



Shrinking Lakes, Growing Concerns: Exploring perceptions of lake level decline as a prism for understanding socionatural hazards

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Abstract

Groß Glienicker Lake and Sacrower Lake are two lakes in the Berlin-Brandenburg region that are facing significant challenges due to declining water levels associated with climate change. A mixed-method approach was employed, incorporating ethnographic research methods, a household survey and stakeholder workshops, in order to elicit perceptions on social-ecological changes and challenges. The interaction of social-ecological structures with these perceptions was analyzed, as well as the willingness to act, both individually and collectively, to address the challenges. The analysis reveals that the hazard of lake level loss offers a prism through which diffracted social-ecological challenges become visible, thus facilitating an understanding of social processes that shape the definition of the hazard beyond ecological aspects and the path forward in governing risks adaptively. This understanding is based on perceptions of social-ecological hazards and the complexity of perceived responsibilities and willingness to contribute to managing risks. The analysis therefore sheds light on practical implications, in that focusing on pure technical solutions to maintaining or raising the water levels fails to orchestrate solutions to the social-ecological hazards.

1 Introduction

The entire capital region of Berlin-Brandenburg in northeastern Germany is known for its numerous lakes, and the proximity of these bodies of water has instilled a sense of familiarity with water in the region's residents (Meyerhoff et al., 2014). The



35 region has 33,000 kilometers of watercourses and approximately 10,000 ponds and lakes (Rücker et al., 2019; BUND
Brandenburg, 2024). Due to lower precipitation levels typical of this region, surface water, groundwater, and wetlands are
important for agricultural use and overall water availability in the region (Germer et al. 2011). In recent decades, however, this
considerable number of surface waters has come under increasing pressure due to climate change, this being exacerbated by
dry and hot summers such as that of 2018 (Germer et al. 2011, Nützmänn and Mey 2007, Heinrich et al. 2019). As a result,
water bodies are affected by falling water levels. In addition to ecological aspects, surface waters around the capital Berlin are
40 highly valued as ecological, cultural and social meeting places. Visitors come to swim or hike, and these lakes become places
of recreational value. For local residents, the lakeshores are points of community social and cultural activities, educational
opportunities, and social gatherings.

In this context, residents of two lakes, namely Groß Glienicker Lake and Sacrower Lake, sounded the alarm in 2015: On the
website of a citizens' initiative, a group of people could be seen on camera standing in the water of Groß Glienicker Lake and
45 holding up a sign that read 'Help'. They have been warning the Berlin and Potsdam administrations for years that the lake's
water level is dropping rapidly. Since then, Groß Glienicker Lake and Sacrower Lake have become the focus of intense
discussions about water management, but they have also opened up discussions about community life and approaches to the
lakes. These debates have exacerbated existing frictions between local citizens on the one hand, and administrative bodies on
the other, over the uncertainties in the search for reasons and solutions to water issues.

50 This paper seeks to understand these new public dynamics in the sense of Pierre Bourdieu (1996), in which local perceptions
are directed towards changes in the environment, social-economic relations and everyday life. In this context, the declared
hazard of lake level loss shapes and is shaped by perceptions. We situated ourselves and the research participants in a reflexive
process and asked questions about the contact and interactions of local residents with administrations and political actors.

The issue of water scarcity is now well documented in Berlin-Brandenburg (Heinrich et al., 2019). Recent studies have
55 attempted to identify potential causes of the observed lake level decline at the two lakes. These include investigations of the
influence of groundwater trends and subsurface flow (Mahmoodi et al., 2024), water balance models (Somogyvári et al., 2024),
and changes in precipitation (Ölmez et al., 2024). These studies suggest that the observed decrease in lake level of Groß
Glienicker Lake between 2002 and 2015 can be attributed to net precipitation, which, however, cannot fully explain the steep
decrease in lake level since 2015. All these studies provide valuable insights into the complexity of managing surface water
60 loss in the region. However, the multitude of factors to be considered also points to the inherent uncertainties and challenges
in deriving a single, actionable (climate) adaptation option (Eriksen et al., 2015).

In recent decades, climate change impacts such as water scarcity have been increasingly problematized in the literature as not
only an ecological but also a societal challenge, calling into question purely technical approaches to climate adaptation
(Nightingale et al., 2020). Moreover, as we will show in the context of Groß Glienicker and Sacrower Lakes, measuring
65 physical indicators such as water levels and property values, while important, only addresses part of the harm experienced by
people and overlooks the complex interplay of factors across physical, political, and cultural domains that contribute to the
overall hazard landscape and understanding of risk in social-ecological systems (see also Spencer and Alexandra, 2024).

Therefore, the concept of hazard should be expanded to include not only the physical reality of declining lake levels, but also the psychosocial harms associated with this ecological change. Hazard, defined as any potential source of harm, includes the uncertain origins of these declining water levels and is only one part of the risk analysis equation. Definitions of hazard have evolved over the decades to include a broader, more interdisciplinary understanding of sociopolitical aspects and how individual and collective perceptions of risk should be recognized for risk governance (Klinke and Renn, 2021). In this paper, we conceptualize declining lake levels as a prism through which a broader set of (ecological and social) challenges are diffracted and thus made legible. While this further blurs the lines of responsibility for the challenges, it is important for addressing these challenges as part of the overall dynamic.

We are thus positioned within contemporary hazards research, which expands the understanding and management of risk through social science perspectives by taking into account human behavior, social structures, and cultural contexts. Social science perspectives identify how the local community perceive and respond to hazards, which is critical for effective risk communication and mitigation strategies. By incorporating these insights, hazards research can develop more comprehensive and inclusive risk management plans that take into account the needs and capacities of diverse populations. This interdisciplinary approach ensures that technical solutions are complemented by strategies that address human and social dimensions, leading to more resilient and adaptive communities (Tierney, 2020; Blaikie et al., 2014; Burton, 1993).

This broader perspective reveals that water hazards are not just material threats but are deeply intertwined with sociocultural dynamics, highlighting the need for a mixed-methods approach that captures the full range of local and collective perceptions to inform adaptive risk governance (Klinke and Renn, 2021). Such an approach includes not only ecological understandings of hazards, but also the social processes that shape the preferences and perceptions of different groups of actors for needed change. The complexity of perceived responsibilities and sources of hazards further necessitates a mixed-methods analysis, as the literature has shown how water should be contextualized in a network of social, cultural, political, and economic aspects of life (Boelens et al. 2016).

Thus, this study adopts an expanded concept of natural hazards as socio-natural phenomena by examining how the decline of the water levels of Groß Glienicker and Sacrow Lakes and the resulting material and psychosocial damage are shaped by the interplay of ecological dynamics, human perceptions, social relations, and institutional frameworks (Boelens et al., 2023), and aims to understand how people perceive and respond to these challenges in the context of complex social, political, administrative, and scientific structures. This requires an interdisciplinary collaboration that draws on a range of different social science methodologies. In the following, we briefly describe the case study, the mixed-methods approach that draws on methods from political science, psychology, economics, and anthropology, and the formulation of the research questions. The research questions that structure this paper concern (1) perceptions of social-ecological change, (2) the social structures that interact with these perceptions, (3) willingness to act and perceptions of responsibility, and (4) local practices for dealing with the challenges. The analysis examines the challenges that the growing water publics in Berlin and Potsdam perceive as central to the lake environment and the rationale behind these risk perceptions. This is followed by a presentation of the current strategies of lake residents and their sense of individual and collective agency in (political and environmental) transformation



processes. Our analysis reveals a dynamic and changing approach to the lake as a shared and private space, the need for individuals to develop self-efficacy, and the problems of adopting one-size-fits-all strategies of action and communication. Finally, we provide insights on how to deal with heterogeneous stakeholder perspectives, drawing on recent studies and lessons learned in the field of adaptive governance.

2 Materials and methods

2.1 Case study area

Groß Glienicker Lake and Sacrower Lake are two freshwater lakes located in the Berlin-Brandenburg region of northern Germany (Fig. 1), between the Berlin district of Spandau district and the city of Potsdam, the capital of Brandenburg. Groß Glienicker Lake spans approximately 67 hectares, with a maximum depth of 11 meters (Berlin n.y., Landeshauptstadt Potsdam, 2025a). The lake is divided by the Berlin-Brandenburg border, separating the localities of Groß Glienicke (as part of Potsdam) and Kladow (part of Berlin's Spandau district). Formerly, the Berlin Wall stood directly on the shores of Groß Glienicke, and the border between East and West Germany ran through the lake itself. Today, the lake is a popular destination for recreational activities such as swimming, boating, and picnicking. Sacrower Lake is located entirely in Brandenburg next to the Potsdam district of Sacrow. It covers an area of approximately 110 hectares and has a maximum depth of 39 meters. It is surrounded by dense forests that are part of the Sacrower Lake and Königswald Nature Reserve (Landeshauptstadt Potsdam, 2025c). The lake is valued for its biodiversity and tranquil setting, attracting visitors interested in hiking, bird watching, and swimming. Unlike the Groß Glienicker Lake, Sacrower Lake is located in a nature reserve area (Flora-Fauna-Habitat) and provides a more natural environment (Landeshauptstadt Potsdam, 2025b).

Approximately 15,000 people live in the immediate vicinity of the two lakes, which are both located in the less densely populated area between Berlin and Potsdam. The lakes play an important role in the daily lives of residents and visitors who spend time on, in and around their shores. Groß Glienicke, a historic village incorporated into Potsdam in 2003, features residential areas, and the community has a mix of urban and rural character with increasing residential development in recent years. Located on the eastern shore of Groß Glienicker Lake, the locality of Kladow is a suburban residential area. It is connected to Groß Glienicker Lake in the west and the river Havel to the east, as well as other natural and cultural attractions. Sacrow is the smallest district of Potsdam and lies between Sacrower Lake to the west and Havel to the south and east. Formerly, there was a connection to Groß Glienicker Lake to the north and to the Havel. This canal towards the Havel, which is now obstructed, is referred to as Schiffgraben. Sacrow is surrounded by the forests of the Sacrower Lake and Königswald Nature Reserve, offering opportunities for outdoor activities and nature conservation.

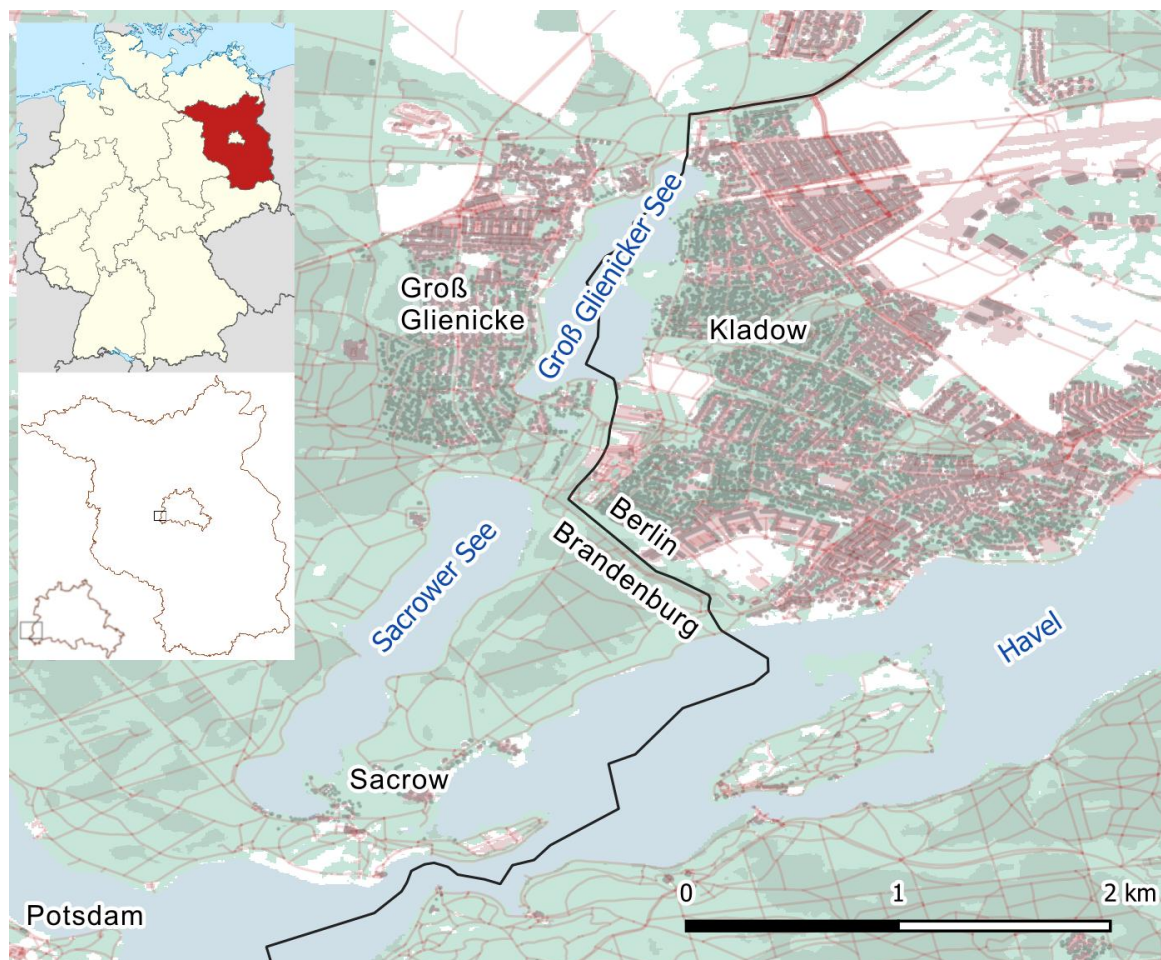


Figure 1: Map of the case study area. Base map © OpenStreetMap contributors 2025. Distributed under the Open Data Commons Open Database License (ODbL) v1.0. Border layers © GeoBasis-DE/LGB, dl-de/by-2-0 (data not changed). Land cover DE - Sentinel-2 - Germany from the German Aerospace Center (DLR).

2.2 Mixed-methods approach

We use a mixed-methods approach in our case study by drawing on qualitative research (i.e., interviews, participant observation, workshops and focus groups with residents and stakeholders) and quantitative research data (i.e., surveys and survey experiments with the local population and the Berlin-Brandenburg population) (Yin, 2014; Guetterman and Feters, 2018). Participants in the research included residents of Potsdam (Groß Glienicke and Sacrow) and Berlin (Kladow), stakeholders involved in the research consortium from citizens' initiatives of Groß Glienicke, Sacrow and Kladow, representatives of the Potsdam and Berlin administrations, and visitors from other Berlin districts. Combining such diverse research methods and sources under the guiding principle of methodological eclecticism helps address complex research questions by leveraging the strengths of each while mitigating their weaknesses. It emphasizes flexibility and practical problem-solving over strict methodological purity and is therefore particularly common in the social sciences, where complex

questions often require interdisciplinary and multidimensional analyses (Greene et al., 1989; Kroos, 2012; Johnson and
Onwuegbuzie, 2004).

2.2.1 Ethnographic methods

For the ethnographic research, qualitative semi-structured interviews, informal discussions and participant observation (Shah, 2017) were conducted. The research questions dealt with local human-water relations in terms of daily activities and the discussions at the lakes. Furthermore, this research sought to understand how residents perceive change and act in times of crisis and transformation. Discussions at events with representatives from each neighborhood were followed by household interviews and informal interviews with 32 interviewees. This was complemented by participation in action days around the lakes and cultural events, and analysis of online representations and documents. Qualitative data analysis was carried out inductively, with codes were grouped into thematic fields (Rädiker, 2023).

2.2.2 Household survey

The insights from the ethnographic research informed the development of a quantitative survey of residents living near Groß Glienicker Lake. Invitations to the survey were sent out using postcards, with 5,000 postcards hand-delivered and 25,000 sent via mailings. Of those invited, 644 residents responded and completed the survey and survey experiment online by scanning a QR-code or following a link to the survey website. While the response rate is low (2.2 %), respondents were heterogeneous in terms of socio-demographic characteristics, perceptions of challenges, and contributions to the lake. A discrete choice experiment assessed trade-offs in lake attributes including water quantity and quality, public paths and facilities and biodiversity against hypothetical costs. Further information on the discrete choice experiment can be found in the Supplement. Retrospectively, the results of the survey aided the generalization of the ethnographic research to a wider population.

2.2.3 Stakeholder workshops

In addition, a series of four transdisciplinary workshops were held between fall 2023 and summer 2024 with 8 to 10 representatives from the citizens' initiatives at the lakes and of the public authorities responsible for the water management around the lakes. This workshop series was built on the resilience assessment framework for farming systems developed by Meuwissen et al. (2019), a participatory and workshop-based approach that allows for the integration of the perspectives of a diverse group of stakeholders and which we adapted to the needs and specificities of social-hydrological systems, i.e., water-centered human-environment systems in which hydrological and social processes influence each other in complex ways (Mao et al., 2017). The first step in this process was to define the study area as such a social-hydrological system based on its main physical and social characteristics, the core and contextual actors that shape it, and the essential functions it is supposed to fulfill. Against this background, eight system functions were selected and operationalized in a participatory manner by identifying indicators that represent these essential system functions. Subsequently, a longitudinal recollection of the development of the most important indicators has been conducted to identify resilience challenges and discuss the strategies



175 applied in response to these challenges and their current performance in terms of the system's resilience. The third step was to
extrapolate the development of the selected indicators into the future in order to identify future resilience challenges. Based
on this, the fourth step was to develop strategies for action corresponding to this future trajectory that adequately address both
current and anticipated resilience challenges so that the system can maintain or, if it is not currently doing so, be enabled to
fulfill its essential functions.

180 To fully exploit the potential of a mixed-methods approach, we considered the empirical data from all three studies and
combined their findings to gain a deeper understanding of the mechanisms behind different local perceptions. Based on the
empirical findings, we generated overarching themes, which we formulated as questions in order to relate results from
individual empirical approaches to each other and to the overarching discussions in the joint research project. After several
iterations, we arrived at these four thematic blocks that structure the results section below: (1) the social-ecological changes
185 that people perceive as challenges, (2) the interrelations of these perceptions with the social, cultural, political, and historical
contexts of life at the lakes, (3) the perceived responsibilities and willingness of citizens to act, and (4) the local practices that
are already underway in the face of the perceived challenges. This iterative, complementary methodological approach
combining qualitative and quantitative methods, allowed us to jointly structure and ultimately answer the research questions
regarding the socionatural hazard of lake level loss as a prism through which both the risk of ecological and social challenges
190 become diffracted and more apparent.

3 Results

3.1 What social-ecological changes do residents perceive as challenges?

The attention of the residents of the lake is strongly drawn to the obvious decline in water. In initial conversations on the street,
in interviews at kitchen tables and at events, the first thing emphasized was the lack of water. This was not only the starting
195 point for conversations initiated by the researchers, but also the linchpin of lake residents' own problem analysis. The
quantitative survey of residents living close to the lakes shows that they are highly aware of several different changes at Groß
Glienicke Lake. Although the problem frames at the lake may vary among residents, groups, and initiatives, the responses in
the quantitative survey paint a clearer picture of recognized changes and challenges at the lake. Nearly 80 % of survey
respondents indicated that they had noticed a sharp decline in the lake level (Fig. 2). 35 % of respondents felt that water quality
200 had declined slightly or greatly, and similar responses were received for bird, insect, and plant diversity. During the initial
interviews to prepare the survey questions, the topic of lake level loss very quickly opened up discussions about further
problems of everyday life in this area, putting into context the other challenges mentioned in close relation to the falling lake
level (also in the initial interviews with residents). Strong majorities perceived that the number of visitors (> 80 %), vehicles
(> 80 %), and litter (65 %) had increased slightly or greatly. Indeed, many open-ended responses highlighted the issues of
205 littering, visitor pressure also leading to trampling of shoreline vegetation, unsanitary infrastructure and wild bathing.

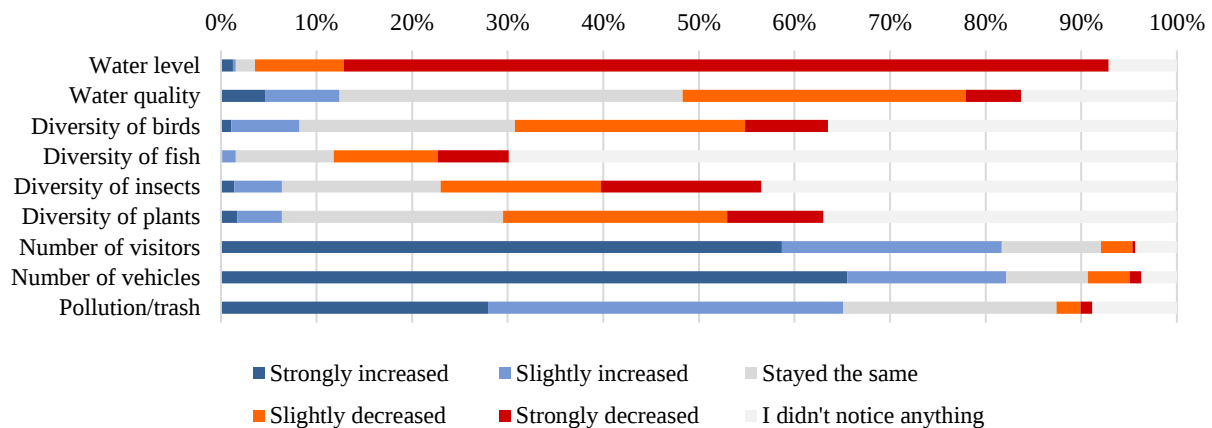


Figure 2. Perceived awareness of changes at Groß Glienicker Lake (N = 644).

This general awareness of current changes actually translates into concerns about the future for the Groß Glienicker lake, in which almost 90 % of the survey respondents reported the water level to be a large or very large challenge for the lake (Fig. 3). Furthermore, people living in this area equally consider higher temperatures, less rainfall, and climate change as challenges. More than half believed private water use to be a high or very high danger for the lake, and 45 % considered groundwater extraction by water utilities to be an issue. In addition to water quantity, the residents identified water quality as a challenge for the future (60 % high or very high). Further qualitative responses in the interviews indicated a certain ecological understanding and means of anthropogenic impact among the residents, how important the water level as well as the natural vegetation along the shore are for maintaining good water quality. Residents see pressures from the population and rising number of visitors and highlighted the ecological challenges that come with such pressures (i.e., trampling of reed vegetation along shore by the increasing number of visitors). When they expressed their concerns, they did so for the lakes as an ecosystem.

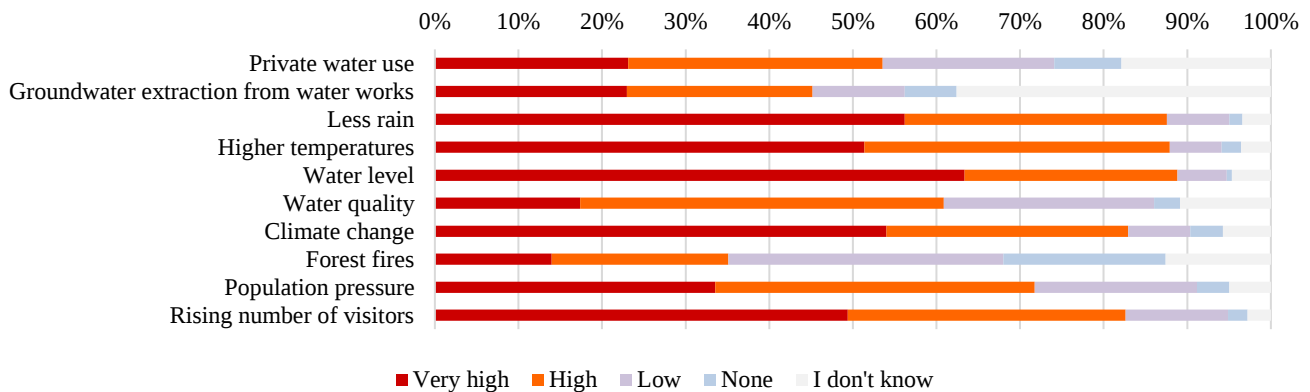


Figure 3. Perceived challenges or dangers for Groß Glienicker Lake (N = 644).



Interestingly, the perceived risks associated with climate-related changes may not be consistent with the overall perception of climate change risks in the region. Over 80 % of respondents perceived climate change to be a large or very large challenge for the lake (Fig. 3). In another set of questions not directly related to the lake, respondents indicated their perceptions on a scale from very true to very false concerning the statements "Climate change is mainly caused by humans," "There are many different scientific opinions about climate change," and "The media exaggerate the possible effects of climate change" (Fig. 4). These responses were also used in the choice model to examine the direction of the effect such perceptions have on the willingness to pay for changes in the attributes of the choice experiment (Section 3.3). Less than 80 % of respondents in the household survey believe that climate change is primarily caused by humans, with less than 50 % agreeing that this statement is very accurate. Moreover, one-third or less believe that the media exaggerate the effects of climate change and that the scientific community is divided on climate change.

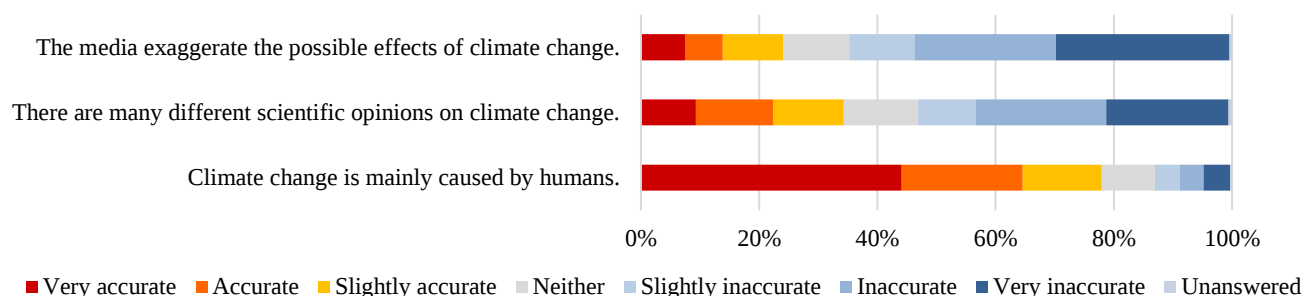


Figure 4. Climate change skepticism among residents (N = 644).

This suggests that the sources of risk perception, such as how climate change plays a role in creating or causing the challenges at the lake, may not always be a potential influencing factor. However, when talking to people, topics connected to global warming, water scarcity and changes in weather patterns are connected to climate politics. While some refrain from being 'distracted' by this topic, it still brings up matters of anthropogenic influences of the environment for them. Human behavior that does not take care of the surroundings was strongly criticized by residents. In this way, life at the lake becomes a first-hand experience of discourses that are otherwise mentioned in political debates or in the media. They turn to other examples of affected water bodies in the region and search for solutions to preserve the water-landscape.

The results of the quantitative survey are very much in line with the assessment of future challenges to the lakes as a social-hydrological system during the participatory resilience workshops. The aims of the two methods were not completely identical, and the approach varied as well, leading to a slightly different, but complementary depiction of the challenges. Whereas the set of challenges in the quantitative survey was predefined in accordance with the explorative interviews in collaboration with the ethnographic research, the challenges in the stakeholder workshops were identified through the process itself and then rated according to their perceived importance. In these workshops, stakeholders (residents and representatives of administration) rated the various challenges on a scale from getting smaller (-2) to staying the same (0) to getting bigger (2), as shown in Fig. 5. Although there is some heterogeneity among the responses, the general result of this assessment is that all these aspects that



are already perceived as challenges were expected to become even more problematic (with the exception of population growth).¹

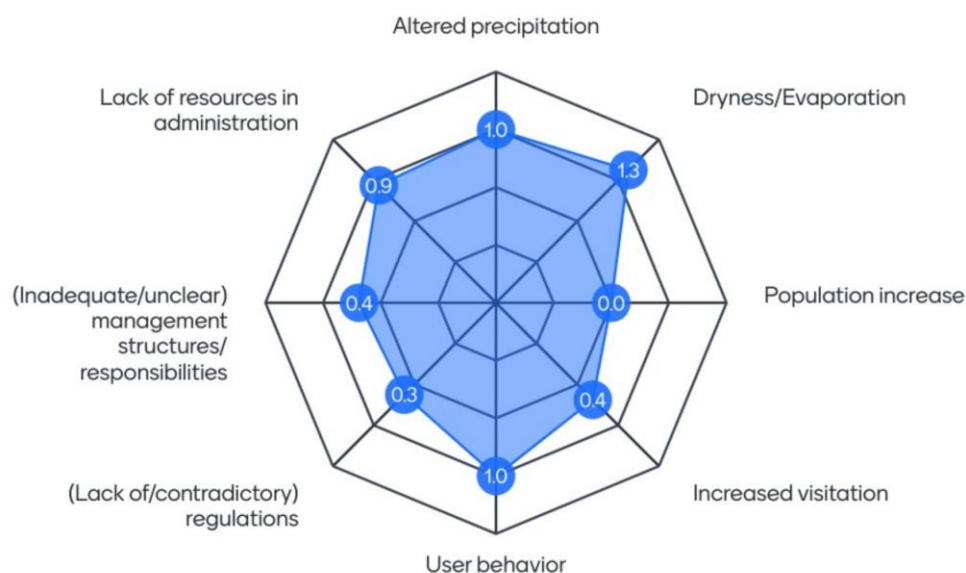


Figure 5. Average stakeholder perception of challenges becoming smaller (-2), staying the same (0) or becoming larger (2) (N = 8).

These results of the stakeholder workshops concerning the biggest future challenges for the socio-hydrological system align with the residents' perceptions of the biggest changes and challenges around the lakes collected in the survey, in that they point to a similar set of ecological changes (such as higher temperatures, more dryness/evaporation, less rain, and altered precipitation patterns) and social developments (such as increased number of visitors, population growth, and harmful user behavior). In addition, the stakeholders' assessment of the biggest future challenges reveals a perceived governance failure around the lakes, as they both identify a lack of resources in administration, (inadequate/unclear) management structures/responsibilities, and a lack of or contradictory regulations as among the currently largest challenges, and expect these three governance-related challenges to become even more relevant in the future (especially the lack of resources in administration).

Having outlined the perceptions of the most important changes and challenges, we now turn to the social structures underlying and interacting with these perceptions.

¹ In addition, there was confusion among workshop participants during the assessment as to whether population increase included only the communities in immediate vicinity or also the wider surroundings of the lakes. During the discussion after the assessment, however, it was clarified that participants expect considerable population growth in the nearby northern areas of Potsdam (see also section 3.2), which is actually expected to aggravate the status of the socio-hydrological system of the lakes. Taking this into account, it can be concluded that all of the currently identified challenges are actually expected to become more severe in the future by the participating stakeholders.



3.2 What social structures underlie and interact with these perceptions?

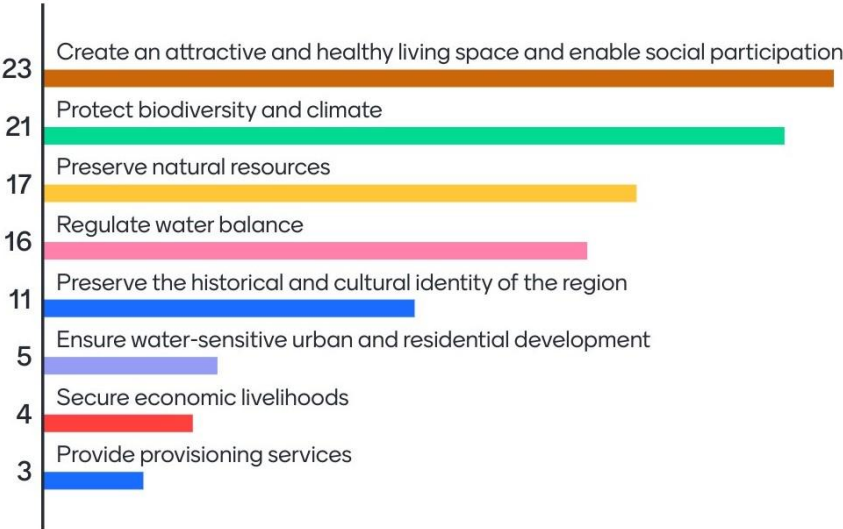
The results of both the quantitative survey and the stakeholder workshops provide a clear picture that, overall, residents and stakeholders strongly perceive changes and recognize future challenges for the lakes, due to the central role that both lakes play in social, political and cultural life. Both lakes are open to the public in places, and restricted in others, either by private ownership or environmental protection zones. Sacrower Lake is used for local recreation; walking and running are popular activities. Swimming is tolerated in a designated bathing area due to the landscape protection regulations. Groß Glienicker Lake has become even more involved in community activities for local residents and is a meeting place for many with its designated bathing areas. Environmental education, political education programs on German history, festivities and gastronomy are always related to the lake. Here, too, social family experiences are linked to the history of the lake. In everyday life, the lake is a meeting place for walkers, runners, swimmers and local anglers who are members of the fishing club. The above-mentioned perceptions of social-ecological changes as (future) threats thus take place in a wider social, cultural, political or historical context. We now turn to those contexts that are important to understand in order to see how certain perceptions have been framed. We first give insights into the general preferences of residents and visitors regarding the lakes, which we found to be related to the social and demographic structure of the lakeside settlements, the political history of the area, and the fragmented administrative responsibilities around the lakes.

3.2.1 General preferences regarding the lakes and their future

When stakeholders were asked about the essential functions of the lake as a social-hydrological system during the workshops (see section 2.2), an attractive and healthy living space offered by the lakes and the social participation they enable were rated highest (see Fig. 6).² This preference is related to the rising number of people and visitors and their (allegedly) harmful behavior, which is perceived as a challenge or threat (see previous section). Closely related to the attractiveness of living space and social participation is the environmental health of the system, represented by the functions of biodiversity and climate protection as well as the conservation of natural resources, which are perceived as being challenged indirectly by the increasing number of users and their harmful behavior, but also - more importantly - directly by the decline in lake water levels and quality. Lastly, the meaning of the lakes with regard to the preservation of the historical and cultural identity of the region plays a meaningful role in the participants' evaluation of the essential functions of the social-hydrological system.³

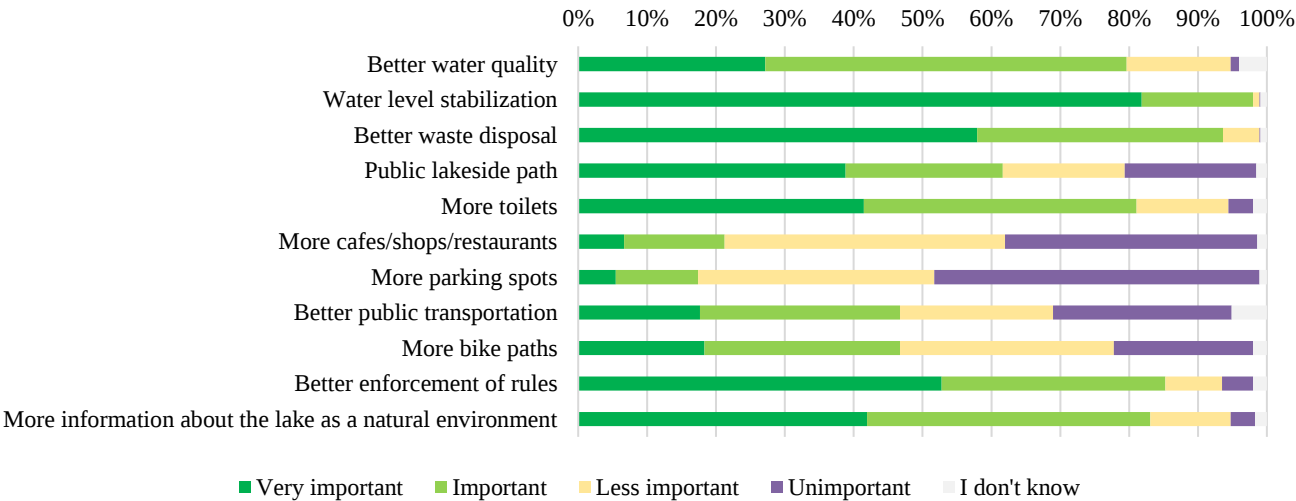
² Although they differ conceptually and with regard to the survey method, we consider the preferences for future changes at the lakes collected in the quantitative survey and the essential functions of the social-hydrological system collected in the stakeholder workshops to be largely identical in meaning, as both are concerned with what is essential to the participants with regard to the lakes.

³ Although ranked lower on the list of essential functions shown below, the lake also has an economic relevance for lake-side property owners. Property values around the lakes have risen considerably in recent decades due to the influx of population into the area (see below), and this value is at least partly dependent on the status (and existence) of the lakes, so the loss of lake levels is also an economic threat to some of the residents (especially to those whose property is (still) directly on the lakes).



290 **Figure 6: Ranking of essential functions of the social-hydrological system of the lakes (N = 8).**

295 These essential functions of the socio-hydrological system align with the preferences for future changes at the lake found in the quantitative survey (Fig. 7). Nearly 100 % of respondents indicated the importance of water level stabilization as important or very important, but improved waste disposal was similarly ranked by over 90 % of respondents. The subsequent issues with the recognized increase in the number of visitors above were also reflected in the importance or high importance of better enforcement of rules and more provision of information about the lake as a natural environment. As a result, residents do not assign a higher importance to more cafes, shops, restaurants or parking spots. Despite this, residents do see value in access to the lake and transportation in general, with just under 50 % of respondents assigning importance or high importance to better public transportation and bike paths.



300 **Figure 7. Preferences for future changes at Groß Glienicker Lake (N = 644).**



Looking at the results of the quantitative survey and the workshops in terms of the general preferences of the residents and stakeholders towards the two lakes, we can distill two overarching themes: first, participants highly value the ecological status of the lakes and the adjacent water-dependent ecosystems and, second, they care about the social services these ecosystems provide, such as an attractive living space, social participation and cultural heritage. However, the economic value of the lakes is less important as reflected in the fact that investments in public infrastructure are only valued if they are perceived to improve the ecological status of the ecosystem and not its tourism value. Rather, they are critical of further changes that enable greater public access, which is consistent with the results presented in the previous section where this aspect was identified as one the main challenges to the lakes and life at the lakes.

3.2.2 Social and demographic structure

These preferences of residents regarding the lakes are partly shaped by demographic developments and the social structure of the region, which therefore also influence the perceptions of social-ecological changes around the lakes. With regard to the quantitative survey, the sample from the study area was older (55 years on average) than the average population age of Berlin and Potsdam. Overall, 66 % of the sample had at least a first degree and the average net income per month was over € 5,000. Almost 60 % of the sample were employed at least part-time during the survey. The average household size was about 2.7 persons, higher than in Berlin and Potsdam. Single-family dwellings form the main component of the settlement structure, especially near the lakes. These figures are in line with the official data on the demographic and social structure in the region, which on both sides of the lakes is characterized by a relatively high proportion of older, wealthier people with a relatively high social and educational status with stable dynamics (Bezirksamt Spandau von Berlin, 2021; Landeshauptstadt Potsdam, 2023).

This demographic structure of the case study area has not always been like this. In fact, it changed significantly after the German reunification in 1990, especially on the Potsdam side. The population of Groß Glienicke, for example, more than tripled from about 1,500 inhabitants in 1990 to about 5,000 inhabitants today, mainly because it became an attractive area for relatively well-to-do elderly people and families from Berlin, but also from other parts of former West Germany. Accordingly, more than 70 % of the (mostly detached and semi-detached) houses in Groß Glienicke were built after 1990 (Landeshauptstadt Potsdam, 2023: 66-67). The population in Groß Glienicke and Sacrow is expected to keep growing steadily in the future, although at a slower pace than before. However, in 2019, the city of Potsdam decided to develop a new city district on a former military site close to the lakes that is expected to be home to 10,000 inhabitants until 2040. Kladow is also characterized by a relatively well-to-do population that grew quite significantly in the last decades, especially in the vicinity of the lake, which is, however, also expected to come close to a halt in the near future (Bezirksamt Spandau von Berlin, 2021). Thus, even though population increase directly at the lakes will probably not grow significantly anymore in the future, overall usage pressure on the lakes from people living directly at or near the lakes and using them for leisure and recreation will probably keep on growing. This will be affecting both the ecological status of the lakes and adjacent ecosystems and the way correspondent changes are perceived and what they are attributed to by the people living in the area.



In addition, both lakes have become a popular tourist destination in the last decade. Local residents pointed out that people were particularly attracted to the nearby lakes during lockdowns due to the coronavirus pandemic in 2020 and 2021. This increase in visitors is associated with several challenges and associated preferences for future changes. These challenges relate to the marking and inspection of marked bathing areas, sanitary and waste disposal facilities, traffic management, etc. (see section 3.1, Fig. 7). Although visitor numbers have peaked during the pandemic, the growing population of the Berlin metropolitan area raises concerns that the pressure of use will continue to increase (see section 3.1).

3.2.3 Political history of the area

The demographic development and social structure of the region has developed from a rural area with a settlement history that dates back to the 13th century, to a village structure mixed with middle-class city dwellers at the beginning of the 1920s, and then has been shaped by separation and finally German reunification. This characterizes the perception of the socio-ecological changes around the two lakes. Similarly, this also applies to the political-administrative structure, which is relatively fragmented with regard to the responsibility for water management in the catchment of the lakes. The division of Germany (1945-1989) resulted in the border running directly through Groß Glienicker Lake and the Berlin Wall running directly along the Groß Glienicke shore of the lake. This had a significant impact on everyday life surrounding the lake, especially on the geographically western (politically eastern) side of the lake as the wall cut off Groß Glienicke residents from access to the lake who had to go to Sacrower Lake instead. The local fishing club of Groß Glienicke is therefore still located at Sacrower Lake. Both village lives were characterized by demarcation and separation. Following the opening of the Berlin Wall in November 1989, the then still independent municipality of Groß Glienicke regained public access to the lake and the former border patrol path on this side of the lake was supposed to become a continuous lakeside path. But due to legal loopholes, there is an ongoing legal conflict with private owners over public access to this path. The village-like residential area became an attractive living area between Potsdam and Berlin (see above). Sacrow has been part of the city of Potsdam since the 1930s, while Groß Glienicke was only incorporated in 2003, becoming one of Potsdam's 32 districts. On the geographically eastern (politically western) side of Groß Glienicker Lake, Kladow was incorporated into Berlin in 1920. From 1929, the area on the eastern shore of the lake was planned as a single-family housing estate for the Berlin population. In addition to their detached house in the estate, the new property owners were also able to purchase private access to the lake with a jetty, which attracted many Berliners to Kladow to settle here as this enabled middle-class Berlin families to construct a weekend residence on the lakefront (Schmiedecke 2002). During the division of Germany, the residents of Kladow still had access to the lake, although it was - with the exception of two public bathing areas - predominantly private, which is still the case today. Thus, German reunification did not change nearly as much on the (geographically) eastern, Berlin/Kladow side of the lake than it did on the (geographically) western, Potsdam/Groß Glienicke side.

To this day, this history is reflected in family stories and biographical narratives. Conversations about the lakes always include references to the lakes as a political monument. This history of the area interwoven with wider political heritage is still part of cultural and educational programs and events along the lakes.



3.2.4 Administrative Fragmentation

German reunification has meant that the Groß Glienicker Lake is no longer divided by a national border. However, it is still divided by the border between Berlin and Brandenburg, i.e., the border between two German federal states, which to this day results in significantly fragmented political-administrative governance structures as it means that the responsibility for water management in the catchment of the lakes is distributed between several authorities of Berlin and Potsdam resp. Brandenburg. In addition, the administrative structures on both sides of the lakes are themselves already considerably fragmented.

In the context of the EU Water Framework Directive (WFD), one of the states takes the lead responsibility for cross-state water bodies. In this context, Berlin is responsible for all lakes where the state border runs through the middle, i.e., also the Groß Glienicker Lake. Responsibility for water management in Berlin is shared between the central state administration and the districts. The Senate Department for Urban Mobility, Transport, Climate Action and the Environment is responsible for groundwater and for the maintenance of all water courses and first-order standing water bodies.⁴ The district authorities, however, are responsible for the conservation and maintenance of second-order standing water bodies such as the Groß Glienicker Lake. This task is carried out by the district offices (Bezirksämter) responsible for nature conservation and green spaces. Thus, the Bezirksamt Spandau is responsible for the Groß Glienicker Lake, while the Senate is responsible for the groundwater in the catchment of the lake and thus also the aquifers traversing the lakes, including its parts belonging to Brandenburg.

Since Sacrower Lake belongs to Brandenburg in its entirety, only Brandenburg authorities are responsible in terms of the surface water. In general, surface waters fall into the responsibility of the Ministry of Agriculture, Food Industry, Environment and Consumer Protection, which is the highest water authority, and the State Office for the Environment, which is the upper water authority. The lower water authority in this case is part of the city administration of Potsdam, which is responsible for monitoring and protecting water bodies from impairment according to the federal and state water law. The Schiffgraben, a water stream connecting Sacrower Lake with the nearby river Havel, falls within the area of responsibility of the water and soil association Nauen, which mows the embankments by hand once a year and clears the ditch of dead wood and debris.⁵ The bridge across the Schiffgraben, however, belongs to the city of Potsdam.

These fragmented governance structures, in the eyes of the residents/stakeholders, hinders the administration as a whole from taking appropriate actions to solve lake-related problems such as the (perceived) residents'/visitors' behavior and lake level loss or to mitigate their effects. Based on their (perceived) past experience, administration is not trusted to solve the lake-

⁴ Standing water bodies in Berlin are administratively divided into first-order standing water bodies (navigable) and second-order standing water bodies (non-navigable).

⁵ In Germany, water and soil associations are self-governing corporations under public law that perform water and soil management tasks in the public interest and for the benefit of their members (mainly public and private landowners). They have their legal basis in the Federal Water Association Act (WVG) and the corresponding implementation laws of the federal states.



related problems, which is why the lack of regulations and their enforcement as well as inadequate management structures were perceived to be salient future challenges both in the quantitative survey and during the stakeholder workshops (see above). The social(-ecological) structures revealed that perceptions of changes and challenges are shaped by the general preferences of residents and stakeholders regarding what is considered essential and desirable. Moreover, the perceptions are linked to demographic characteristics and the social structure of the communities around the two lakes through the political history of the region as well as the associated, fragmented administrative structure. Given the emergent incapability of action, the question arises as to what the perception of responsibilities are and what the willingness to actively participate in dealing with the challenges is exhibited.

3.3 What are people willing to do and who do they consider responsible?

Observing the rapid lake level loss of both lakes for a decade, many people started discussions about what this loss would mean to them. While economic conditions such as house price developments etc. of residents also shape individual preferences to some degree, there are also strong indicators for common care. Results of the quantitative survey suggested that residents of the study region (8 km radius) are in fact willing to take things into their own hands (Fig. 8). Approximately 95 % of respondents indicated that they observe nature conservation rules and take care of their own trash when spending time at the lake. Furthermore, over 90 % of respondents reported not entering natural shore areas, one of the critical points brought up by the residents about the damaging effects of the visitors. Interestingly, almost 60 % of respondents agreed to reduce their personal water consumption, even though the perceived change in the lake level was high and stabilizing the level was perceived as very important. In terms of types of contributions, respondents appear to be more willing to take action on their own behavior and its consequences (i.e. obeying rules, collecting their own trash and using the toilets provided), but less willing to make contributions that compensate for the actions of others (i.e. voluntary environmental actions, collecting rubbish, informing others about nature conservation rules) or for hazards such as water level decline that are more likely to be caused by climate change impacts.

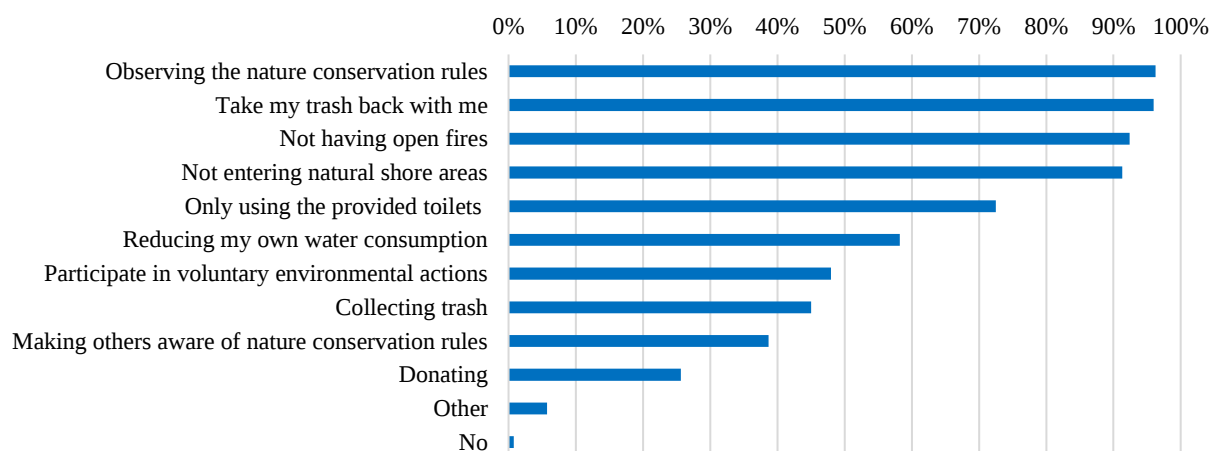


Figure 8. Indicated willingness to contribute among the respondents to the improvement of the situation at Groß Glienicker Lake.

The willingness to contribute was also reflected in the results of the discrete choice experiment. A conditional logit model was used to model the sample's preferences for changes to the lake in terms of maintaining or improving water levels, improving or allowing water quality to deteriorate, making the lakeshore path public or private, adding garbage cans or garbage cans and clean toilets, or improving or reducing biodiversity. Results of the interaction model (Tab. 1) indicate a high willingness to act in terms of making a monetary contribution to the improvement of several attributes. Moreover, the negative willingness to pay (WTP) indicates unfavorable attributes, and the magnitude shows the compensation that individuals would require to accept such a decline in the state (i.e., 70.29 € per household would need to be compensated for the removal of the currently partially public lakeside path). The responses concerning climate change skepticism (Section 3.1) were included in the model as interactions with the attributes after re-coding the first two items, the average of the responses across the three items was calculated before interaction with the attributes. Significant interactions with the climate change skepticism responses were found and demonstrated that on average, higher climate change skepticism leads to a lower WTP for maintaining or improving water levels, improving or allowing for a decrease in water quality, fully opening the lakeside path to the public and improvements in biodiversity.



Table 1. Willingness to pay (WTP) estimated through the conditional logit model including interaction terms.

	WTP per household and year	Standard error
Alternative specific constant	-62.27***	18.57
Higher water levels	422.10***	32.849
Maintaining water levels	303.55***	30.851
4 m visible depth	67.13***	21.979
1 m visible depth	-3.08	23.23
No public lakeside path	-70.29***	10.947
All public lakeside path	88.77***	19.822
Trash cans and toilets	45.18***	11.12
Trash cans	19.47*	10.688
Biodiversity deterioration	-116.73***	11.307
Biodiversity improvement	141.60***	20.976
Higher water levels * climate change skepsis	-46.10***	7.22
Maintaining water levels * climate change skepsis	-31.08***	7.643
4 m visible depth * climate change skepsis	-21.39***	6.341
1 m visible depth * climate change skepsis	-14.08**	6.941
All public lakeside path * climate change skepsis	-23.75***	5.72
Biodiversity improvement * climate change skepsis	-32.33***	5.926
Log likelihood	-4801.68	
Null log-likelihood	-5476.62	
Pseudo R2	0.12	
number of choices	5136	
number of respondents	642	
AIC	9639.36	
BIC	9757.15	

The results of the choice experiment demonstrated an average willingness to act in terms of financial contributions, but a more detailed investigation of open-ended responses following the choice experiment provided additional insights concerning dissonance and differences between respondents. Whereas some individuals demonstrated decreased self-efficacy in helping the lake through financial contributions (“It is naïve to believe that private payments can stop the sinking of the groundwater table.”), other respondents questioned “Why impose a tax only on residents? Not the day tourists too?”, which was further supported by other responses (“The beneficiaries are the people from elsewhere, we suffer as a result and are also expected to finance it”). Therefore, although on average there is a general WTP for improvements, a challenge for governance pathways of the multitude of ecological and social challenges diffracted through the prism of lake loss is complicated by the perception of responsibility for making changes financially possible. Through this lens, although the responsibilities for the level of the lake itself and the quality of the water may be more clearly defined in laws and regulations (although complicated by interstate boundaries), residents perceive a more complex structure of responsibilities given their perceptions of the challenges and their causes. Overall, residents participating in the household survey perceived that a shared responsibility exists along the levels of



government and administration as well as by visitors, associations and the residents themselves (Fig. 9). The majority of the sample perceived the cities Potsdam and Berlin to be centrally responsible, but also a large majority perceived the municipalities and the states to be at least co-responsible.

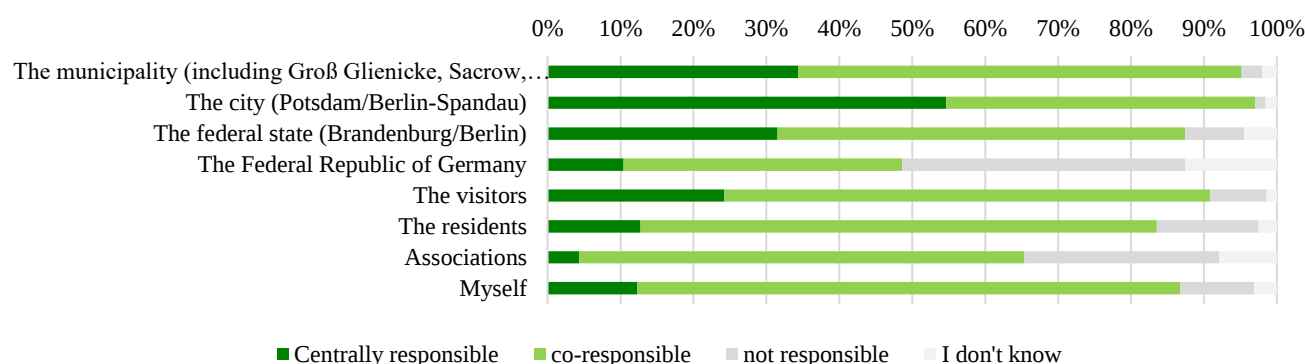


Figure 9. Perception of responsibility by the residents concerning who should implement improvements at the Groß Glienicke Lake.

While residents showed a general willingness to act, either through financial contributions or behavioral changes, the interplay of perceived challenges and perceived responsibilities among various stakeholders emphasizes the need for collaborative and multi-level governance to address the social and ecological hazards that are diffracted through the prism of the perception of lake level decline.

3.4 What are local practices of dealing with perceived challenges?

The previous section underlines the importance of understanding how diverse actor groups respond to pressing social and ecological challenges through local practices that require not only individual contributions but also collective action. In this context, while some ask themselves what their contribution could be, others get active. So, how do the different actor groups, especially the latter, practically deal with the perceived challenges and responsibilities?

3.4.1 Initiatives on site

Despite its relatively small size and population, there is a flurry of citizens' initiatives in the three residential areas around the lakes concerned with the lakes and their ecosystems. The approach of the representatives of the citizens' initiatives is based on their own research and mitigation activities at the lakes themselves. This also helps them retain agency and compensate for a lack of structural support. For example, as one of the smallest parts of Potsdam, the remote Sacrow has a very active and influential citizenry for all matters relating to this neighborhood and stakeholder underlined the importance of taking care of their lakes. Their own research has made the people their own experts in water management, which resulted in a newly founded 'water working group', a cooperation across all citizens' initiatives from all sides of the lakes, to gather and share information about scientific and political approaches. Popular topics became e.g., the water transfer from rivers to lakes, using the lakes as water storage in order to provide freshwater for the metropolitan region. Both options were drawn from comparable lakes in



470 the region. For immediate results, especially water use and water extraction from residents and the nearby waterworks were
put in focus. Although private consumption is difficult to track, the stakeholders were surprised that figures from the
waterworks were not available (however numbers show that these have a minor effect on water levels). Above all, there is
growing concern among this water working group that the lake continues to be regarded as an infinite water resource and
neither local people, visitors or institutions respect its limitation and thus rethink their water use, including groundwater use.

475 In addition to these discussions, people are turning to concrete activities. One example is the lakeside working days: One of
these activities at Sacrower Lake brought together people from the area, supported by a few representatives from the Potsdam
administration. Due to the increasing number of visitors to Sacrower Lake, which is not a designated bathing lake, more and
more guests are entering the protected shores of the Flora and Fauna Habitat. The local forester is concerned about the
ecological balance of the lake and has set himself the task of surrounding the lake with wooden fences. He explained that the
480 aum is not to prohibit potential swimmers from coming to the lake, and hence they leave gaps between wooden fences. Rather
they wanted to create awareness that you can't just go straight to the lake' (stakeholder representative). While the barriers were
being erected on the shore, small groups of walkers passed by and suddenly complained about the new boundary, interpreting
it as a sign that the lake dwellers wanted the shore to themselves. Aware of this ambivalence and their privileges, the lake
dwellers argued that they had also taken on the task of caring for their lakes. When asked, one of the younger volunteers on
485 the day explained: "I'm here today because we have to do something so that this lake doesn't disappear. We like living here".
However, some of them also indicated that their privilege of living close (and also being able to swim) in these also comes
with certain responsibilities, on their own grounds but also on the city's property.

On the Kladow side of the Groß Glienicker Lake, the chairwoman of the local citizens' initiative to protect the lake also believes
that private ownership goes hand in hand with protecting the natural environment by maintaining the shoreline. There has been
490 a growing conflict over whether private jetties should be removed. This local discussion was once only about one's own access
to the lake and its ecological effects, but has now broadened its scope to include preventing further siltation and weed growth
on the shore. There is now a proposal that private owners should also be responsible for monitoring water levels, plant species
and animal populations. In their view, this is a task that the district office is not fulfilling. Here, too, some residents see
themselves as responsible. However, there is no consensus on what this kind of landscape management should look like, and
495 there is no governing authority.

All in all, the activities on the ground relate to the formation of new groups for the exchange of information and joint strategy
development. Here, the lakes become a connecting element. Nevertheless, there are differences in the degree of commitment.
While on the one hand, those involved in groups are annoyed about too little participation, others are overwhelmed by the
issue and wonder how their own actions can play a role here.

500 3.4.2 Local citizens and administration between confrontation and dialogue

These activities and discussions among the active citizens around the lakes have an intrinsic value, but also a political one as
they are co-addressing local administration and politicians with their actions with a view to save the lake both as an ecosystem



and as a historical and cultural heritage. For example, the citizens' initiative at the Kladow side of Groß Glienicker Lake mentioned above has issued a 16-page petition to the district office in Spandau in 2019, in which it documents the environmental degradation and pressures on the natural ecosystems on the side of the lake caused by the drying up of large areas of shoreline and the increasing usage pressure from visitors. Based on this, they urged the district office to withdraw the request to dismantle the private jetties in the lake, as these have a positive effect on the riparian ecosystem, and instead to work more closely and trustingly with the lake residents to jointly improve the ecological situation at the lake. In this context, they also offered to become active and take on certain tasks themselves, such as regular observations and measurements on site (e.g., photographic documentation) as well as active maintenance measures under the guidance of the specialist authority. In 2023, they documented the changes in the water level and the associated degradation of flora and fauna around the lake over the past decade as part of an exhibition entitled “Our lake, (not) a climate victim?”, providing information on both the scientific basis and the suspected causes, as well as making demands on politicians and the municipal administration.

Another example is the Citizens' Advisory Council for Sacrow, a body initiated by the citizens of the village themselves to represent their interests vis-à-vis the city administration of Potsdam. Among other things, this group has focused its work on the Schiffgraben, a connecting ditch between the Sacrower Lake and the river Havel. This Schiffgraben has been interrupted since the 1980s by a meanwhile dilapidated retaining structure, which causes the Schiffgraben to become increasingly silted up and smelly, thereby also increasingly jeopardizing the water quality of Sacrower Lake. In this context, the group has been trying for years to understand and fix this problem, both independently and in cooperation with the local and state administration. For example, it has independently commissioned a nature conservation report to discuss whether and how the dam on the Schiffgraben should be renewed to retain water in Sacrower Lake, prevent eutrophic Havel water from entering the lake and ensure fish passability. The CI repeatedly approached the responsible authorities at local and state level with specific local expertise such as this in order to enter discussions with them and collaborate on solutions to the problems perceived by the CI.

With actions such as these, on the one hand, the CIs encounter rejection and inaction on the part of the authorities, at least according to their own perception, which leads to considerable frustration and resignation. The different points of contact resulting from the overlapping responsibilities (see section 3.2) continue to create uncertainty among committed citizens. As we described earlier, the responsibilities for surface water and groundwater are distributed differently, and are also dependent on long-term cooperation. As a result, committed groups encounter ambiguous areas of responsibility, which in turn pass these commitments on to other bodies. This results in what local residents like to call an 'administrative Mikado', in which responsibilities overlap and therefore the questions and demands of the committed public end in a dead end. In discussions with the administration, this is mainly due to the range of different tasks as well as to staff shortages (see also section 3.1).

On the other hand, the actions of the citizens' initiatives also lead to more and better understanding and cooperation, both among themselves and between CIs and the local authorities. For example, even though many groups were not specifically focused on the lake level drop from the outset (but rather on locally specific issues such as the jetties at the Kladow side of Groß Glienicker Lake, the lakeside path on the Groß Glienicke side of Groß Glienicker Lake, or the Schiffgraben in Sacrow),



the overwhelmingly problematic situation of the lakes has led to the CIs from the three residential areas networking more closely and also planning and carrying out joint campaigns. In this sense, the lakes and their problems have served as a kind of boundary object for new societal cooperation, not only among the CIs, but also between CIs and the municipal administration (Franco-Torres et al., 2020).

In reaction to the manifold problems around the lakes and the discontent of the citizens, the district office of Spandau and the city administration of Potsdam teamed up in 2021 to start a citizen dialogue on the two lakes that aimed at jointly preparing the call for tender for a feasibility study on future options for water management of the two lakes. The goal of this dialogue was to work out the requirements for such a feasibility study together with the citizens involved to represent all their viewpoints and preferences in the process and in the final feasibility study. The dialog process consisted of four meetings between spring 2022 and summer 2023, in which the relevant people, groups, institutions and organizations discussed and agreed on which aspects of a feasibility study need to be examined, presented and demonstrated in order to develop a clear target perspective for the future development and future handling of the two lakes. The fundamental aim was to promote and facilitate the comprehensibility of the results and the broadest possible agreement of all stakeholders on the objectives of a feasibility study. The call for tender for the feasibility study will be published by the end of 2024 and the feasibility study itself will be prepared in 2025/2026 and then serve as a basis for the subsequent implementation of concrete measures. While it is not yet clear how this process will end and what fruits it will ultimately bear (which is why it is still viewed with much skepticism), it carries many of the elements of agonistic participation, deliberation and learning that are necessary in unstructured problem situations where there is little agreement on both the norms and values at stake and the type of knowledge required to solve the problem (Hoppe et al. 2013).

4 Discussion

We showed how the declining water levels in Groß Glienicker Lake and Sacrower Lake were perceived as a serious challenge by local residents and stakeholders. The shrinking lakes became a growing concern. Both the survey of the wider population and the stakeholder workshops drew attention to the falling water levels. Based on this new attention to the lakes, we showed that topics such as environmental protection, water management, but also issues of social and economic infrastructure and community care had gained a new presence for the people and were perceived as challenges. These perceived challenges are related to and are influenced by social structures and a political history of division that has had an impact on the different private and public approaches and responsibilities for the lakes today. Fragmented governance also causes delays in local efforts. We referred to the blurry, dispersed responsibilities for dealing with the problem and what local practices already exist to deal with it. These local practices of concerned citizens on the ground indicate that concerted efforts on the part of the residents are appreciated, but also that responsibilities should be more clearly distributed between citizens, administration and politics. The survey revealed a more diverse picture, with attention partly leading to motivation to act, but with a desire for greater public control in the public sphere and uncertainty about one's own efficacy.



The case of the shrinking lakes thus demonstrates how water issues are becoming a public concern and how people are getting involved in discussions about governance. In these approaches, people identified many challenges that are linked to all aspects of their daily lives in the area. These lives are connected to the water: social relations are created through and over the water, and economic factors play a role in decision-making, private and common interests have to be negotiated along the water (Krause and Strang 2016). Furthermore, new pressing water issues create new water publics, which raises questions about sustainable water distribution and the governance of water in a private and common approach (McDonald 2018). In the case presented, there is no clear solution in sight and approaches are influenced by interests and show ambivalence. However, as income and education levels of stakeholders and residents indicate, they have the means and privilege to make efforts for the future of the lakes. Discussions and practices at the two lakes aim at further communication about the future of and at the lakes. They want to have an informed discourse about possible actions, including both technical solutions and new forms of management and communication along the shores of the lakes. They value discussions in forums and platforms where they do not just want their wishes to be implemented, but where the different parties involved think together about solutions. This includes making political decision-making processes transparent and accessible to those who would like to act but have personal or economic constraints, or do not yet know how to contribute.

In light of this reasoning, discussions on the potential options for action considered should not be limited to technical options for restoring lake levels. Rather, it is important to understand the social and emotional entanglements of the hazard as well as the socio-political structures that manifest in the hazard and to take them into account when discussing options for future action. Starting points for such options for climate adaptation “beyond technical fixes” (Nightingale et al., 2020) can be broadly conceptualized as instances of adaptive governance, a concept that emphasizes the need for flexible governance mechanisms capable of dealing with uncertainty and complexity in social-ecological systems that traditional top-down governance approaches often fail to address (Chaffin et al., 2014). Central aspects of adaptive governance involve utilizing feedback loops, interconnecting policy actors across multiple levels, and involving a broad diversity of perspectives and stakeholders (Visseren-Hamakers et al., 2021).

Reflecting on our case of the decline in water levels in Groß Glienicker Lake and Sacrower Lake as a socionatural hazard through this lens, our analysis offers a few starting points for a more adaptive governance at the lakes. First, the governance challenges mentioned in 3.1. are partly caused by the fragmented administrative responsibilities mentioned in section 3.2, which, in the opinion of many stakeholders, contribute to the perceived inactivity or inability to decide and act on the part of the responsible administrative bodies. Second, the perceived lack of implementation of existing regulations and uncertainties regarding the planning of growing neighborhoods are reflected in the residents' desire for better enforcement of rules, as highlighted in section 3.2, for which, as section 3.4 shows, the local authorities are held particularly responsible. Third, against this background, the willingness to act on the part of residents, as shown in section 3.3, and the already existing local practices of dealing with perceived social-ecological challenges, described in section 3.4, are particularly relevant with regard to the implications of our research and possible starting points for future action. They show that, despite all the frustration on the part



of citizens, there is still a considerable willingness both to enter into dialogue and cooperate with local politicians and administrators as well as to take action themselves.

From an adaptive governance perspective, these local practices of citizens around the lakes and their relations to local administration and politics are valuable resources because they resemble the two classic roles of NGOs in environmental governance, which Jasanoff captioned as “criticism/reframing” and “epistemic networks”. The first role, in Jasanoff’s words, describes the “criticism of dominant scientific and policy frameworks (...) founded on (...) local environmental knowledge” (Jasanoff 1997, p. 581). The campaigns of the CIs mentioned in section 3.4 are good examples of this, as they produce and present “localized knowledge of nature gained through non-scientific activities” (ibid., p. 583) to challenge the authority of both procedures and knowledges administrative (non-)decisions around the lakes are usually based on. The second role, which is characterized by “creating more inclusive ‘epistemic networks’ around (...) defined environmental objectives” and facilitating “consensual action because of their experience in integrating environmental concerns with other aspects of community life” (ibid., p. 581), is represented both by the internal collaboration between the CIs involved and by the cooperation with the authorities in the context of the dialogue. The internal collaboration between the CIs involved as well as their outreach to other community members represent “bonding and bridging processes” within the affected civil society, while cooperation with the authorities in the context of the dialogue represents “linking processes” between civil society and administration (van Dam et al. 2014, p. 336).⁶

Even though things are far from perfect in terms of the cooperation between citizens and local authorities, these processes of bonding, bridging and linking spurred by the local CIs are indispensable for building good relations, developing trustful relationships and collaborating successfully on the local level (see also Hassink et al. 2016). To improve this, the existing governance challenges and the current lack of adaptive governance referred to above should be recognized and be addressed, both through transparent communication and by creating options for controversial discussions and participation. Such a holistic approach would ensure that local problems such as the lake level decline as well as underlying challenges such as climate change, demographic change and lacking government capacities can be dealt with in the best possible way.

5 Conclusion

The objective of this study was to understand lake level loss of Groß Glienicker Lake and Sacrower Lake as a hazard through the socionatural relations and how these relations frame discussions about the hazard. We analyzed our empirical data by using a multidisciplinary social science mixed-methods approach. In doing so, we gained insights into how people perceive the

⁶ Van Dam et al. describe bonding as building “trusting co-operative relations between members of a network who are similar in terms of social identity”, while bridging refers to building “connections between those who are unlike each other yet are ‘more or less equal in terms of their status and power’” and linking refers to connecting “individuals and groups in different social strata in a hierarchy where power, social status and wealth are accessed by different groups. (...) Applied to the practice of citizens’ initiatives, the process of bonding refers to the interaction between the initiators and their fellow residents; the process of bridging refers to the interaction between the initiators and other local groups with different interests or orientation such as farmers, entrepreneurs, local residents who go back generations and more recent arrivals; and the process of linking refers to the interaction between initiators and institutional actors” (van Dam et al. 2014, p. 326).



current hazard in a challenging context of diverse administrative jurisdictions and complex scientific investigations and into how and why they (still or precisely because of the complexities) feel responsible and inclined to act.

We therefore sought to conceptualize and understand the decline in lake water levels as a natural hazard in a broader sense, i.e., as a (relatively abrupt) change in the biophysical environment that causes various forms of human harm, namely material or physical harm as well as social, political, emotional and psychosocial harm. Examining this type of hazard specifically from a social science perspective explicitly highlights these latter dimensions of human harm. We therefore conclude that the hazard of the dropping lake level is not just a natural hazard but a *socionatural* hazard that must be conceptualized as characterized by various natural, social and cultural aspects. The declining lake levels thus become a prism through which the social embeddedness of this natural hazard becomes visible. This paper contributes to such a broadened conceptualization of natural hazards as *socionatural* hazards and, in addition, showed that this endeavor is not purely academic, but also has concrete practical implications.

The manner in which society manages water resources is undergoing substantial transformations, driven not only by climate change but also by a multitude of local challenges. The case of Groß Glienicker and Sacrower Lakes in Berlin-Brandenburg demonstrates how the impacts of these changes vary depending on the highly heterogeneous social and hydrological conditions present, even within a relatively small geographical area. These contrasts in local contexts, from differing risk perceptions of water shortage to distinct governance needs, underscore the necessity of adaptive governance approaches that are fine-tuned to the specific social-hydrological systems in question. It is imperative that governance strategies address not only nature-related risks, but also the diverse social challenges and functions presented by these systems. This means incorporating the wider needs of society. The study has provided a novel view of risks beyond the hydroecological aspects of water level decline by adopting a highly interdisciplinary approach to the study of hazards as *socionatural* hazards. Furthermore, it harnessed the potential of transdisciplinary research by discussing the complexities of risk management efforts with the public, thereby also highlighting the constraints of such approaches, particularly in the context of addressing the more profound and transformative changes required for long-term adaptation. Nevertheless, recognizing and accounting for the heterogeneity of local risks and perceptions will be pivotal in developing more effective and responsive risk management models.

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