objectives, e.g., decoupling from the drainage system, infiltration, water reuse.
3. Ensuring the extension of the public system: Property owners are prevented from supporting stormwater management by their own actions. At the same time, municipalities establish appropriate conditions for extending the services provided by the public system and for refinancing them in a sustainable way.
4. Conserving the status quo: Property owners have no incentive to adopt decentralization measures: the existing public system adequately meets the objectives of stormwater management.

The reasons behind choosing a certain strategy can vary. Prioritizing objectives like conflict-free refinancing or ensuring controllability clearly require strategies that prevent property owners from using decentralized options (e.g., the strategy of “ensuring the extension of the public system”), in order not to reduce the number of contributors to public system refinancing and not to increase the number of actors involved. Further, the availability of public space for building and operating decentralized
options may influence strategy regarding whether to incorporate private owners or to use public land for decentralization. As the availability of space has a major impact on costs, choosing a strategy may be a matter of cost effectiveness. Finally, whether to incorporate property owners or not is only relevant if there is a need to improve stormwater management at all.

Since the factors mentioned above will differ between municipalities, there is no straightforward method for deciding which strategy is the best one.

2.5. Institutions for Integrating Property Owners

As mentioned above, the key institutions of interest in stormwater governance in Germany are (i) municipal provisions regarding compulsory connection and usage and (ii) stormwater charges.

(i) The provisions on compulsory connection and usage define the decision-making competencies of property owners for choosing local stormwater technologies, and this in turn has direct consequences for the degree of decentralization that can occur. If a compulsory connection and usage is given, property owners are obliged to connect their property to the public sewage system and to discharge into this system. In the case of wastewater disposal, compulsory connection and usage is enforced very strictly by municipalities [35]. In the case of stormwater, however, the situation is less strict, provided it does not undermine public interests, such as environmental compatibility, and the functionality and economic viability of the traditional sewage systems. It should be stressed that while the strict enforcement of compulsory connection and usage reduces the freedom of choice for property owners and therefore greatly reduces the likelihood of decentralization, it does not completely prevent the use of decentralized options for stormwater management, since not all the practical options available are covered by the regulation (see Table 2).

Table 2. Effects of institutional settings on addressing decentralized options of stormwater management.

| Option                              | Significance of Compulsory Connection and Usage | Special Rebates Required for Incentivizing Effects by Stormwater Charges |
|-------------------------------------|-------------------------------------------------|------------------------------------------------------------------------|
| Partial unsealing                   | No                                              | Yes                                                                    |
| Complete unsealing                  | No                                              | No                                                                     |
| Green roof with connection to public sewer | No                                              | Yes                                                                    |
| Green roof + infiltration           | Yes                                             | No                                                                     |
| Cistern with overflow to public sewer | No                                              | Yes                                                                    |
| Cistern + infiltration              | Yes                                             | No                                                                     |
| Infiltration system with overflow to public sewer | Yes                                             | Yes                                                                    |
| Complete infiltration system        | Yes                                             | No                                                                     |
| Surface infiltration                | Yes                                             | No                                                                     |
| Infiltration pond                   | Yes                                             | No                                                                     |

(ii) The costs of providing urban drainage systems have to be covered by levying charges. Since the compulsory introduction of new stormwater charges in Germany in recent years, stormwater drainage and wastewater are paid for separately by property owners (“split wastewater charge”). The wastewater charge is still based on the amount of drinking water consumed (euros per m$^3$), while the amount payable for stormwater drainage depends on the size of the drainage area connected to the mains system (euros per m$^2$), analogous to the polluter pays principle.

In addition to this financing function, charges have a steering function. The implementation of stormwater charges creates incentives for property owners to reduce the size of the connected drainage areas and the amount of stormwater runoff [36]. The level of the charge itself creates an incentive to decouple drainage areas by means of unsealing and infiltration, though not to adopt local measures that will not change the size of the drainage area, such as green roofs or cisterns. Special rebates on stormwater charges are needed to systematically promote (or to hinder) the latter technologies. This is done by granting or not granting rebates for the use of local measures and by setting an appropriate rebate level (e.g., rebates for the installation of green roofs, cisterns or infiltration measures—see
Table 2). The design of stormwater charges thus enables municipal authorities to influence the behavior of property owners regarding decentralization.

2.6. Institutional Designs

The institutional design should reconcile the decisions of property owners with the strategies and objectives of the municipality. At the same time, both the institutions under scrutiny here interact with one another. As discussed above, provisions regarding compulsory connection and usage may limit the number and range of technologies that are possible, while the design of stormwater charges (i.e., the level of charges and the number and level of rebates) should secure the refinancing of public systems while at the same time setting incentives (or not) for decentralization measures on the part of property owners. If compulsory connection and usage is a given, it restricts the steering effect even of high stormwater charges and ultimately increases the effect of refinancing and controllability. In addition, as some local measures cannot be prevented by compulsory connection and usage, the spread of these options can be significantly hindered nevertheless by setting low stormwater charges and by not granting special rebates.

When both institutions are combined, institutional designs that fit with the four strategies of integrating property owners as described above become feasible. They can further be linked to specific sets of objectives. This is shown in Figures 2 and 3, which are based on Table A1 in the Appendix A. For simplification, it is assumed that the three institutions behind the design are dichotomous variables: compulsory connection and usage is mandated or not; either all rebates are granted or none, and charge levels are either high or low.

The two decentralization strategies can be implemented by means of the following institutional designs (see Figure 2):

1. Forced decentralization is induced when, first, there is no compulsory connection and usage, second, the stormwater charges are very high and, third, a large number of special rebates for decentralized measures are offered. In this way, all the decentralization options are allowed and are “rewarded”. This strategy could be chosen by municipalities that depend heavily on property owners to contribute towards improving the water balance and flood protection/surface water protection while accepting the high potential for conflict regarding refinancing and a significant loss of control.

2. Selective decentralization can be induced by a combination of no compulsory connection and usage, high charges and no rebates. This design makes it possible to promote flood protection/surface water protection—especially by having property owners decoupled from public system. In addition, the water balance will be improved with the help of property owners. This strategy should be chosen by a municipality if it is prepared to accept quite high risks regarding refinancing and a loss of control.

The willingness of property owners to decentralize increases with increasing charge levels and an increasing number of rebates (see orange arrows in Figure 2).

In contrast, the following institutional designs correspond to strategies suited to exclude property owners from stormwater management (see also Figure 3):

3. Ensuring the extension of the public system is achieved by combining compulsory connection and usage with high charges. At the same time, no special rebates on charges should be granted. This design could be chosen if property owners are to contribute towards stormwater management by co-financing the public system—even if the latter is enlarged and becomes more expensive (high charges). The risk to refinancing is significantly lower in comparison to the strategy of “selective decentralization”. At the same time, the objective of controllability is addressed. However, as property owners are still permitted to unseal sealed surfaces and are rewarded for doing so, a small risk regarding refinancing and controllability remains.
(4) Conserving the status quo can be achieved by having an institutional arrangement that combines compulsory connection and usage, a low level of stormwater charges and no special rebates on charges. This reduces the options for decentralization by property owners and simultaneously minimizes their incentive to do so. Long-term controllability and conflict-free refinancing is ensured in this way. This design should be chosen when municipalities can cope in the long run with low charges in order to meet all the objectives of stormwater management.

Figure 2. Correspondence between institutional designs, strategies for integrating property owners and sets of objectives—when compulsory connection and usage is not in force.

Figure 3. Correspondence between institutional designs, strategies for integrating property owners and sets of objectives—when compulsory connection and usage is in force.
The willingness of property owners to take decentralization measures increases only with an increasing number of rebates on high charges (see orange arrows in Figure 3). Figures 2 and 3 reveal that other institutional designs are possible. However, they show notable inconsistencies with regard to the objectives and strategies pursued and are therefore not considered to be coherent. This is the case, for example, when no compulsory connection and usage is given while at the same time no (or insufficient) incentives for decentralization measures are granted in a situation of low charges (see the lower quadrants in Figure 2). The same applies in the case of implementing elaborate incentive systems (many rebates) but simultaneously maintaining compulsory connection and usage (see the right-hand quadrants in Figure 3).

3. Empirical Study

3.1. Objectives, Materials and Methods

In the empirical section below, we examine whether the four institutional designs to integrate property owners, identified above as being coherent, are pursued in practice. Further, we are interested in discovering which of them are preferred by municipalities and in what direction stormwater systems are being steered. To address these questions, we assessed the institutional framework conditions of 44 selected cities in Germany using the analytical framework presented above (see Sections 2.1 and 2.6). This was done by analyzing the current local municipal statutes regarding drainage regulation (Abwassersatzung) and wastewater charges (Abwassergebührensatzung) with a view to the local characteristics of “compulsory connection and usage” and “stormwater charges” (see Tables A2 and A3 in the Appendix A for more details). Municipal statutes are legally binding rules that govern local arrangements in detail. Although differences exist on the basis of different state laws and the varying practices of city councils, the overall structure of municipal statutes is almost everywhere the same. The authors’ interpretation of the relevant paragraphs has been backed up by lawyers. In addition, information material provided by the cities about options for stormwater management on private property was also evaluated.

The systematic selection of cities is based on a ranking in terms of the level of charges [37], and consideration was given particularly to those cities with the highest and the lowest charges. To ensure a broad regional spread, the sample was supplemented by cities in federal states that were not included in the study.

3.2. Empirical Results—Institutional Designs in Practice

Our empirical analysis reveals considerable differences among German municipalities in the specific design of institutional settings. The results are presented below.

3.2.1. Compulsory Connection and Usage

Three types of compulsory connection and usage were found in municipal statutes:

- Type 1: No compulsory connection and usage.
- Type 2: Compulsory connection and usage; exemptions may be requested.
- Type 3: Compulsory connection and usage without exemptions.

In more than the half the sample (27 cities), there is no compulsory connection for stormwater (type 1), while in a third of the sample (16 cities) compulsory connection and usage exists but is attenuated by the possibility of an exemption. Compulsory connection and usage without any exemptions was found in only one city. In a previous study from 2012, telephone interviews were conducted with municipal stakeholders in “type 2 cities” (n = 20) in order to better understand the administrative procedure for granting exemptions and to reveal the underlying justifications for and against granting exemptions [38]. The study showed that numerous cities approve applications for exemptions provided there is evidence of the infiltration capacity of the soil. Only a few cities based their
decisions on other considerations, including refinancing issues, the design of the infrastructure system in place (separate sewerage system or not) and the risk of overload in cases of heavy rainfall events. When asked why they decided against the strict enforcement of compulsory connection and usage (type 1), numerous municipalities expressed their interest in exploiting the benefits of decentralization, especially to avoid the costs of reconstructing their sewerage systems. Some municipalities cited the legal requirements of state water law as a reason for granting exemptions. At the same time, most of the municipal administrations interviewed opposed the total abolition of compulsory connection and usage because they wanted to maintain control over the development of their infrastructure systems. They also wanted to prevent infiltration measures being carried out at inappropriate places and to avoid financing difficulties (see Table 3). Overall, three out of four requests for an exemption from compulsory connection for stormwater were granted in practice.

### Table 3. Permission policy and reasons for decisions in municipalities with application procedures.

| Approval of Applications | Factors Influencing Decision | Why No (Strict) Compulsory Connection? | Why Application Procedure? |
|--------------------------|------------------------------|---------------------------------------|-----------------------------|
| Yes                      | Infiltration Capabilities    | Refinancing                           | Separate Sewer System       |
|                          |                              |                                       | Overload                    |
|                          |                              |                                       | Interest in Infiltration    |
|                          |                              |                                       | Legal Requirements          |
|                          |                              |                                       | Flexibility                 |
|                          |                              |                                       | Control Option              |
|                          |                              |                                       | Refinancing                 |
| 15                       | 5                            | 13                                    | 4                           |
| 4                        | 4                            | 3                                     | 10                          |
| 5                        | 6                            | 15                                    | 5                           |

Source: based on [38] (p. 219).

#### 3.2.2. Stormwater Charges and Special Rebates

The stormwater charges found in the sample range from 0.29 €/m² to 1.93 €/m² and, thus vary significantly between the municipalities. The unweighted average stormwater charge in the sample was 0.85 €/m², which is consistent with the current German average [39]. Furthermore, the study examined whether the drinking water charge correlates systematically with the stormwater charge, as this may provide an incentive to re-use rainwater by means of cisterns. However, as drinking water prices and stormwater charges are not correlated in the sample, no presumption can be made regarding the possibility that drinking water prices have a systematic influence on the effect of stormwater charges.

There are also considerable differences between municipalities with regard to the design of the special rebates applicable to property owners; the spectrum ranges from “no reduction” to “full refund of charges” if one of the following technologies is used:

- Infiltration system with overflow to public sewer,
- Cistern (outdoor watering) with overflow to public sewer,
- Cistern (indoor use) with overflow to public sewer,
- Unsealing of surface(s),
- Green roof with connection to public sewer.

When comparing the municipalities, no clear preference for a certain technology was found, although the installation of green roofs and unsealing measures were rewarded more often than measures involving infiltration with overflow to public sewers. It is also striking that more than half of the cities surveyed promote at least four of the above-mentioned technologies, while one fifth does not even apply the instrument of special rebates (see Figure 4).
represents the type of municipality regarding compulsory connection and usage. The type 2 cities are treated in two ways. Since it is not known exactly whether the exemptions are granted or not, the left-hand diagram maps the situation of a liberal permission policy where all requests for exemption from measures involving infiltration with overflow to public sewers. It is also striking that more than half of the cities surveyed promote at least four of the above-mentioned technologies, while one fifth does not apply.

3.3. Institutional Designs

Which of the coherent institutional designs for integrating property owners can be found in practice? Figure 5 maps the institutional combinations that are found in the sample when using the analytical scheme of quadrants (see also Table 4). The x-axis shows the number of special rebates for stormwater charges, while the y-axis shows the corresponding level of charges for each city studied. To determine the quadrants, the average level of charges and half of the range of special rebates were chosen. This methodical approach should not be understood as applying a selective distinction between the types of strategies discussed above. However, it does allow a crude classification of the cities according to obvious differences between strategic approaches to stormwater management.

Figure 4. Specifications of special rebates for stormwater technologies in municipal statutes; (a) shows how often the individual technologies were promoted; (b) shows to what extent special rebates were applied.

Figure 5. Characteristics of key institutions of stormwater management in the sample (n = 44); (a) liberal permission policy; (b) restrictive permission policy.
Table 4. Frequency of municipal strategies in the sample (n = 44).

| Strategy for Integrating Property Owners | Institutional Design | Frequency |
|-----------------------------------------|----------------------|-----------|
|                                         | Compulsory Connection | Stormwater Charges |                 |
|                                         |                       | Level of Charges | Special Rebates | |
| Permission policy is liberal            |                       |                 |                 |  |
| Decentralization strategies            | Forced decentralization | no | high | many | 9 | 14 |
|                                         | Selective decentralization | no | high | few | 5 | |
| Structure preserving strategies         | Ensuring extension of the public system | yes | high | few | 0 | 0 |
|                                         | Conserving status quo | yes | low | few | 0 | |
|                                         |                       | no | low | few | 11 | 30 |
|                                         |                       | no | low | many | 18 | |
|                                         |                       | yes | high | many | 1 | 30 |
|                                         |                       | yes | low | many | 0 | |
| Permission policy is restrictive        |                       |                 |                 | |
| Decentralization strategies            | Forced decentralization | no | high | many | 3 | 6 |
|                                         | Selective decentralization | no | high | few | 3 | |
| Structure preserving strategies         | Ensuring extension of the public system | yes | high | few | 2 | 7 |
|                                         | Conserving status quo | yes | low | few | 5 | |
|                                         |                       | no | low | few | 6 | |
|                                         |                       | no | low | many | 15 | |
|                                         |                       | yes | high | many | 6 | 31 |
|                                         |                       | yes | low | many | 4 | |
Each dot of Figure 5 represents a municipality contained in the sample. The color of the dots represents the type of municipality regarding compulsory connection and usage. The type 2 cities are treated in two ways. Since it is not known exactly whether the exemptions are granted or not, the left-hand diagram maps the situation of a liberal permission policy where all requests for exemption from compulsory connection and usage are granted (Figure 5a), while the right-hand diagram shows the case of a restrictive permission policy, where all applications are rejected (Figure 5b).

In both cases, the heterogeneity of institutional designs chosen by the municipalities is apparent. Nevertheless, the sample suggests an overall trend towards those designs that pursue a more decentralization-orientated strategy and seek to integrate property owners. The results show that, independently of the prevailing permission policy, the obligatory use of centralized infrastructure systems in the case of stormwater is less common these days. Even if all type 2 municipalities (with an application procedure for exemption from compulsory connection and usage) pursued a restrictive permission policy, only 17 out of 44 municipalities would impose compulsory connection and usage. As stated above, most applications for exemptions have been granted in the past. This makes the observation of a declining importance of compulsory connection even more striking.

The trend towards decentralization-oriented strategies becomes particularly evident when assuming a liberal permission policy for all type 2 municipalities. In this case, 14 cities would pursue one of the two strategies of decentralization but would not implement any structure-preserving strategies. Even in the unrealistic case of a restrictive permission policy by all type 2 municipalities, decentralization and structure-preserving strategies would have been almost balanced (decentralization: six, structure preserving: seven).

However, in two out of three municipalities in the sample we can observe inconsistencies in the implementation of the institutions. While decentralization measures are basically permitted in most of the municipalities, they are either not promoted or are promoted but to only a small extent. This contradicts our theoretical analysis (see Figure 5 and Table 4).

3.4. Recent Changes in Institutional Designs

A study conducted in 2012 by the authors of this article [38] enables a comparison of some of the results over a period of time. First, it must be noted that there are no big differences between 2012 and 2019 (see Table A2 in the Appendix A for an overview). This can be explained by overall institutional inertia and mostly gradual changes in the urban water sector [9]. However, some changes over this period are worth mentioning. For instance, the development of the level of stormwater charges reveals a mixed picture. While seven cities stayed at the same level and 22 cities increased their charges, 15 cities reduced them (see Table 5). This is a surprising finding as we expected that the effects of inflation, population decline and more stringent requirements regarding flood protection would have led to an overall rise in charges. It would also imply that these municipalities most likely do not use stormwater charges to promote local stormwater management.

Table 5. Changes of key institutions in the cities analyzed in recent years.

| Institution                        | Change          | Number |
|----------------------------------|-----------------|--------|
| Compulsory connection and usage  | Abolition of application procedure | 4      |
|                                  | Introduction of application procedure | 1      |
| Level of stormwater charge       | Increased       | 22     |
|                                  | Reduced         | 15     |
| Special rebates                  | Expanded        | 4      |
|                                  | Reduced         | 3      |

Regarding the provisions for compulsory connection and usage, we observed only minor changes. Four cities decided to abolish the application procedure, which means that property owners can now freely decide to use decentralization measures if local conditions allow (e.g., infiltration ability of
the soil). We can only speculate about their reasons for doing so: it is possible that the application procedure was seen to be too complicated. It is also possible that experience showed that only a few people requested disconnection and that the functionality of the system was thus not threatened. However, one municipality did just the opposite by introducing an application procedure.

There is no uniform picture either when looking at the special rebates on charges. On the one hand, four cities expanded their portfolio of special rebates, possibly in order to pursue decentralization more actively. On the other hand, three cities curtailed special rebates. One city obviously decided to promote only those technologies that do not provide for overflow to public sewers, because rebates are now only granted if soils are unsealed. Some cities abolished the reduction for cisterns, with one city justifying its decision by reference to the requirements of the Local Tax Act [40].

It would be interesting to know whether the recent changes resulted from a desire to achieve more coordinated strategies or whether they are rather the result of “normal” operational decisions. It is difficult to answer this question for cities that have only changed the level of stormwater charges. The reason for doing so may be that they want to promote or hinder decentralization and to better coordinate the institutions of stormwater management, but numerous other factors could also be responsible for the price changes, e.g., changes in operational costs. We observed an increasing level of charges combined with a simultaneous expansion of rebates in only two cities. One of these cities also abolished the application procedure. This indicates that these cities are more actively pursuing a strategy of decentralization, even though both still use a level of stormwater charge that can be classified as “low” compared with the median charge levels of the municipalities evaluated above.

All in all, it can be stated that changes in institutional settings over time do not reveal any particular robust trend among municipalities.

4. Discussion

The empirical results show that decentralization-oriented strategies that invite property owners to play an active part in stormwater management are pursued more through the design of key institutions than strategies to exclude property owners from stormwater management. This might lead to the conclusion that municipalities value the positive contributions made by property owners regarding flood protection, surface water protection and water balance more highly than a loss of controllability and a higher risk of refinancing. However, such an interpretation presupposes that municipalities are free in their choice of strategies and corresponding institutions and that the relevant actors are interested solely in optimizing the performance of the infrastructure overall. The large number of inconclusive and ineffective combinations of institutions that we observed in our study, however, indicates that barriers to implementing coherent strategies at the municipal level do exist. In the following, we will explain the possible barriers to implementing coherent strategies that exist as a result of the following factors: constrained decision making within municipalities, divergent interests of stakeholders, and the need for greater robustness in institutional design under conditions of uncertainty.

First, it is conceivable that decision-making power within municipalities is distributed among many actors, which can result in inefficient coordination based on unequal access to information and differing interests [41]. The task of devising meaningful objectives along with concomitant strategies for integrating property owners and of harmonizing institutions so that these strategies can be implemented in a coherent way requires a combination of decision-making power and access to relevant information regarding the key institutions. This requirement is often not met in practice. The water management facility operators usually possess specific knowledge about adaptation requirements and corresponding options, while municipal bodies with different tasks and objectives (e.g., finance department, environment office) are responsible for drawing up legislation and, thus, for designing institutions. Furthermore, it is likely that negotiations will lead to compromise solutions that try to please everybody. The large number of non-coherent combinations of institutions that are neither one thing nor the other could be an outcome of such negotiation processes.
Another closely related explanation, suggested by public choice theories, could be that decision makers pursue their own interests and that these are not necessarily compatible with the above-mentioned “social” objectives and strategies of sustainable stormwater management. According to this understanding, the design of institutions—here, especially the level of stormwater charges and the characteristics of special rebates—is a result of the varied political intentions of the stakeholders and of their bargaining power than a balanced design aimed at achieving a specific overall strategy. For instance, an unpopular measure such as increasing the level of charges contrasts sharply with the motivation of politicians seeking to maximize their popularity in order to improve their chances of being re-elected [42]. This implies that the great potential for inducing decentralization by increasing charges has not been fully exploited in most cases yet. This applies all the more since political decisions on infrastructure development often generate visible results only in the distant future, while the political costs (loss of votes) accrue in the present.

It should also be mentioned that legal stipulations imposed by higher political authorities reduce the freedom of choice of municipalities. As shown above, the level of stormwater charges is often very low and probably not adequate to give incentives for decentralization measures. This is also a result of the prevailing legal guidelines for calculating charges, the principal aim of which is the refinancing of existing infrastructure systems. The guiding principles of the Local Tax Act (Kommunalabgabengesetz), such as the principles of cost recovery, equivalence and equality, set limits for municipalities to apply charges as a steering tool. Although municipalities have some creative leeway to overcome these restrictions (e.g., when choosing the methods regarding depreciation and cost unit accounting or deciding on the imputed cost of capital), it may be too arduous to exploit this existing scope for freedom rather than to stick to routines.

Additionally, it should be more widely acknowledged that charges are a steering tool and not merely an instrument of financing. This became obvious after split sewage charges were introduced in Germany and property owners put significantly more pressure on municipal authorities to gain exemptions from compulsory connection and usage [43]. Thus, greater freedom in the design of charges would be desirable. One option, for example, would be to include the opportunity costs incurred by not pursuing decentralization [44].

Apart from legal requirements, routines, practices and instructions can also be misleading. For instance, “model statutes” that suggest how to apply legal requirements (such as state water law or municipal codes) are frequently used in the wastewater sector. Again, it is feasible that a higher federal authority might provide instructions that do not match local requirements and objectives. The current model statute of Baden-Württemberg, for instance, could be understood as a proposal to exploit the use of rebates in favor of decentralized systems [45]. As explained in Section 2, this is only consistent with one out of four coherent strategies for integrating property owners. Moreover, the institutional interplay between charges and rebates is not mentioned at all. The extent to which such model statutes are capable of being adapted and applied to local objectives will depend on local administrative capacities and the above-mentioned distribution of competencies. This problem may lead to non-coherent institutional designs.

A further reason for non-coherent combinations of institutional measures could be a lack of local differentiation within municipalities. Different conditions within a municipality may require different stormwater strategies, which may differ considerably between, for example, existing settlements and new housing estates. In the latter, decentralized options are already more common, due to the new requirements of water legislation. However, there is usually no small-scale differentiation of institutional settings, e.g., in the case of special rebates, thus making a compromise design attractive.

Finally, we need to reflect on the remarkable number of cases where compulsory connection and usage is softened by the possibility of exemptions. This approach could simply be the most straightforward application of the municipal constitution (Gemeindeordnung) of the different federal states, as many of them offer this option (e.g., the municipal constitutions of North Rhine-Westphalia, Hesse and Saxony). However, it may also be seen as a means of maintaining control over system
change and, thus, increasing the robustness of institutional design under conditions of uncertainty. While municipalities currently make use of the benefits of decentralization, they can simply promote the aim of refinancing the existing system in future, if necessary. Even though this generates administrative costs (e.g., the application procedure), the cost-benefit balance might nevertheless be positive once all the transaction costs are included. Municipalities acquire detailed information about the extent to which decentralized options are being implemented; this enables them to monitor objectives and, if necessary, make institutional adjustments. Further, it is possible to prove in advance whether infiltration measures are subject to restrictions (e.g., proof of infiltration capability by property owners), which reduces subsequent information costs for municipalities. In the case of a general exemption from compulsory connection and usage, these costs may arise when liability issues need to be addressed as a result of inadequate infiltration.

To summarize, there may be understandable reasons for the combinations of approaches which at first sight seem to follow no clear strategy. This includes the restricted freedom of choice of municipalities, diverging political objectives, barriers due to institutions imposed at higher federal levels, and the need for robustness in institutional design under uncertainty. In cases where, according to our theoretical analysis, combinations of institutions appeared coherent, the municipalities concerned seem to be setting a course for decentralization, even in existing settlements.

5. Conclusions

This article has examined theoretically and empirically the design of key municipal institutions for integrating property owners into sustainable stormwater management in Germany. With climate change making itself increasingly felt, the challenge of governing the transformation of stormwater management systems arises, first, from the need to reassess the multiple objectives of stormwater management locally, and, second, from the difficulty of translating a set of objectives into a technical infrastructure design. As part of this transformation, property owners can be encouraged or hindered in implementing and operating decentralized measures. The benefits and risks of both strategies ultimately depend on local objectives and framing conditions. This paper has identified a number of coherent institutional designs suited to incorporating property owners into stormwater management and has presented an empirical analysis of current local governmental practice.

It was shown that the individual effects of the key institutions under scrutiny are complex. As stated above, ensuring the enforcement of compulsory connection and usage is, in and of itself, not suited to prevent the use of at least some decentralization measures. Yet it is only by abolishing this institution that the whole range of decentralized technologies is explicitly made available and only then that important aspects of water balance (e.g., groundwater recharge) can be addressed in practice. Stormwater charges play an important but ambiguous role here, since they are both an institution for refinancing (public systems) and an incentive toward decentralization at the same time. Additionally, the application of charges only can provide an incentive for all decentralization measures if they are sufficiently high and are complemented by a system of rebates.

The analysis highlights the complexity of “institutional interplay”, i.e., the mutual effects of different institutions. We found four institutional designs where the impacts of compulsory connection and stormwater charges mutually reinforce each other and lead to consistent strategies for achieving a specific set of objectives in a targeted way by involving property owners to varying degrees.

Taking our theoretical findings as a starting point, we analyzed the current practice of 44 large cities in Germany. The institutional designs studied indicate that municipal decisions are made in favor of decentralization on private properties:

- The vast majority of cities allow measures of local stormwater management; in one third of these cases, an application procedure applies.
- There are considerable differences between municipalities regarding the level of stormwater charges and the design of the special rebates.
A comparison with the results of a prior study from 2012 showed only minor changes in general. There was no evidence to suggest that municipalities nowadays pursue more coordinated strategies of stormwater management.

Although we found examples of coherent institutional designs, the numerous non-coherent institutional designs were a surprise; we found inefficient “strategies” of decentralization that involved no proper incentives to implement appropriate measures very often. Potential explanations for shortcomings in the strategic design of institutions were discussed above. These include, for example, constrained decision-making capacity within municipalities, divergent individual interests, barriers erected by institutions at higher federal levels, and the need for robustness in institutional design under conditions of uncertainty.

This paper has sought to contribute to the ongoing debate about sustainable stormwater management:

- It shows empirically that decentralization on private properties is becoming increasingly important.
- Second, in revealing a gap between realized institutional settings and theoretical considerations regarding coherent institutional designs, it serves as an encouragement to municipal stakeholders to acknowledge the interplay of institutions when revising them in future.
- Finally, this paper calls for a differentiated view of local stormwater management, as the effects of institutional designs and their interplay can be understood only against the background of the specific set of local objectives, strategies and framing conditions involved.

Although this paper has offered some insight into the interplay between institutions, technologies and strategies, much more work needs to be done to understand the mechanisms in more detail. If sustainability-led stormwater management is to be successful, it is crucial to understand these interdependencies. Effective and appropriate institutional designs at the municipal level as well as at the state and federal level can make a decisive contribution in practice.

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Appendix A

Table A1. Effect of institutional settings towards the possible contributions of property owners towards the targets of stormwater management.

| Compulsory Connection and Usage | Rebates | Groundwater Recharge | Evapotranspiration | Fresh Water Substitution | Total | Retention | Decoupling Sealed Surface | Total | Conflict-Free Refinancing */Controllability ** |
|---------------------------------|---------|----------------------|--------------------|--------------------------|-------|-----------|---------------------------|-------|----------------------------------------------|
| no                              | none    | 4.5                  | 4                  | 1                        | 9.5   | 5         | 5.5                       | 10.5  | 6                                            |
| no                              | many    | 6                    | 6                  | 2                        | 14    | 8         | 5.5                       | 13.5  | 10                                           |
| yes                             | none    | 0.5                  | 0.5                | 0                        | 1     | 0.5       | 0.5                       | 1     | 1                                            |
| yes                             | many    | 1                    | 2                  | 1                        | 4     | 2.5       | 0.5                       | 3     | 4                                            |
| **Maximum Score**               |         | **6**                | **6**              | **2**                    | **14**| **8**     | **6**                      | **14**| **10**                                       |
| **Percentage of Maximum Score** |         | **75%**              | **67%**            | **50%**                  | **68%**| **63%**   | **100%**                   | **100%**| **78%**                                     |
| no                              | none    | 75%                  | 67%                | 50%                      | 68%   | 63%       | 100%                      | 100%  | 78%                                         |
| no                              | many    | 100%                 | 100%               | 100%                     | 100%  | 100%      | 100%                      | 100%  | 100%                                        |
| yes                             | none    | 8%                   | 8%                 | 0%                       | 7%    | 6%        | 9%                        | 7%    | 70%                                         |
| yes                             | many    | 17%                  | 33%                | 50%                      | 29%   | 31%       | 9%                        | 22%   | 60%                                         |

Scoring is done by adding the effects of those technologies (referring to Table 1) that are allowed and supported by charges/rebates (referring to Table 2); * Conflict free refinancing is scored inversely to the number of options allowed and supported by charges/rebates; it depends on high charge levels. ** Controllability is scored inversely to the number of options allowed and supported by rebates.

Table A2. Characteristics of relevant institutions of stormwater management in 2012 and 2019 (sort by level of stormwater charges in 2019, n = 44).

| City    | 2012 | 2019 |
|---------|------|------|
|         | Type of Compulsory Connection | Stormwater Charges in Euro | Number of Special Rebates | Type of Compulsory Connection | Stormwater Charges in Euro | Trend Charges | Number of Special Rebates |
| 1 Wuppertal | 3 | 1.93 | 3 | 3 | 1.95 | ↗ | 3 |
| 2 Berlin   | 1 | 1.90 | 5 | 1 | 1.84 | ↘ | 5 |
| 3 Velbert  | 2 | 1.58 | 3 | 2 | 1.67 | ↘ | 3 |
| 4 Dresden  | 1 | 1.69 | 3 | 1 | 1.56 | ↘ | 3 |
| 5 Essen    | 2 | 1.23 | 2 | 2 | 1.56 | ↘ | 2 |
| 6 Witten   | 2 | 1.86 | 5 | 2 | 1.48 | ↘ | 5 |
| 7 Oberhausen | 2 | 1.12 | 3 | 2 | 1.41 | ↘ | 3 |
| 8 Remscheid | 2 | 1.39 | 1 | 1 | 1.38 | ↘ | 1 |
| 9 Magdeburg | 1 | 1.20 | 2 | 1 | 1.30 | ↘ | 2 |
| City               | Type of Compulsory Connection | Stormwater Charges in Euro | Number of Special Rebates | Type of Compulsory Connection | Stormwater Charges in Euro | Trend Charges | Number of Special Rebates |
|-------------------|-------------------------------|---------------------------|---------------------------|-------------------------------|---------------------------|---------------|--------------------------|
| Munich            | 1                             | 1.30                      | 5                         | 1                             | 1.30                      | →            | 5                        |
| Bonn              | 2                             | 1.25                      | 2                         | 2                             | 1.26                      | ↘            | 2                        |
| Potsdam           | 1                             | 1.37                      | 0                         | 1                             | 1.23                      | ↘            | 1                        |
| Bergisch Gladbach | 2                             | 0.93                      | 4                         | 2                             | 1.19                      | ↗            | 4                        |
| Pforzheimer       | 1                             | 0.97                      | 4                         | 1                             | 1.01                      | →            | 4                        |
| Saarbrücken       | 2                             | 1.06                      | 4                         | 2                             | 0.95                      | ↗            | 4                        |
| Mannheim          | 1                             | 0.81                      | 4                         | 1                             | 0.83                      | ↘            | 4                        |
| Darmstadt         | 1                             | 0.99                      | 4                         | 1                             | 0.82                      | →            | 4                        |
| Leipzig           | 1                             | 0.89                      | 4                         | 1                             | 0.82                      | ↘            | 1                        |
| Wiesbaden         | 1                             | 0.70                      | 5                         | 1                             | 0.76                      | ↗            | 5                        |
| Freiburg im B.   | 2                             | 0.70                      | 2                         | 2                             | 0.74                      | →            | 2                        |
| Hamburg           | 1                             | 0.73                      | 5                         | 1                             | 0.74                      | ↗            | 5                        |
| Gütersloh         | 2                             | 0.54                      | 5                         | 2                             | 0.72                      | →            | 5                        |
| Augsburg          | 1                             | 0.71                      | 0                         | 1                             | 0.71                      | →            | 0                        |
| Stuttgart         | 2                             | 0.57                      | 5                         | 1                             | 0.71                      | →            | 5                        |
| Münster           | 2                             | 0.55                      | 5                         | 2                             | 0.68                      | →            | 4                        |
| Rostock           | 4                             | 0.46                      | 4                         | 2                             | 0.67                      | →            | 4                        |
| Nuremberg         | 1                             | 0.51                      | 2                         | 1                             | 0.65                      | →            | 2                        |
| Schwerin          | 1                             | 0.69                      | 5                         | 1                             | 0.64                      | →            | 5                        |
| Bremen            | 1                             | 0.72                      | 5                         | 1                             | 0.63                      | →            | 5                        |
| Ingolstadt        | 1                             | 0.44                      | 3                         | 1                             | 0.61                      | →            | 5                        |
| Braunschweig      | 1                             | 0.61                      | 5                         | 1                             | 0.60                      | →            | 5                        |
| Mainz             | 2                             | 0.60                      | 0                         | 2                             | 0.60                      | →            | 0                        |
| Furth             | 1                             | 0.66                      | 1                         | 1                             | 0.59                      | →            | 1                        |
| Hildesheim        | 2                             | 0.53                      | 4                         | 1                             | 0.59                      | →            | 4                        |
| Hanau             | 1                             | 0.70                      | 5                         | 1                             | 0.55                      | →            | 5                        |
| Heidelberg        | 1                             | 0.55                      | 3                         | 1                             | 0.54                      | →            | 5                        |
| Gera              | 1                             | 0.35                      | 0                         | 1                             | 0.53                      | →            | 0                        |
| Wolfsburg         | 1                             | 0.51                      | 0                         | 2                             | 0.51                      | →            | 0                        |
| Kaiserslautern    | 2                             | 0.50                      | 4                         | 1                             | 0.5                        | →            | 4                        |
| Würzburg          | 1                             | 0.46                      | 3                         | 1                             | 0.46                      | →            | 0                        |
| Salzgitter        | 2                             | 0.43                      | 0                         | 2                             | 0.43                      | →            | 0                        |
| Regensburg        | 2                             | 0.53                      | 0                         | 2                             | 0.42                      | →            | 0                        |
| Flensburg         | 2                             | 0.29                      | 4                         | 1                             | 0.41                      | →            | 5                        |
| Villingen-Schwenn. | 2                             | 0.33                      | 5                         | 2                             | 0.35                      | →            | 5                        |

Type 1: No compulsory connection and usage; Type 2: Compulsory connection and usage; exemptions may be requested; Type 3: Compulsory connection and usage without exemptions.
### Table A3. Versions of municipal documents evaluated.

| City             | Municipal Statutes | Drainage | Charges |
|------------------|--------------------|----------|---------|
| 1 Wuppertal      | 01.01.2011         | 01.01.2019 |         |
| 2 Berlin         | 29.01.2019 *       | 29.01.2019 * |       |
| 3 Velbert        | 23.04.2018         | 12.12.2018 |         |
| 4 Dresden        | 15.12.2005         | 18.11.2016 |         |
| 5 Essen          | 30.11.2015         | 04.12.2018 |         |
| 6 Witten         | 07.12.2017         | 07.12.2017 |         |
| 7 Oberhausen     | 15.07.2013         | 15.07.2013 |         |
| 8 Remscheid      | 15.12.2014         | 10.12.2018 |         |
| 9 Magdeburg      | 01.12.2005         | 01.01.2019 |         |
| 10 Munich        | 28.08.2018         | 28.08.2018 |         |
| 11 Bonn          | 18.12.2017         | 14.12.2018 |         |
| 12 Potsdam       | 01.03.2017         | 01.03.2017 |         |
| 13 Bergisch Gladbach | 18.12.2018     | 18.12.2018 |       |
| 14 Pforzheim     | 25.10.2009         | 25.10.2009 |         |
| 15 Saarbrücken   | 22.11.2016         | 05.12.2017 |         |
| 16 Mannheim      | 27.10.2015         | 27.10.2015 |         |
| 17 Darmstadt     | 18.12.2013         | 15.12.2018 |         |
| 18 Leipzig       | 20.05.2015         | 29.01.2019 * |       |
| 19 Wiesbaden     | 18.12.2014         | 18.12.2014 |         |
| 20 Freiburg im B. | 29.02.2016       | 29.02.2016 |         |
| 21 Hamburg       | 23.01.2018         | 29.01.2019 * |       |
| 22 Gütersloh     | 28.05.2010         | 02.02.2019 * |       |
| 23 Augsburg      | 30.04.2014         | 03.12.2014 |         |
| 24 Stuttgart     | 17.07.2014         | 08.12.2005 |         |
| 25 Münster       | 16.12.2016         | 14.12.2018 |         |
| 26 Rostock       | 14.07.2016         | 14.07.2016 |         |
| 27 Nuremberg     | 01.12.2015         | 01.12.2015 |         |
| 28 Schwerin      | 22.03.2016         | 01.04.2017 |         |
| 29 Bremen        | 01.12.2015         | 31.01.2017 |         |
| 30 Ingolstadt    | 21.08.2017         | 30.07.2018 |         |
| 31 Braunschweig  | 01.04.2014         | 06.11.2018 |         |
| 32 Mainz         | 03.12.2009         | 21.01.2015 |         |
| 33 Fürth         | 10.11.2017         | 10.11.2017 |         |
| 34 Hildesheim    | 18.11.2013         | 03.12.2015 |         |
| 35 Hanau         | 01.01.2019         | 01.01.2019 |         |
| 36 Heidelberg    | 20.12.2018         | 28.11.2018 |         |
| 37 Gera          | 02.06.2017         | 28.12.2018 |         |
| 38 Wolfsburg     | 07.12.2016         | 21.12.2017 |         |
| 39 Kaiserslautern | 29.07.2016         | 29.07.2016 |         |
| 40 Würzburg      | 16.12.2018         | 26.04.2018 |         |
| 41 Salzgitter    | 25.04.2001         | 01.01.2016 |         |
| 42 Regensburg    | 01.09.2016         | 04.12.2008 |         |
| 43 Flensburg      | 07.12.2017         | 13.12.2018 |         |
| 44 Villingen-Schwenn | 28.11.2018     | 28.11.2018 |         |

* Alternative documentations (e.g., information brochure, websites of water service providers).

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