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Climate Change Perception and Adaptation in Small and Medium-Sized Municipalities in Central Germany

Anika Zorn¹, Susann Schäfer^{2*}

¹ Heidelberg University, Institute of Geography, Economic and Social Geography, Berliner Str. 48, 69120 Heidelberg, Germany;

anika.zorn@uni-heidelberg.de; <https://orcid.org/0009-0002-4543-1747>

² Heidelberg University, Institute of Geography, Economic and Social Geography, Berliner Str. 48, 69120 Heidelberg, Germany; Heidelberg Center for the Environment (HCE), Heidelberg University, 69120 Heidelberg, Germany; susann.schaefer@uni-heidelberg.de; <https://orcid.org/0000-0002-4390-2958>

* corresponding author

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Abstract

The focus of research on municipal climate adaptation has been predominantly on large cities. Although research on climate adaptation in small and medium-sized municipalities is increasing, there is a lack of perspectives from local decision-makers in those municipalities. In this paper, we analyze the perceptions of climate change and the role of local climate adaptation in small and medium-sized municipalities in Central Germany. We analyze the sensory observations of climate change and climate risks, the attitudes and awareness of climate change, the integration of climate knowledge and information, the local discourses and interpretations of climate change, the perception of climate risk management, and the relevance of the policy field. Our database consists of a survey of local decision-makers in the region. The results reveal that decision-makers in smaller municipalities tend to be less aware of climate change and corresponding risks, incorporate less climate information into their daily work, and discuss climate policy more negatively than in larger municipalities. Furthermore, climate policy is less institutionalized in smaller municipalities. Our perception-based approach provides an actor-centered perspective on local climate adaptation, which is particularly valuable for small and medium-sized municipalities. We contribute to a more nuanced understanding of climate adaptation at the local level.

Keywords awareness, climate policy, Saxony, Saxony-Anhalt, Thuringia

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1. Introduction

Recent political developments, such as the Federal Climate Adaptation Law in Germany, indicate that increasing efforts are being taken to minimize the negative impacts of climate change. Concepts and strategies with concrete measures for adaptation to undesirable climate change impacts are being developed at different political levels (Kern, 2018). An important basis for strategic climate change adaptation is the question of whether and to what extent climate change and its impacts are perceived as problematic (Hathaway & Maibach, 2018; Soubry et al., 2020). Therefore, scientists research how different actors perceive climate change in various parts of the world (Zorn et al., 2023). The climate change perceptions of political decision-makers have so far been studied less intensively (Zorn et al., 2023). Although the perception of environmental changes does not necessarily determine adequate adaptive behavior, it is an important foundation for systematic engagement with climate action (Zorn et al., 2023).

Political and scientific actors consider municipalities key actors in climate adaptation in Germany and many other countries because they govern various climate-relevant public services (European Environment Agency, 2024; Federal Ministry for Environment, Nuclear Safety and Consumer Protection, n.d.; Kern, 2018; Mees, 2017). Since municipalities have different natural, economic, sociodemographic, infrastructural, and financial conditions, there is no blueprint for effective municipal climate adaptation (Riach et al., 2023). Instead, local-specific risk analyses and adaptation strategies must be developed and implemented. Pioneers in the field of climate adaptation are predominantly large cities (Otto et al., 2021), while small and medium-sized municipalities have often lacked the capacity for climate adaptation (Fila et al., 2024; Fünfgeld et al., 2023).

For this reason, we address the following question in this paper: *How do decision-makers in small and medium-sized municipalities perceive climate change in Central Germany?* Following Zorn et al. (2023), we analyze sensory observations of climate change and climate risks, attitudes and awareness of climate change, integration of climate knowledge and information, local discourses and interpretations of climate change, perception of climate risk management, and relevance of the policy field. The region of Central Germany serves as our case study. Central Germany

encompasses the federal states of Saxony, Saxony-Anhalt, and Thuringia. We sent a questionnaire to all heads of the region's 1,307 municipalities and municipal associations. 324 (24.8%) questionnaires were completed online. The results contribute to a better understanding of political decision-makers' perception of climate change. Since the region is dominated by small and medium-sized municipalities, this study provides a more nuanced understanding of climate change perception and adaptation beyond large cities. As this is a German case study, this paper frequently refers to other research within the German context. Where findings are internationally applicable, we also reference international studies.

In the second section of this paper, we provide an overview of the current state of research on municipal climate adaptation and explain how climate change perception and climate change adaptation are interconnected. In Section 3, we introduce our case study and methodological approach. We present our empirical findings on climate change perception in the study region with a focus on differences concerning the size of municipalities in Section 4. In Section 5, we summarize and discuss our results before concluding with a summary and outlook in the final section.

2. Climate Change Perception and Climate Adaptation in Municipalities

Research on climate governance no longer focuses solely on the international relations of global climate policy (Pattberg et al., 2022). Polycentric and multi-level governance perspectives increasingly recognize that, in addition to national-level policies, subnational decision-making plays a critical role in climate change governance (Heinen et al., 2022; Kellner et al., 2024). The core assumption is that, alongside state regulations, decision-making processes at local levels are essential for both climate mitigation and adaptation. Urban areas, as primary sources of greenhouse gas emissions, are a key focus of research in this field (Castán Broto & Westman, 2020).

In addition to urban areas, small and medium-sized municipalities are increasingly gaining attention in climate adaptation research (Fila et al., 2024). These municipalities, which also need to adapt to climatic changes and risks, often have fewer resources than larger cities. Our study aims to contribute to a more nuanced understanding of the role of local levels in

polycentric and multi-level climate governance. Similar to national governments, municipalities have varying resources and contextual factors that shape their adaptation capacity. We examine how decision-makers in small and medium-sized municipalities perceive climate change and related policies. We argue that these perceptions are crucial for different types of adaptation.

2.1 Climate Adaptation in Municipalities

Climate adaptation concepts are central objects in research on municipal climate adaptation, as they provide insights into planned or already implemented local climate policy measures (Otto et al., 2021). Analyzing climate action plans or other municipal strategies for climate adaptation can contribute to systematically assessing the state of local climate policy. Aboagye and Sharifi (2024) note that the suitability of climate action plans in cities can vary regionally. Other studies show that predominantly large cities with more than 500,000 inhabitants are pioneers in climate adaptation (Otto et al., 2021; Otto, Kern, et al., 2021). Urban climate policy can vary depending on local economic conditions. Old industrial cities perform worse in climate adaptation than, for example, university cities (Haupt et al., 2023). Climate mitigation is more strongly represented in urban strategies and concepts than adaptation. The integration of mitigation and adaptation in concepts is expandable in most cities (Grafakos et al., 2020). However, municipalities that engage more in climate mitigation also tend to adapt more actively (Otto, Kern, et al., 2021). Reckien et al. (2023) examine the quality of urban adaptation plans in Europe using an index that captures the factual basis, goals, measures, implementation, and monitoring. They find that while the quality of adaptation plans is generally low, it improves over time (Reckien et al., 2023).

The analysis of municipal adaptation concepts has three limitations. First, adaptation measures are not always named as such or can be side effects of other planning measures. Eckersley et al. (2023) argue that such unintended or hidden adaptations may not be visible in concepts for municipal climate adaptation. Second, not all municipalities have adaptation concepts. The examples cited above indicate that larger cities with more resources tend to develop climate adaptation strategies. Small and medium-sized municipalities and those with fewer resources often

lack such concepts (Buschmann et al., 2022; Fila et al., 2024). Schulze and Schoenefeld (2023) found that greater institutionalization of climate adaptation leads to more measures being implemented, although this relationship does not necessarily work in reverse. Depending on the size of the municipality and its vulnerability to climate change, it is conceivable that adequate adaptation measures may be taken within the municipality, even without a formalized climate adaptation concept. The exact population size attributed to small and medium-sized municipalities varies depending on the country and research context. For example, Fila et al. (2024) categorize municipalities with fewer than 20,000 inhabitants as small and those with fewer than 200,000 inhabitants as medium-sized.

Third, there are also actor-related factors that influence adaptation. The specific contents of climate adaptation concepts can be related to the underlying motivation. In a comparison of municipalities in the German state of Hesse and in Finland, Schoenefeld et al. (2023) conclude that municipalities in Hesse are predominantly prompted to adapt by experiences with extreme weather events and damages, while in Finland, the well-being of the local population is the primary concern. The engagement of key figures in municipal administration plays an important role in climate adaptation. Heikkinen et al. (2020) show that mayors who participate in adaptation networks also adapt more actively. Mayors can contribute to ambitious local climate policy even in regions with less favorable conditions (Haupt et al. 2022). Agency (Haupt et al. 2024) and attitudes (Simonet & Leseur, 2019) of local officials can play a significant role in the implementation of climate policies in municipalities. In political decision-making processes in small and medium-sized municipalities, such committed individuals with their values and views play a particularly important role in the implementation of environmental policies at the local level (Beveridge & Naumann, 2023). We conclude that in addition to institutional and structural conditions, individual factors of (non-) committed individuals can be very relevant for local climate action. To make these individual factors visible, it is not sufficient to analyze existing concepts, as these provide little information about their genesis and background.

2.2 Perceptions of and Adaptation to Climate Change in Municipalities

One research approach that considers actor-centered perspectives focuses on climate change perception. Although there is no universally accepted definition of climate change perception (Soubry et al., 2020), the term refers to the cognitive processing of environmental stimuli by individuals and is shaped by social and cultural factors (Ruhlemann & Jordan, 2021). The underlying assumption in this research strand is that although perception does not determine action, there is a connection between the perception of climate change and adaptation action (Zorn et al., 2023). While the climate change perception of agricultural actors has already been extensively studied (Soubry et al., 2020), there is a lack of systematic research on the perception of political decision-makers, who are primarily responsible for implementing local climate adaptation measures (Zorn et al., 2023). In a systematic literature review on climate change perception, Zorn et al. (2023) identify seven dimensions in which climate change can be perceived: sensory observations, risk, attitude/awareness, information/knowledge/uncertainty, discourse/interpretation, risk management, and policy field. The following sections elaborate on these dimensions in the context of municipal climate adaptation.

2.2.1 Sensory Observation

Changes in temperature and precipitation patterns, the natural environment, or the impacts of extreme weather events can be seen, felt, or heard. Research on the sensory perception of climate change primarily focuses on private households (Ngo et al., 2020) or agricultural actors (Soubry et al., 2020). The underlying assumption is that individuals take intended adaptation actions when they perceive environmental changes sensually (Zorn et al., 2023). However, little is known about how local decision-makers observe climatic changes. If we follow the assumption that sensory observation of climatic changes is relevant for ensuring intentional adaptation, then research from the perspectives of local administrations is important due to their extensive planning competence in Germany and other countries.

2.2.2 Risk

Individuals can also perceive climate risks. In addition to economic losses (Ahmed et al., 2021) due to extreme weather events or gradual changes in temperatures and precipitation, there are risks for the public sector. These include damages to infrastructure (Becker et al., 2015) or in the healthcare sector (Hathaway & Maibach, 2018) due to extreme weather events. In Germany, disaster management is a municipal responsibility. Studies show that experiences with damage caused by extreme weather events can facilitate climate adaptation measures (Kichamu et al., 2018; Li et al., 2021). After extreme weather events, a temporally limited window of opportunity can emerge (Giordano et al., 2020), which may promote adaptation measures (Braunschweiler & Ingold, 2023) but can also lead to maladaptations (Schipper, 2020). Experiencing damage does not necessarily lead to adequate adaptation. Nevertheless, reducing expected financial and health risks is considered an important incentive for intended climate adaptation (Simonet & Leseur, 2019).

2.2.3 Attitude/Awareness

Awareness of climate change means that actors are informed about the existence of global climate change and understand that it is mainly caused by anthropogenic greenhouse gas emissions. However, awareness of anthropogenic climate change is not initially required to implement adaptation measures. Climate awareness becomes relevant when climate adaptation and mitigation are considered in an integrated manner to prevent maladaptations (Lenzholzer et al., 2020). Consequently, scientists advocate awareness-raising as an important measure to enhance climate policy at various levels (Lenzholzer et al., 2020). At the same time, studies point to the limitations of awareness-raising, as there is a gap between awareness and climate action (Hochachka, 2024). The results of a French study by Simonet and Leseur (2019) suggest that climate awareness among local representatives is one crucial driver for climate adaptation. Therefore, examining the climate awareness of municipal actors is relevant for local climate adaptation.

2.2.4 Information/Knowledge/Uncertainty

Climate change and its impacts are subjects of scientific debate. As evident in the assessment reports of the Intergovernmental Panel on Climate Change (IPCC), a broad knowledge base concerning the genesis and impacts of climate change on various sectors and regions exists, which is repeatedly questioned by climate-skeptical actors (Petersen et al., 2019). The assessment of future risks and the evaluation of adaptation measures for effective adaptation often requires projections at the local level. However, such projections are not always available at a sufficiently precise scale for local application, and when they are available, appropriate resources, institutional frameworks, and trust in the robustness of information are required to apply and evaluate them in municipal planning (Lorenz et al., 2017).

2.2.5 Discourse/Interpretation

Media discourses and collective interpretations frame climate change and thus shape its perception. Single extreme weather events, or climate change in general, are often discussed in the media (Shewly et al., 2023; Painter et al., 2023; Gillings & Dayrell, 2023). Similarly, within political debates or climate action plans, various narratives, images, and ideas are linked to climate change (Islam et al., 2020). Local decision-makers consume media and the climate discourses they (re-)produce. At the same time, it is likely that these actors shape local discourses that can influence the acceptance of climate policy measures (Karakislak & Schneider, 2023).

2.2.6 Risk Management

Mitigation and adaptation measures that involve infrastructure or construction projects are often visible in the landscape. These measures alter the everyday environment of the local population, which can either approve or oppose the measures (Drews & van den Bergh, 2016). Additionally, the design of the planning processes for such measures can influence their acceptance among the public (Hügel & Davies, 2020). For local climate adaptation, this means that the implementation of measures largely depends on how local actors perceive these measures and their planning processes (Samaddar et al., 2021).

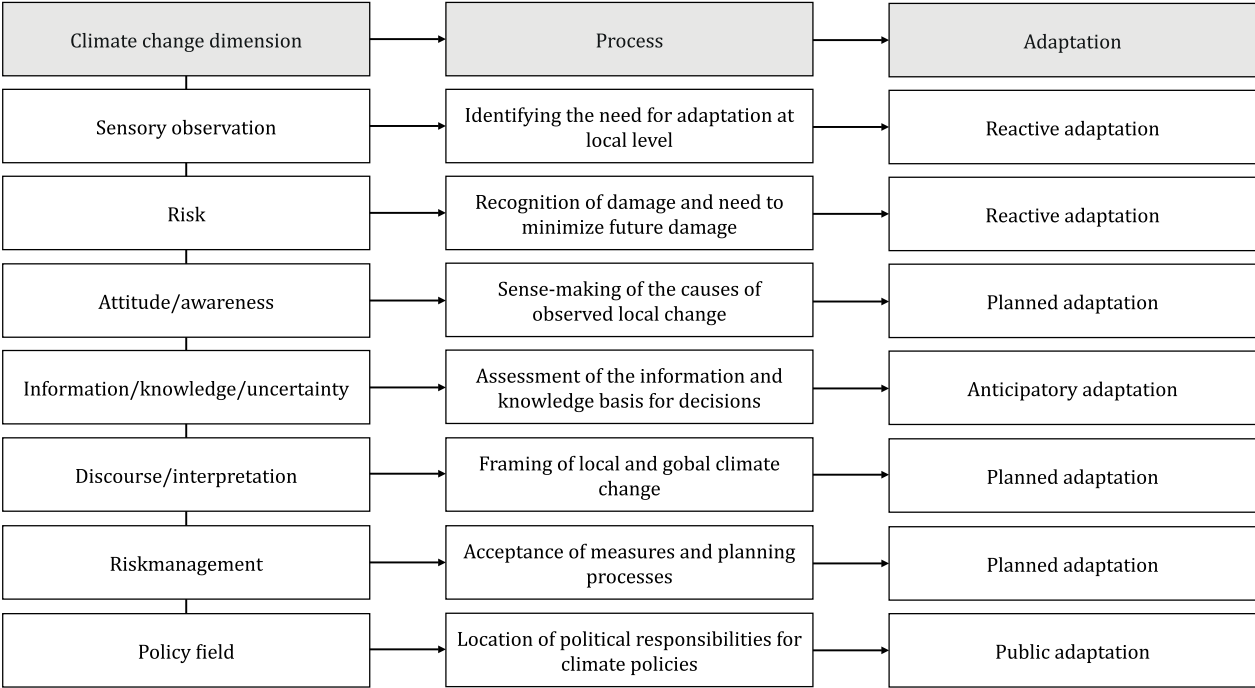
2.2.7 Policy Field

Climate policy is a policy field within a multi-level governance system (Ishtiaque, 2021). However, the relevance of climate policy varies depending on attitudes, institutional anchoring, and financial resources within administrations. Political decision-makers can locate the policy field and the corresponding responsibilities at different political levels or contexts (Essl & Mauerhofer, 2018). Cities and municipalities are identified as central actors in climate adaptation (Kern, 2018). However, little research has been conducted on how municipal actors perceive and position the policy field of climate adaptation themselves.

Individuals perceive different dimensions of climate change. These dimensions are not always clearly distinguishable and can overlap, such as sensory observations and risk perceptions, or awareness and discourses. Nevertheless, we argue that the systematization outlined above can help to better understand the complexity of climate change and its perception. How municipal actors beyond large cities perceive climate change is still under-researched.

We argue that, in addition to legal and economic conditions, local decision-makers' perceptions of climate change form a foundation for specific types of adaptation. Drawing on the IPCC's typology, we differentiate between reactive, planned, anticipatory, and public adaptation (Ara Begum et al., 2022). These forms are not mutually exclusive. For instance, if a decision-maker only perceives climatic changes through sensory observation and recognizes risks of extreme weather events, while neglecting other dimensions, adaptation is more likely to be reactive. This occurs because if the underlying causes of the changes are not reflected upon, adaptations are not undertaken on the basis of anticipations, and they may not be embedded in political frameworks. In contrast, planned adaptation requires an awareness of climate change as a human-induced phenomenon, one that is interpreted as such and accompanied by socially accepted risk management measures. Anticipatory adaptation depends on the perception and integration of robust climate information. When adaptation is established as a policy field at the local level, we can refer to this as public adaptation within municipalities. Figure 1 illustrates the relationship between climate change dimensions and adaptation.

Figure 1 Association Climate Change Dimensions and Local Adaption



Note. Source: Own illustration.

3. Case Study Central Germany

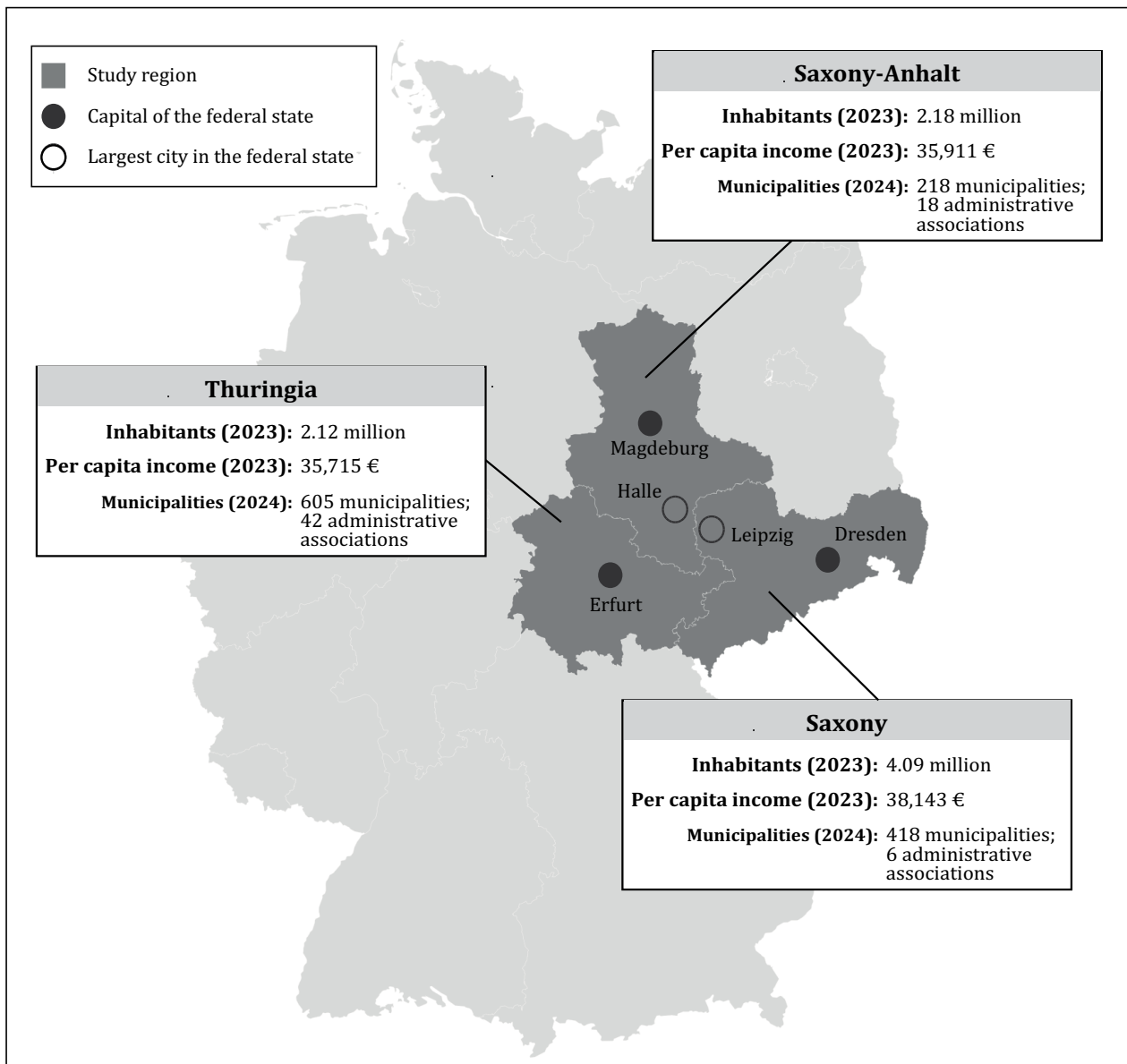
3.1 Climate Adaptation in Germany

Climate adaptation in Germany is embedded in a multi-governance structure. The European level (European Environment Agency, 2024) and the national level (Federal Ministry for Environment, Nuclear Safety and Consumer Protection, n.d.) identify essential aspects of climate adaptation as being relevant for the local level. In July 2024, the Federal Climate Adaptation Law came into force, requiring the states to report on municipal climate adaptation strategies (Federal Ministry for Environment, Nuclear Safety and Consumer Protection, 2023). Until then, climate adaptation was a voluntary task for municipalities, typically undertaken by larger cities with more resources. With the new law, climate adaptation as a policy field has potentially moved onto the agenda for all municipalities in Germany. However, it is still unclear how exactly the individual federal states will implement the law. For this reason, perspectives from municipalities beyond flagship projects are of particular interest to both researchers and decision-makers at the state level.

3.2 Study Region Central Germany

The study region of Central Germany encompasses three Eastern German states: Saxony, Saxony-Anhalt, and Thuringia (see Figure 2). The region is naturally diverse, including low mountain areas and agricultural basins, several forests, and rivers. The natural diversity goes along with corresponding climate vulnerabilities. A total of 8.39 million inhabitants live in the region (Federal Statistical Office of Germany, 2024). The per capita incomes of the three federal states are below average in a Germany-wide comparison, with Saxony-Anhalt and Thuringia even being the federal states with the second-lowest and lowest per capita incomes in Germany (Statistical Offices of the Federal States and the Federal Government, 2024). According to Koschatzky and Kroll (2019), the region of Central Germany tends to be predominantly structurally weak. The region includes a total of 38 counties, 66 administrative associations (*Verwaltungsgemeinschaften*, *Verwaltungsverbände*, or *Verbandsgemeinden*), and 1,241 municipalities (Landesportal Sachsen-Anhalt, 2024; Statistical Office of the State of Saxony, 2024; Statistical Office of the State of Thuringia, 2024a).

Figure 2 Study Region



Note. Source: Own illustration based on Federal Statistical Office of Germany, 2024; Statistical Offices of the Federal States and the Federal Government, 2024; Landesportal Sachsen-Anhalt, 2024; Statistical Office of the State of Saxony, 2024; Statistical Office of the State of Thuringia, 2024a.

The right-wing populist and climate-skeptical party *Alternative für Deutschland* (AfD) is relatively strongly represented in many municipal bodies in the study region (Boecher, et al., 2022). The AfD won around one quarter of the votes in the county and municipal council elections in May 2024 (Statistical Office of the State of Thuringia, 2024b). The economic and political situation in the region indicates that it can largely be characterized as left behind (Rodríguez-Pose et al., 2023). The developments following the reunification of Germany in 1990 are considered to be a main cause

of these differences compared to Western German states (Dickey & Widmaier, 2021). Figure 2 summarizes the background information on the study region.

More than two-thirds of the municipalities in Central Germany have less than 5,000 inhabitants. The biggest cities are Dresden and Leipzig, with more than 500,000 inhabitants each. Due to the dominance of municipalities with under 5,000 and the small number of municipalities with more than 100,000 inhabitants, we classify the municipality sizes here contrary

to Fila et al. (2024) and based on *Kommunale Gemeinschaftsstelle für Verwaltungsmanagement* (KGSt, 2024) as follows: small municipalities with less than 5,000 inhabitants, small medium-sized municipalities with 5,000 to 24,999 inhabitants, large medium-sized municipalities with 25,000 to 99,999 inhabitants, and large municipalities with 100,000 or more inhabitants. We argue that this classification of municipality size represents the study region best. However, one should consider the adapted classification when interpreting or transferring the results.

Numerous municipalities in the study region are already implementing single measures to adapt to climate change or are planning to do so, such as watering public green spaces during dry periods. Concepts for single aspects of climate adaptation, like flooding protection, exist in some of the municipalities. However, only 7.7% of municipalities have an integrated climate adaptation strategy. A separate office for climate adaptation management was created by 8.3% of the municipalities, and 4.6% of those surveyed stated that they had created such an office together with another administrative unit. Climate adaptation in the region, therefore, tends to take the form of singular measures or concepts rather than integrated strategies or dedicated offices. Friedrich et al. (2024) find that 12.0% of all German municipalities have a climate adaptation concept. The predominantly small and medium-sized municipalities in Central Germany are therefore slightly less likely to have climate adaptation strategies than municipalities in the rest of Germany.

3.3 Data and Methods

The data for our analysis is based on a survey conducted in April 2024. We addressed the survey to the mayors of all politically independent municipalities in Saxony, Saxony-Anhalt, and Thuringia, as well as to the heads of administrative associations in the three federal states. In collaboration with the respective state environmental offices, we sent a letter to all recipients, informing them about the online survey on climate change, extreme weather events, climate mitigation, and climate adaptation. The response rate is 24.8%. Smaller municipalities are underrepresented in the sample (see Figure 3). We analyzed the data descriptively and calculated the correlation with the defined municipal size classes using Kendall's tau-c.

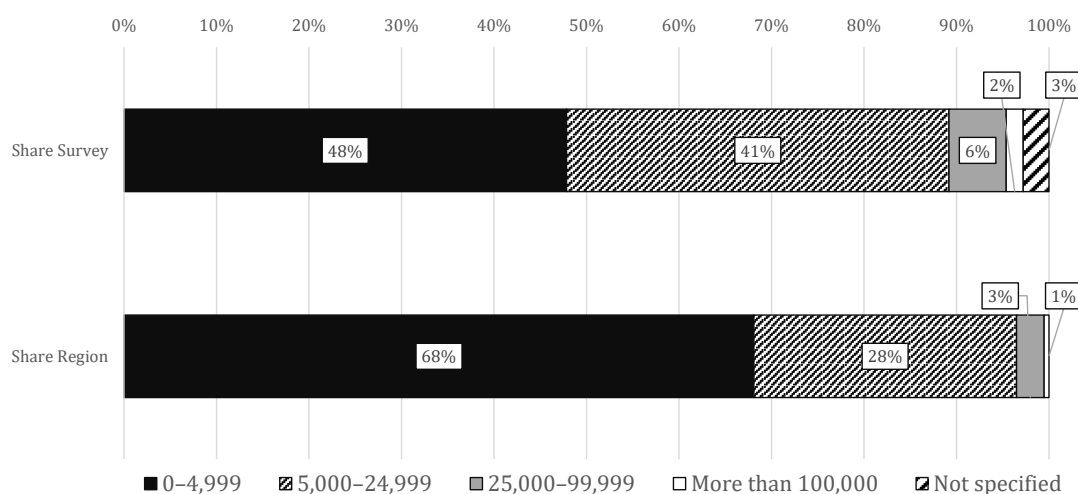
4. Climate Change Perception in Municipalities

Based on the survey results, we systematically analyze the seven dimensions of climate change that individuals can perceive.

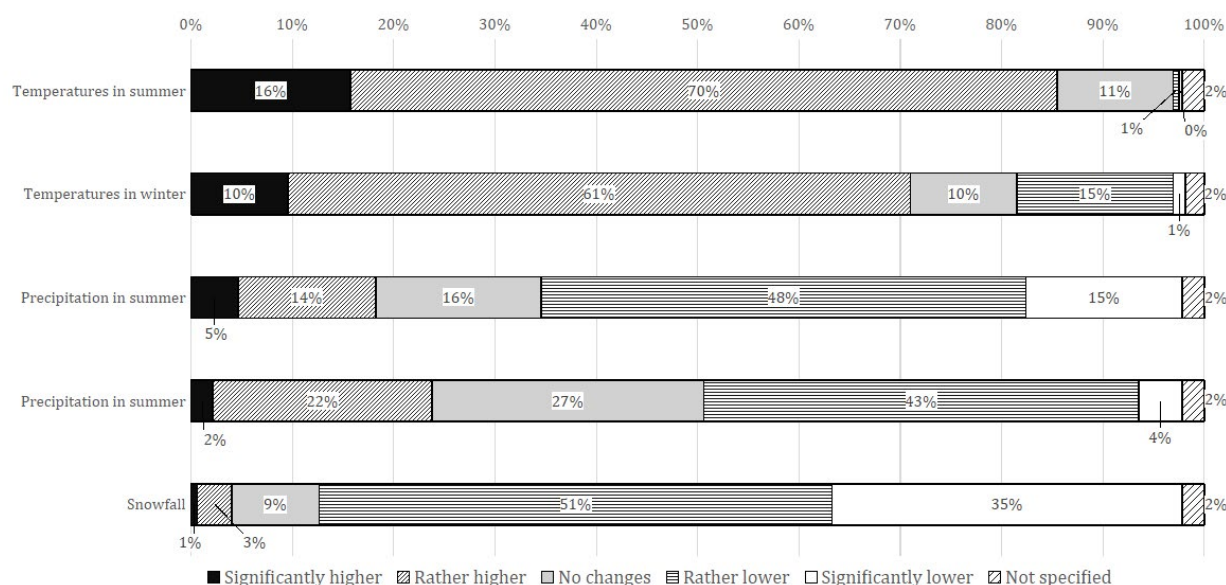
4.1 Sensory Observations

Figure 4 shows that nearly all respondents perceive climatic changes over the past 10 years. More than 85.0% of respondents have observed an increase in summer temperatures and a decrease in snowfall. A majority of respondents also report an increase in winter temperatures. While 63.2% of respondents believe that summer precipitation has decreased over

Figure 3 Share of Municipal Size Classes in the Study Region and Survey ($n = 324/1307$)



Note. Source: Own illustration.

Figure 4 Municipal Decision-Makers' Sensory Observations of Climatic Changes in the Last Decade ($n = 324$)

Note. Source: Own illustration.

the same period, just under half conclude that this applies to winter precipitation as well. These perceptions align with actual climatic changes, as both summer and winter temperatures have risen, and precipitation patterns in the region have shifted (Regional Climate Information System for Central Germany [ReKIS], 2024). At a sensory level, local decision-makers perceive a measurable increase in the slow-onset climate change impacts, like temperature and changes in precipitation patterns. We found no statistically significant difference between the sensory observation of climatic changes across different municipality size classes.

4.2 Risk

82.1% of respondents report that risks from drought have increased over the past 10 years. A similar proportion notes increased risks from heavy rainfall. Additionally, more than 70.0% perceive an increase in risks due to strong winds, storms, and heat. Around half of the respondents report elevated risks from flooding (see Figure 5). The lower perceived risk of flooding compared to other hazards can be explained by the fact that not all municipalities are geographically exposed to flooding risks. The assessments of past risks largely align with expectations for risks from extreme weather events for the next ten years.

Approximately 90.0% of the surveyed municipalities report having experienced damage to their trees

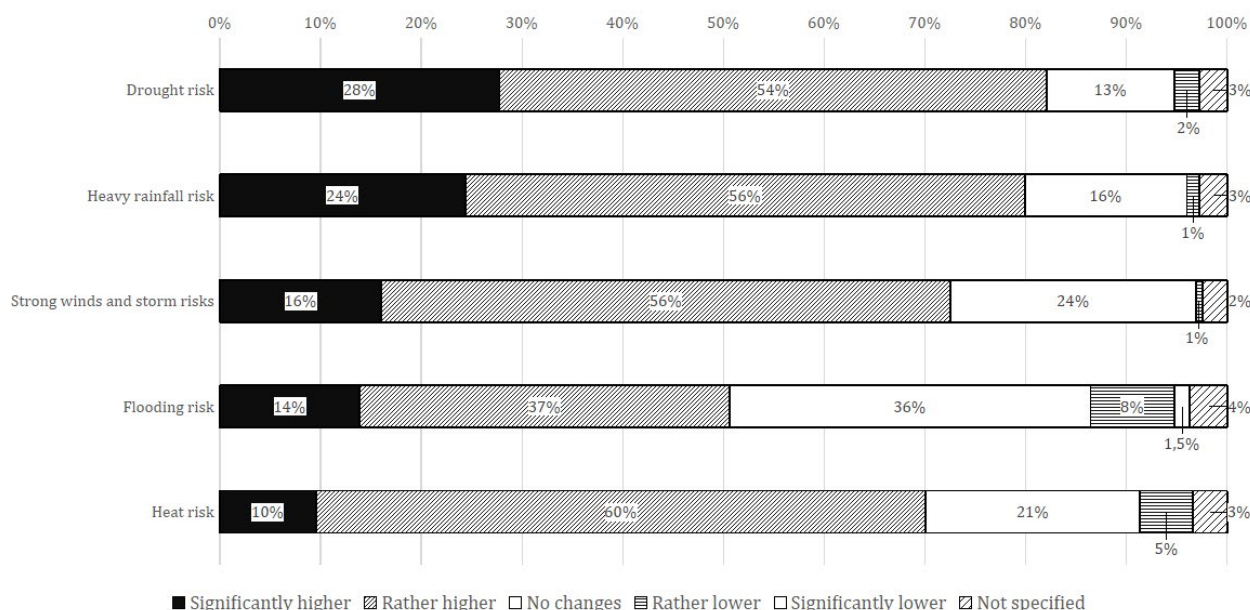
and green spaces due to drought or strong winds and storms over the past 10 years. Over 70.0% of respondents note damages from flooding as a result of flood events or heavy rainfall. Fewer municipalities report damages from heat, but nearly half of the respondents indicate high thermal stress and issues in livestock farming and crop cultivation within their municipalities. Additionally, almost 30.0% of respondents report problems related to medical care and an increase in health complaints during heatwaves. Figure 6 shows that the majority of municipalities expect to face damages from extreme weather events in the next 10 years, with heavy rainfall and drought being particularly relevant.

There are differences between municipality size classes in terms of expected future damages from extreme weather events. A slight correlation exists between the size of municipalities and the extent of expected damages from heat events (Kendall-tau-c = 0.164; $p < 0.001$) and drought (Kendall-tau-c = 0.157; $p < 0.001$). Larger municipalities thus expect greater damages from heat and drought compared to smaller ones.

4.3 Attitudes/Awareness

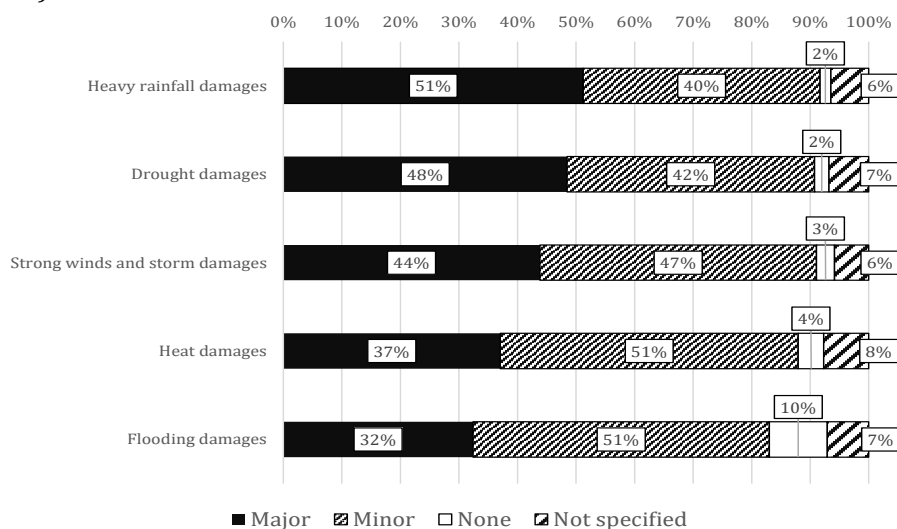
44.4% of respondents believe their municipality is currently affected by climate change. An additional third at least partially agrees with this assessment.

Figure 5 Municipal Decision-Makers' Risk Perception of Extreme Weather Events in the Last Decade (n = 324)



Note. Source: Own illustration.

Figure 6 Municipal Decision-Makers' Expectations of Damages due to Extreme Weather Events in the Next Decade (n = 324)



Note. Source: Own illustration.

We found a slight correlation between the size of the municipality and agreement on current climate change impacts (Kendall-tau-c = 0.217; $p < 0.001$). The larger the municipality, the more likely it is to agree that it is currently affected by climate change. A larger proportion of respondents (58.3%) estimate that their municipality will be affected by climate change in the future. Including those who partially agree, 83.3% of municipalities in the study region expect to be impacted by climate change in the future. Here

again, we observe a slight statistical correlation with municipality size (Kendall-tau-c = 0.208; $p < 0.001$).

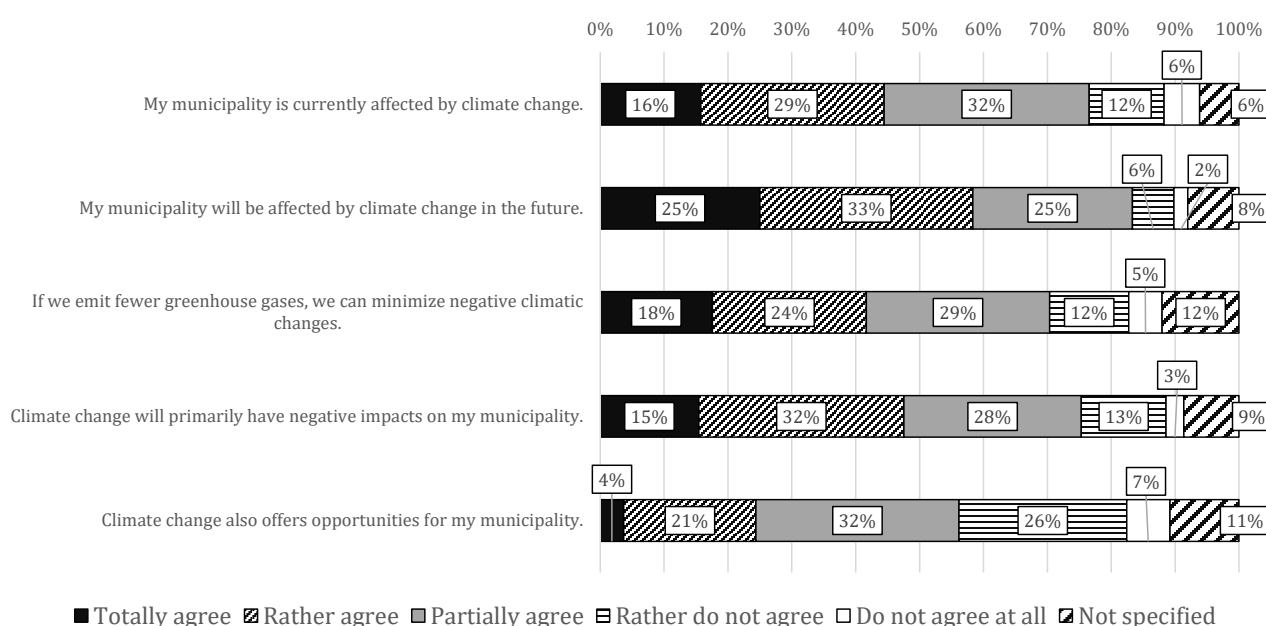
A smaller proportion of respondents agree that climate change is caused by greenhouse gas emissions. Only 70.4% of respondents at least partially agree with this statement. Agreement with the anthropogenic cause of climate change is also slightly correlated with municipality size (Kendall-tau-c = 0.135; $p = 0.003$). The impacts of climate change for the

municipality are generally perceived as negative, and this perception is again slightly associated with municipality size (Kendall-tau-c = 0.212; $p < 0.001$). Larger municipalities tend to view the impacts of climate change as more negative. However, in more than one-fifth of municipalities, regardless of their size, respondents also recognize potential opportunities arising from climatic changes. The levels of agreement on attitudes and awareness of climate change are visualized in Figure 7.

mate information, which is at least partially utilized by a majority of municipalities. This skepticism varies slightly according to municipality size (Kendall-tau-c = -0.141; $p = 0.001$). Smaller municipalities tend to perceive climate information as less certain compared to larger ones.

However, these results contrast with the fact that only one in five municipalities is familiar with the Regional Climate Information System for Central Germany (ReKIS), and only 4.3% report actually using it. Given

Figure 7 Municipal Decision-Makers' Attitudes and Awareness of Climate Change ($n = 324$)



Note. Source: Own illustration.

4.4 Information/Knowledge/Uncertainty

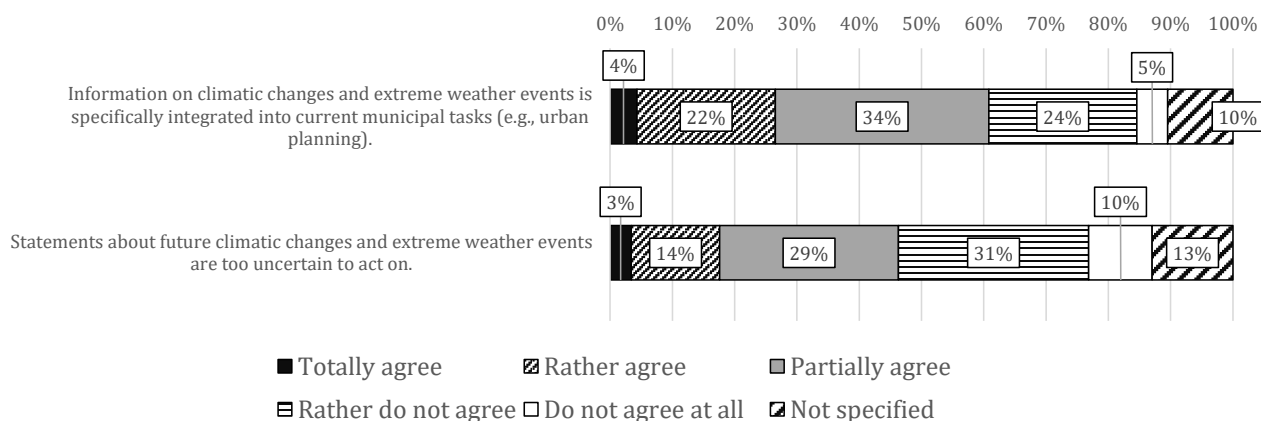
Approximately one in four surveyed municipalities reports actively incorporating climate information into their current tasks, with an additional third doing so at least partially. Consequently, climate-related information already plays a role for a significant portion of municipalities. A slight correlation exists between municipality size and the incorporation of climate information into current tasks (Kendall-tau-c = 0.142; $p = 0.002$), indicating that larger municipalities are more likely to include such information. More than 40.0% of respondents consider projections of future climatic changes reliable enough to act based on them (see Figure 8). This suggests that there is slight skepticism regarding the robustness of cli-

mate information, which is at least partially utilized by a majority of municipalities. This skepticism varies slightly according to municipality size (Kendall-tau-c = -0.141; $p = 0.001$). Smaller municipalities tend to perceive climate information as less certain compared to larger ones.

the relatively low usage of ReKIS, it remains unclear what alternative sources of information municipalities use, as well as the quality and resolution of the data they rely on. Due to the limited number of municipalities using ReKIS, it is difficult to establish precise statistical correlations with municipality size, though there is an indication that municipalities using ReKIS tend to be larger. It is also unclear how this applies to planning processes that local administrations outsource to private consultancies.

Only 38.3% of respondents report that climate change impacts have already been discussed within their municipality, while in about one-third of the cases, this has been partially addressed. The discussion of climate change impacts slightly correlates with

Figure 8 Local Decision-Makers' Handling of Information, Knowledge, and Uncertainty of Climate Change (n = 324)



Note. Source: Own illustration.

Table 1 Municipal Decision-Makers' Narratives on Climate Change and Empirical Examples

Nr.	Narrative	Empirical example
1	There are too few resources for local climate policy.	"[Name of the municipality] has [fewer than 10,000] residents and is broke, like all the municipalities in [name of administrative unit]. How are we supposed to pay for [climate policy]? We already can't fulfill all our mandatory tasks [...]. We've already closed a sports hall, and parks and green spaces are maintained by private initiatives because we've slashed the staff in the public works department. [...]. The fire department is operating with outdated vehicles, and we're understaffed because personnel are moving to [name of nearest city] (20 minutes by train), where they get much higher pay grades for the same work. With what personnel and financial resources are we supposed to engage in climate mitigation?" (Survey)
2	Municipalities are already very committed.	- In very small municipalities, there is no need for strategies or specific measures because "people help each other." (Survey) - Strict funding regulations are the only barriers to effective adaptation.
3	Climate policy is an urban issue that is being forced on rural municipalities.	"In cities, people glue themselves to the streets. We go out into nature to pick up trash, most of which is left behind by city dwellers on the weekends, or at least a large portion of it." (Survey; note: Gluing on the streets is a reference to protest actions of the German climate activist group <i>Letzte Generation</i> [Last Generation], who glue themselves on streets in many cities during rush hours to block traffic and draw attention to climate change.)
4	Climate policy does not make sense (here).	As part of the outreach to municipalities regarding the survey or within the survey itself, a few expressed skepticism about whether climate policy in Germany or in general is even meaningful.

Note. Source: Own illustration.

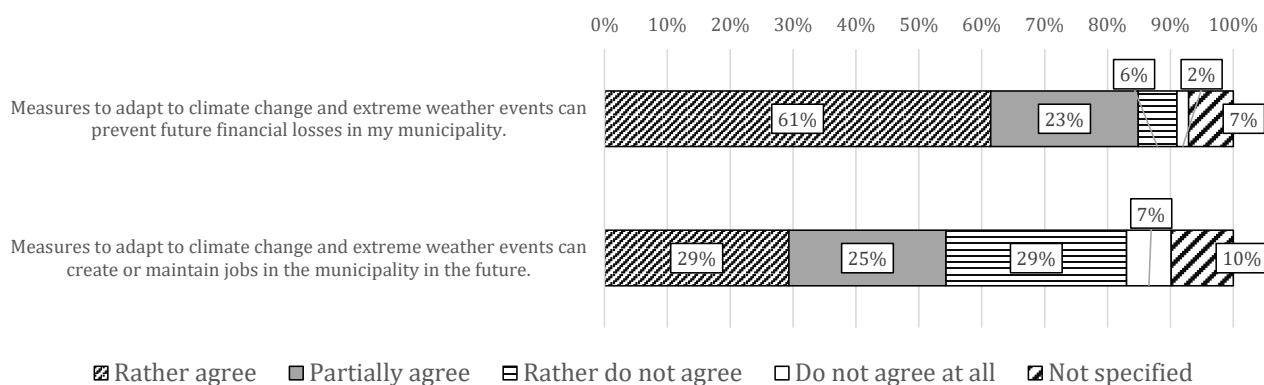
municipality size (Kendall-tau-c = -0.243; $p < 0.001$), indicating that larger municipalities are more likely to have discussed the issue. In an open-ended question, 40 municipalities (12.3%) provided additional comments on climate change. We identified four key narratives (see Table 1).

These narratives illustrate that local climate policy is negotiated and interpreted depending on the size of the municipality. Smaller municipalities, in particular, emphasize their limited financial and personnel resources. Additionally, climate policy is often per-

ceived as an urban issue that has limited practical relevance for smaller municipalities.

4.6. Risk Management

Regardless of municipality size, most municipal decision-makers (61.4%) believe that they can prevent future damage through adaptation measures. However, only 29.3% of the surveyed municipalities think that these measures can lead to the creation of new jobs (see Figure 9). There is a slight statistical correlation between the size of the municipality and agree-

Figure 9 Municipal Decision-Makers' Assessment of Risk Management ($n = 324$)

Note. Source: Own illustration.

ment with the idea that climate adaptation can create or maintain jobs (Kendall-tau-c = 0.251; $p < 0.001$). Larger municipalities tend to see more economic opportunities from climate adaptation measures than smaller ones.

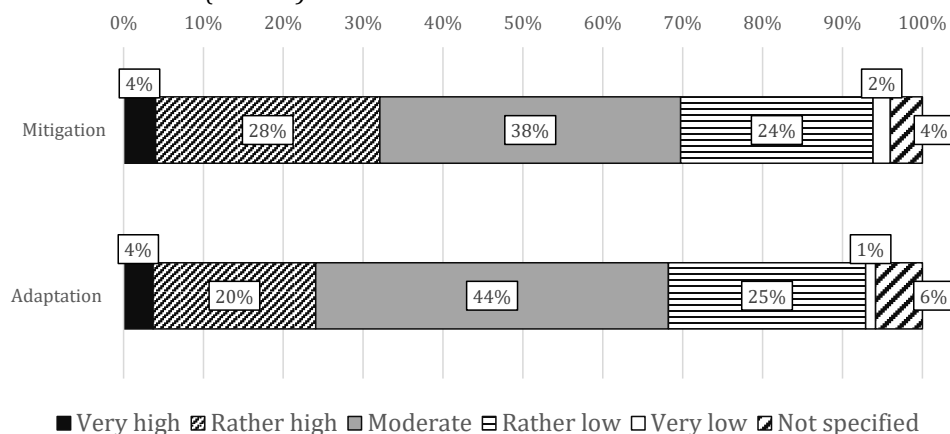
A small portion of respondents report a lack of acceptance and support for risk management measures in local politics, administration, or the population. About one in five municipal decision-makers notes a lack of support in local politics or the population, while 13.3% observe this issue within the local administration. We found no statistically significant correlation between the lack of acceptance and the size of the municipality.

4.7 Policy Field

Compared to other municipal issues and regardless of municipality size, climate change holds a relatively

low priority for respondents, likely because it is not a mandatory task for local governments yet. One-third of the respondents consider climate mitigation at least moderately important, with a slight correlation to municipality size (Kendall-tau-c = 0.128; $p = 0.003$). Larger municipalities are more likely to assign higher importance to mitigation than smaller ones. Climate adaptation is viewed as having at least moderate importance by about one-quarter of the municipalities, with no significant correlation to municipality size (see Figure 10). The relatively low priority given to climate change topics in the study region is also reflected in their political anchoring.

Only 13.9% of the respondents report a dedicated climate mitigation management office, and around one in five municipalities assigns this task to an existing department. Although the number of cases in the larger municipality class is too small for statistical analysis, it is notable that five out of six large muni-

Figure 10 Municipal Decision-Makers' Assessment of the Relevance of Climate Mitigation and Adaptation Within Local Administrations ($n = 324$)

Note. Source: Own illustration.

palities have a mitigation management office, while less than half of the small municipalities do. Climate adaptation is managed by a dedicated position in only 8.3% of municipalities. Another 4.6% share climate adaptation management with another administrative unit. Even though the sample size is also too small here for statistical analysis, we observe that half of the large municipalities have a position for climate adaptation management, compared to only 5.2% of small municipalities.

Regarding the Federal Climate Adaptation Law, more than half of the respondents indicate that it confronts them with significant uncertainties. These uncertainties vary slightly depending on the municipality size (Kendall-tau-c = -0.137; $p = 0.004$). Smaller municipalities experience greater uncertainties regarding the new law compared to larger ones. Regardless of municipality size, over one-third of respondents (including partial responses, 73.2%) believe that data and projects on climate change are more important for the supra-regional level.

5. Discussion

We assigned the individual dimensions of climate change perception of the four municipal size classes to low, medium, and high (see Figure 11). Mean values from the survey items and qualitative assessments served as the basis for this. The further away a line is from the center, the stronger the dimension scores. Figure 11 illustrates that decision-makers in municipalities with up to 24,999 inhabitants perceive the dimensions of climate change relatively similar (although gradual differences may occur). Decision-makers in municipalities with more than 100,000 inhabitants score the highest in all dimensions. Large municipalities also engage more actively in climate adaptation action.

Regardless of municipality size, local decision-makers sensually observe local climate change with accuracy. Municipal representatives are also able to describe climate risks with relative precision. We find it worth highlighting that heat is not only an urban problem (Gabbe et al., 2021), but also affects small and medium-sized municipalities. However, larger municipalities expect greater damages from heat and drought than smaller ones. Local decision-makers of all size classes see the management of climatic changes and risks as a way to prevent future financial losses. Larger municipi-

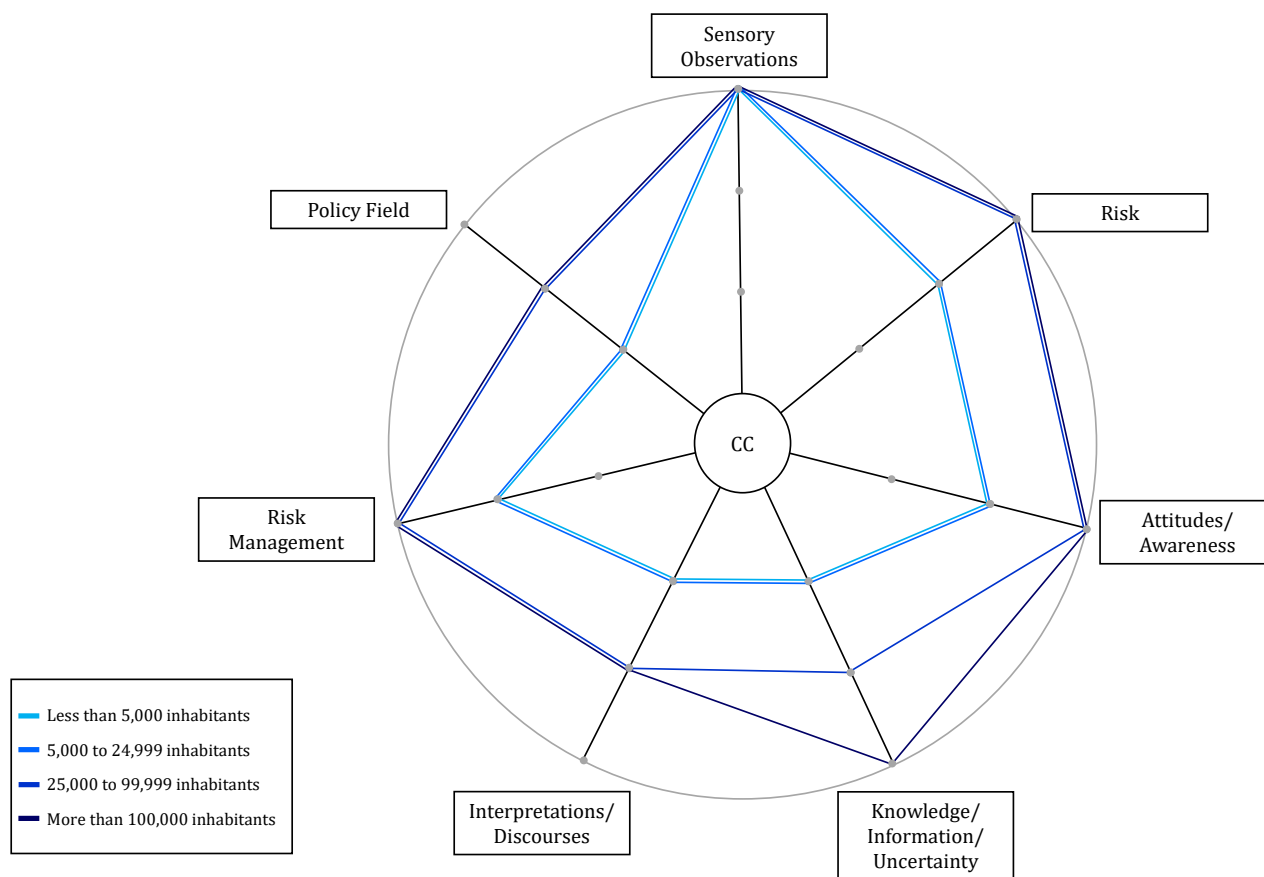
palities are more likely to view risk management as an opportunity to preserve and create jobs. We presume that there is a difference between self-assessment and the actual use of climate information. This suggests that there is still potential, particularly among small and medium-sized municipalities, to better integrate and transfer diverse forms of climate knowledge (Siebenhüner, 2018).

Although our findings indicate a certain degree of climate change awareness, responsibility for the causes is viewed more ambivalently. These attitudes are slightly correlated with municipality size, indicating that decision-makers in larger municipalities tend to have a stronger awareness of climate change. This may be influenced by local discourses and interpretations, where certain decision-makers express skepticism regarding whether they are responsible for addressing the problem—or, in some cases, whether the problem exists at all. This skepticism may reflect a sense of “being left behind” by policies perceived to come from or be designed for large cities (McKay et al., 2024) or a general skepticism toward climate change in a region heavily influenced by a right-wing political party (Lockwood, 2018).

Although municipalities have been regarded as central actors in climate adaptation by political institutions and scientists for years (Kern, 2018), and large cities have partially fulfilled this role (Otto, Kern, et al., 2021), the policy field has scarcely reached municipalities in the study region with fewer than 25,000 inhabitants. Especially among small and medium-sized municipalities, climate adaptation is weakly institutionalized and has relatively low priority. This outcome is not surprising, given that municipalities in Germany are not yet required by law to engage in climate adaptation. Furthermore, small and medium-sized municipalities have such limited resources that they struggle even to meet their mandatory responsibilities (Fila et al., 2024; Simonet & Leseur, 2019).

In municipalities with fewer than 25,000 inhabitants, the perception of the dimensions of climate information, interpretation, and political embedding is relatively low. We conclude that these municipalities are more likely to have the prerequisites for reactive adaptation and, to some extent, for planned adaptation. Similarly, municipalities with over 25,000 inhabitants also exhibit the prerequisites for reactive adaptation. However, we hypothesize that the stronger presence of dimensions such as awareness, knowl-

Figure 11 Characterization of Climate Change (CC) Perception



Note. Characterization of climate change (CC) perception according to municipality size classes in low (closer to the center), medium, and high (outer circle). Source: Own illustration.

edge, interpretation, risk management, and political embedding increases the likelihood of planned, public, and anticipatory adaptation. This is particularly true for municipalities with populations exceeding 100,000, as they are more likely to integrate climate knowledge.

The legal and economic context of the study region, coupled with an administrative structure dominated by municipalities with fewer than 5,000 inhabitants, can be described as a barrier to local climate adaptation. Based on our analysis of local decision-makers' perceptions of climate change, we argue that municipalities with fewer than 25,000 residents often lack the prerequisites for anticipatory, planned, and public adaptation at the actor level. Although actor-level prerequisites are generally more favorable in larger municipalities, the political embedding of climate adaptation remains insufficient even in these cases.

These results must be understood within the specific context of the study region. Mewes et al. (2024) demonstrate that attitudes toward climate change in Eastern German states are more skeptical compared to those in Western Germany. This difference does not appear to be uniquely German. According to research by Poortinga et al. (2019), variations in climate change perception between Eastern and Western regions are also observable at the European level.

6. Conclusions

The results of the municipal survey in Central Germany reveal that local decision-makers perceive different dimensions of climate change to varying degrees. The slow-onset impacts of climate change and risks from extreme weather events are relatively clearly recognized and reported by most municipalities, with only small differences between municipal size classes. The local decision-makers perceive the management

of climate risks as relatively relevant, which is particularly true for municipalities with 25,000 or more inhabitants. Furthermore, the results show a certain level of climate change awareness among the municipal decision-makers, which is higher in municipalities with 25,000 or more inhabitants. The incorporation of climate knowledge is more intense the more inhabitants a municipality has. The policy field has so far been less anchored at the local level, particularly in municipalities with fewer than 25,000 inhabitants. Reasons for the relatively weak institutionalization of climate adaptation in smaller municipal administrations include climate-skeptical discourses, a lack of local support, and the absence of a legal framework and financial resources for municipalities.

In this article, we have argued that the relatively weak perception of certain dimensions of climate change among local decision-makers in municipalities with fewer than 25,000 inhabitants, combined with the rather constraining legal and economic conditions in the study region, results in only limited prerequisites for planned, anticipatory, and public adaptation. As a consequence, measures are more likely to be reactive.

We expect that the Federal Climate Adaptation Law and its implementation at the federal state level will establish a legal framework for municipal climate adaptation and potentially provide financial resources for planning and implementing measures. Municipalities with fewer than 25,000 inhabitants, in particular, need greater awareness and knowledge of climate impacts at the local level, as well as a stronger political institutionalization of climate policy. However, we highlight that there are also few adaptation pioneer municipalities beyond large cities in the region.

Our perception-based approach provides an actor-centered perspective on local climate adaptation, which is particularly valuable for small and medium-sized municipalities. We contribute to a more nuanced understanding of climate adaptation as part of climate governance at the local level. On one hand, we demonstrate that differences in the perception of climate change dimensions between municipal size classes create varying prerequisites for adaptation. On the other hand, our findings suggest that the predominantly structurally weak study region engages in relatively little climate adaptation overall and perceives the dimensions of climate change only weakly.

Our case study represents structurally weak regions with a history of economic transformation and a relatively high level of support for right-wing populist parties. Such regions are often referred to as Left Behind Places (Rodríguez-Pose et al., 2023). Future studies could undertake comparative analyses with similar regions in former Eastern Bloc countries or systematic comparisons with prosperous rural regions to enhance the geographical differentiation of climate adaptation in small and medium-sized municipalities. It should be noted that in this study, small municipalities are defined as those with fewer than 5,000 inhabitants, whereas other categorizations extend this definition to include municipalities with up to 20,000 inhabitants (Bundesinstitut für Bau-, Stadt-, und Raumforschung, 2021).

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Authors Contributions

Anika Zorn: Concept, planning of the study, data collection, data analysis and interpretation, writing
Susann Schäfer: Planning of the study, writing, founding

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