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Brief communication: What do we need to know? Ten questions about climate and water challenges in Berlin-Brandenburg

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Abstract. As climate change escalates, the Berlin-Brandenburg region faces new challenges. Climate change-induced extreme events including droughts, heatwaves, and floods, are expected to cause new conflicts to emerge and aggravate existing ones. To guide future research, we engaged a transdisciplinary academic community of experts to co-develop a list of key questions on these climate and water challenges in the region. Our findings highlight the urgent need for integrated and participatory research approaches. We expect this list of key questions to provide a roadmap for scientists and policymakers to foster actionable knowledge production to address climate and water challenges in the region.

1 Introduction

As climate change accelerates, the number and complexity of associated problems in the agriculture, water, health, infrastructure and energy sectors often exceed the time needed and resources available to address them effectively (IPCC, 2022; UNESCO, 2020). To ensure measurable progress in adapting systems to future challenges, it is crucial to identify and prioritise the most pressing climate and water-related issues. As a community of scientists, we can guide this focus by establishing priority lists of problems or questions, a strategy that has proven effective in the past. In 1900, the mathematician David Hilbert presented the mathematical community with a list of 23 fundamental problems that profoundly shaped the development of the discipline (Hilbert, 1902). Inspired by this approach, frameworks such as the "Twenty-three unsolved problems in hydrology" paper (Blöschl et al., 2019) have contextualised research and catalysed innovation across disciplines.

Motivated by this concept, we aim to apply a similar methodology to one of Germany's most vulnerable regions to the impacts of climate change: the Berlin-Brandenburg region. As one of the driest and warmest areas in Germany (558 mm mean annual precipitation compared to 789 mm for Germany and 8.7 °C mean temperature compared to 8.2 °C for Germany for the reference period 1961–1990) (DWD, 2022), with predominantly sandy soils, the drought-sensitive region of Berlin-Brandenburg faces significant challenges under climate change (Reyer et al., 2011). Furthermore, the region is already experiencing increasingly extreme climate patterns, including prolonged droughts, more frequent heatwaves, and heavy rainfall events (Paton et al., 2024; Pohle et al., 2025; Luo et al., 2024). These climate extremes place increasing stress on regional water resources to meet the needs of the agriculture and forestry sectors, provide water for all users, and ensure human health, while also challenging many regional ecosystems (Conradt et al., 2023).

Compounding these climate-induced pressures are the consequences of the German gradual phase-out of lignite mining by 2038, particularly evident in the Lausitz region in southeastern Brandenburg. While this transition represents a necessary step towards reducing national carbon dioxide emissions, it introduces significant socio-economic and environmental challenges in the wider region. It will not only impact regional employment and economic stability associated with the lignite mining, energy, and automotive industries but will also disrupt established water management practices. The River Spree catchment and post-mining landscapes such as reservoirs and artificial lakes have been supported for over 60 years by a constant, if unsustainable, inflow of sump water from lignite mining (Uhlmann et al., 2023; Chen et al., 2023). Downstream, this artificially increased discharge benefits the Spreewald wetlands, a critical area for nature conservation, cultural activities, and tourism, as well as the water supply for the densely populated urban area of Berlin (Uhlmann et al., 2023).

To address these interconnected challenges, it is essential to advance knowledge and research on Berlin-Brandenburg's adaptability to climate change, which can be viewed as representative of other drought-sensitive, heavily anthropogenically changed, extensive lowland regions. The interplay between ecological vulnerabilities and socio-economic transitions underscores the need for inter- and transdisciplinary approaches. This paper explores how science can contribute to these efforts by identifying future research priorities that bridge gaps between science, policy, and practice, and outlines a more adaptive and cohesive strategy for a resilient and sustainable Berlin-Brandenburg region.

2 Focus area: Berlin-Brandenburg region

The Berlin-Brandenburg region (BBR – Fig. 1) represents a complex interplay of urban and rural dynamics and interdependencies, where water and energy demand, agriculture, forestry, nature conservation, and tourism are closely interlinked. Shaped by glacial processes during the Pleistocene, the region is characterised by sandy soils with low water retention capacity, making it particularly vulnerable to hydrological fluctuations such as droughts and groundwater storage decline. This low water retention is further intensified through an extensive network of artificial drainage channels and straightened river channels. The Havel and Spree rivers, along with a network of lakes and canals, form the backbone of the regional water system, which has undergone extensive modification over the centuries to support agriculture, urban development, and industrial activities, including lignite mining. For example, up to 70 % of drinking water for Berlin's 3.4 million inhabitants is sourced from groundwater and bank filtration from surface waters (SenUMVK, 2022).

Furthermore, the region is home to valuable landscapes for nature conservation and cultural heritage, including the UNESCO-designated Spreewald Biosphere Reserve. However, climate change, urban expansion, and the planned coal phase-out in the Lausitz pose significant challenges, highlighting the need for sustainable water management and integrated supra-regional planning to ensure the future resilience of the BBR (SenUMVK, 2022). Due to the high variability of local extreme events, the region is considered particularly vulnerable to the consequences of climate change. Climate projections (CMIP5 – Pfeifer et al., 2021) indicate an increase in annual mean temperature (+0.4 to +5.3 °C) and uncertain trends in annual total precipitation (−11.3 % to +31.0 %). Despite the possible increase in annual total precipitation, this may occur in the form of fewer but larger magnitude precipitation (Lisonbee et al., 2025) and more frequent dry periods (Alencar and Paton, 2024; Paton et al., 2024).

The political and administrative responses to climate-related water challenges in the BBR operate across multiple levels (Beveridge et al., 2017; Ibisch et al., 2014; Vogelpohl and Feindt, 2024). While key responsibilities lie with regional and municipal institutions, they are embedded in a dense framework of state federal, national and EU-level regulations (Beveridge et al., 2017; Vetter et al., 2016), showing a high degree of institutional fragmentation, with overlapping responsibilities among state agencies, municipal utilities, and, in some cases, private sector actors (Hüesker et al., 2011; Schaefer and Warm, 2014).

Recent political efforts to address climate-related water issues include federal and state-level strategies such as Brandenburg's Low Water Concept (Landesniedrigwasserkonzept – MLUK, 2021) and Berlin's Water Master Plan (Masterplan Wasser – SenUMVK, 2022), as well as cross-federal state strategies like the forthcoming Water Strategy for the Capital Region 2050 (Wasserstrategie Hauptstadtregion 2050 – Landes Berlin, 2024) and the Position Paper of the Water Management Administrations of Saxony, Brandenburg and Berlin (Guenther et al., 2022). These initiatives aim to improve strategic alignment and governance coherence across administrative boundaries.

However, coordinated and effective action is hindered by a number of issues, including: increasing competition for landscape functions and natural resources, weak economic incentives for proactive adaptation, the privatisation and commercialisation of water services, unclear institutional responsibilities, and limited stakeholder participation – all of which are particularly pertinent given the region's growing vulnerability to climate extremes (Hüesker et al., 2011; Ibisch et al., 2014; Vetter et al., 2016).

3 Methodology

Addressing the complex challenges of climate and water dynamics in the BBR requires input from a broad community of experts. The Research Unit Climate and Water under Change (CliWaC), a transdisciplinary group of 28 project leaders from leading research institutes in the Berlin area, brought together expertise across a wide array of environmental and social sciences. As active researchers in the region, this group of specialists was selected as the reference group for co-producing relevant research questions for the coming decade in the BBR.

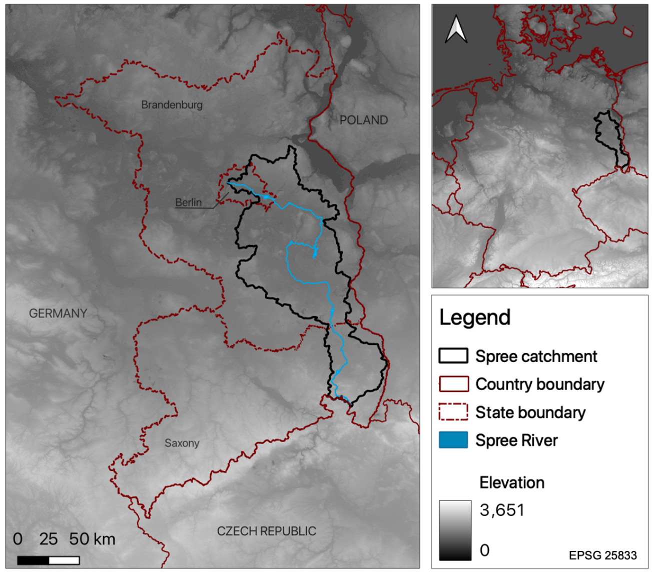

Figure 1. Area of relevance to the study. The federal states of Berlin and Brandenburg and the Spree catchment.

The process of the co-production was divided into 3 steps (Fig. 2):

- S1 – the input phase: all CliWaC members were invited to provide statements related to their view of current and future water and climate threats in the BBR for the coming decade.
- S2 – the consolidation phase: during this phase, the statements were translated into research questions and evaluated by the community via an online questionnaire
- S3 – the communication phase: the questionnaire answers were analysed and communicated to the reference group for final reflection.

S1 was kicked off during the project meeting in November 2023 in Kremmen (Brandenburg) with 50 project members involved. In the following months, statements were provided by the community (S1). Once all statements had been collected (a total of 82), they were organised and translated into 48 research questions. These research questions were presented to the reference group as a questionnaire to evaluate their relevance and potential positive impacts on the BBR in the coming decade (S2).

The questionnaire presented to the participants during S2 (see Supplement to the paper) contained 48 potential questions divided into the five categories (climate adaptation and resilience; water management; technological solutions and innovation; past, present and future impacts; and governance

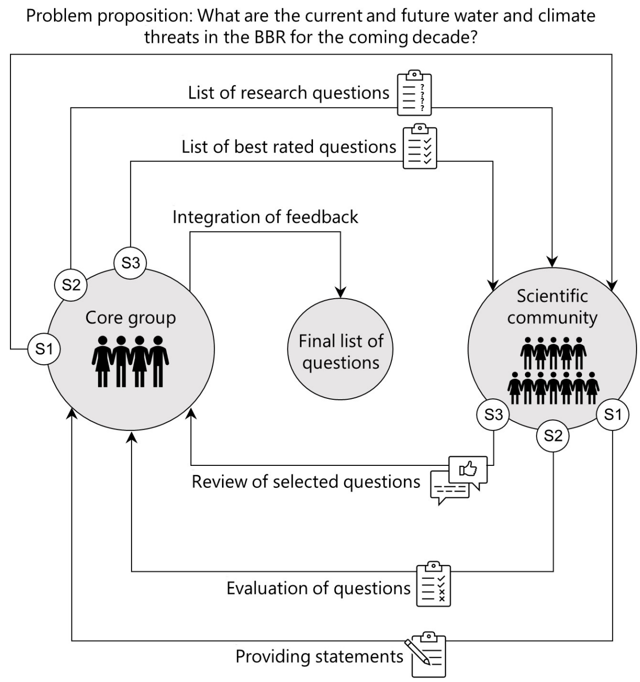

Figure 2. Flowchart of the interactive process of co-production to obtain the list of relevant questions for the Berlin-Brandenburg region on the topic of climate and water.

and public awareness). The evaluation was based on a scale of 1 (irrelevant) to 4 (very relevant). Once all the answers to the questionnaire had been collected (S3), the most pertinent questions were selected based on a weighted mean of answers scaled within each category, providing a single relevance grade for each of the 48 questions (Supplement). The top two questions in each of the five categories were selected. The list of 10 questions was shared with the reference group for a final reflection and rephrasing of the propositions.

4 Results and discussion

The top ten questions selected based on the questionnaire responses were compiled into a list, presented in Table 1.

Half of the questions in Table 1 are related to climate hazards, particularly droughts. This is likely due to the dry conditions predominant in Brandenburg (DWD, 2022) and its susceptibility to drought and climate change-related hazards (Brill et al., 2024; Alencar and Paton, 2024; Alencar et al., 2024; Mahmoodi et al., 2024; Somogyvári et al., 2024). Additionally, the recent 2018–2019 and 2022 droughts in the BBR (Blauhut et al., 2022; Biella et al., 2024) were likely causes of higher perceived relevance of topics related to drought monitoring, management, mitigation, and adaptation present in the list (Q1, Q2, Q4, Q5, Q9). Among these questions, Q1 and Q9 are more general, addressing topics of extreme events and hydroclimatic extremes, including droughts, floods, windstorms, and heatwaves.

Issues related to changes in mining operations in the Lausitz are also perceived as highly relevant (Q3, Q7). The rapid change in the flow regime of the River Spree, driven by the end of mining operations and the artificial transfer of water resources into the system that provides drinking water to Berlin and the surrounding areas, is a significant threat to the city's capacity to meet its water needs in the coming years (Uhlmann et al., 2023). The foreseen decrease in water supply could intensify conflicts in the Berlin-Brandenburg relations (urban-rural). Understanding how climate change has affected these regions and its expected impact on water resources and the landscape in the coming years is also considered a pressing issue (Q8).

Focusing on nature-based solutions, Q6 indicates that the scientific community considers the design of solutions that integrate practice, community, and nature to be a relevant approach. Berlin fosters blue-green infrastructure (BGI) (SenUMVK, 2022; Warter et al., 2025) through solutions such as green roofs, green façades (Hoffmann et al., 2021), urban trees and grasslands (Kuhlemann et al., 2021; Tams et al., 2024; Kluge and Kirmaier, 2024), and rainwater harvesting (Paton et al., 2023). Integrating BGI into urban and rural landscapes to support sustainable water management is a significant challenge that has not yet been thoroughly explored (Warter et al., 2025). The interest in community participation and awareness is illustrated by the perceived relevance of more transdisciplinary and participatory methods such as co-creation (Q10).

We would like to note that although the scientific community participating in this assessment is highly diverse (e.g., multiple research fields, age, and career stages), the list presented in Table 1 is not a fully comprehensive summary of the topics currently in focus within the region. However, we can assess seemingly more popular or relevant issues by looking at the top-rated questions (for a complete list of the collected questions, please see the Supplement). We can also observe some biases due to local conditions (e.g., regional economic and political characteristics that influence the participants), temporal conditions (the BBR has experienced multiple drought years in the past decade, making droughts a more sensitive topic than floods, for example), as well as particular converging interests of the group being assessed.

Furthermore, considering the listed biases and the compiled list of questions, conflicts between research and policy agendas may emerge. Some examples include Q1, Q2, and Q4, which aim to balance the allocation of limited resources between agricultural and urban demands. Additionally, Q9 and Q10 take into account local knowledges and expectations, which might conflict with other groups and regions across the region.

Our results reveal that a significant focus is directed to anthropogenic and profitable landscapes, such as agriculture,

Table 1. List of most relevant scientific questions for the Berlin-Brandenburg region for the coming decade on the topic of Climate and Water. The values μ and σ are the mean and standard deviation of votes, respectively. Respondents could vote on questions from a scale from 1 to 4. Votes were normalised to the range [0, 1].

Category	Question	μ	σ
Category 1 – Climate adaptation and resilience	Q1 – How can ecosystems and agriculture adapt to hydroclimatic extremes expected in the future?	0.83	0.25
	Q2 – What changes in management and policy can make the Spree catchment more resilient to droughts?	0.76	0.27
Category 2 – Water management	Q3 – What are the possible scenarios for the Spree catchment and the city of Berlin after the mining phaseout in the Lausitz given accelerating climate change?	0.80	0.25
	Q4 – What management strategies can be adopted to cope with water scarcity periods in the Berlin-Brandenburg region?	0.78	0.26
Category 3 – Technological solutions and innovation	Q5 – How feasible is the implementation of a multi-sector impact-based drought monitoring and forecasting system?	0.58	0.30
	Q6 – To what extent can nature-based solutions be effectively implemented in Berlin (urban) and Brandenburg (rural) to increase resilience and community awareness of climate change and water?	0.72	0.33
Category 4 – Past, present, and future impacts	Q7 – What other regions have experienced such drastic changes in river flow and what were the long-term impacts? How can the Berlin-Brandenburg region benefit from this knowledge exchange?	0.68	0.28
	Q8 – How has climate change affected and will affect the multiple urban and rural water services in the Berlin-Brandenburg region?	0.71	0.31
Category 5 – Governance and public awareness	Q9 – How can individual and community perceptions of extreme events improve impact assessment and monitoring in the Berlin-Brandenburg region?	0.64	0.32
	Q10 – How can co-creation of water knowledge assist in integrating science, administration, and society to face climate change challenges?	0.59	0.35

forestry, and urban areas. These highly managed ecosystems and landscapes are more strongly disrupted by droughts, leading to cascading impacts (Cavalcante et al., 2025). Solutions to climate change are also perceived to depend on (i) technical and nature-based solutions, such as improved monitoring and forecasting of extreme events and re-engineering of urban and rural spaces to adapt to climate change; and (ii) policy and management adaptations with some level of community involvement.

The motivating question presented in step S1 focused on the next decade for coping with climate change in a limited geographical region. This narrow framework may be the cause for the lack of statements (step S1) and questions (step S2) that tackle more structural issues leading to climate change, such as economic, production, and societal arrangements (Cortinhas et al., 2024). In a next step, a broader audience (beyond the scientific community) and scope should be applied to assess potential cross-cutting research questions with such a structural change perspective.

Finally, individual contributions and the compiled list emerge from a context of abundant and growing interest in climate change impacts in the region. The Federal Ministry of Education and Research (BMBF; now BMFTR) has also recognised the need to adapt to the increased occurrence of extreme water events and is/was funding 12 joint projects in the "Water Extreme Events (WaX)" funding guideline. Some of these address the issues identified here as particularly relevant. For example, the Spreewasser:N project developed a drought forecasting system that provides irrigation recommendations for farmers. However, the quality of the recommendations depends on the reliability of the short-term and the seasonal weather forecast, the latter being associated with significant uncertainties (Q5). Spreewasser:N also developed a statistical forecast model for drinking water demand and identified maximum daily temperature as the most important climate variable (Q8), and evaluated the past impacts of climate change and lignite mining in the Spree catchment (Q2 – Koch et al., 2024). Project Inno_Maus dealt with the management of urban heavy rain risks, with a focus on real-time forecasting and risk mapping (Seleem et al., 2023). One work package investigated the potential for water retention through green infrastructure, intending to mitigate the effects of heavy rain (Q6). Therefore, not all questions from the compiled list in Table 1 are new or original, but often point to a still critical research topic for the coming years.

5 Concluding remarks

This work was based on the premise of identifying what is considered relevant to climate and water sciences in the BBR region over the next decade. This initiative has proven successful, having compiled a comprehensive list of ten timely and overarching questions that seek to tackle hydroclimatic extremes, resource management, adaptation, and integration between the academy and society. These questions could provide the foundation for framing future climate and water-related research and funding in the region, offering a comprehensive list of priorities for governments, funding agencies, and research institutes.

Drought has been a topic on the research agenda at BBR for a long time. Nevertheless, only a small fraction of the knowledge and recommendations produced by researchers have been put into practice, leaving many of the existing (and new) challenges unsolved. Past and current research in international and regional contexts has called for more integrated strategies for the sustainable use of water and water bodies at regional scales, considering the impacts of climate change, new technologies, socioeconomic change processes, land-use change, and extreme events. The survey results also revealed that the issues of extreme events and hydroclimatic extremes, including droughts, reduced discharge from the Lausitz in the post-mining era, and the need for nature-based solutions, are the most urgent and critical issues to be addressed. The survey also indicates that attention needs to be paid to anthropogenic changes, such as environmental pollution, degradation, and land-use change.

Our results emphasise the need for continued research to address the climate-water nexus, taking into account natural and human habitats and activities (biodiversity, agriculture, forestry, etc.) and involving many agents and stakeholders. The findings imply a shift in perspective regarding the structure of research and the emergence of new, more collaborative methods, including transdisciplinarity, the sharing of resources and information, social science protagonism, and community-led science, which involves local people in developing local solutions. The compiled list of ten questions is not exhaustive due to time constraints, under-representation of research areas, and sample size. Notwithstanding, it points in a positive and optimistic direction for collective action. We hope the list serves as the first step and motivation for similar initiatives to identify and address local and regional problems.

Data availability. Data can be made available upon request.

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