UNSEEN URGENCY? PROJECTIONS OF EXTREME SEA LEVEL EVENTS AND STAKEHOLDER PERCEPTION ON THE GERMAN NORTH SEA ISLANDS OF NORDERNEY AND BORKUM

Christiane Lawrenz, Gesa Witt, Amelie Bernzen and Boris Braun

With 5 figures, 2 tables and appendix
Received 4 March 2025 · Accepted 13 August 2025

Summary: Sea Level Rise (SLR) has been widely acknowledged as a long-term challenge that threatens large numbers of coastal areas. Yet, extreme sea-level rise (ESLR) often has an even more immediate impact on planning local coastal defense infrastructure. This is also the case for the German North Sea islands, including Norderney and Borkum. Existing studies often lack detailed localized projections and comprehensive assessments, creating a gap in precise impact estimation and stakeholder engagement. Understanding stakeholder perceptions of urgency is critical for informed decision-making. This article aims to address this gap by providing high-resolution ESLR projections and examining the perceptions and priorities of different stakeholder groups on these islands. A hybrid modeling approach, integrating physical and geostatistical components, was employed to project ESLR for the years 2050 and 2100 under various Representative Concentration Pathways. Furthermore, semi-structured interviews with stakeholders from tourism, politics, administration, and environmental management were conducted to capture the range of attitudes and concerns regarding ESLR and related adaptation measures. The results indicate a potential sea level rise of more than 2 meters for Norderney and Borkum by 2100. Yet, stakeholder interviews reveal a wide disparity in perceptions; environmental actors express high urgency, while others, particularly among those in the tourism sector, see ESLR as a more distant concern, leading to a reduced motivation for immediate action as other, more pressing short-term challenges are prioritized. Our findings highlight the need for policy strategies that integrate economic and environmental goals, ensuring effective adaptation measures that address both current and future challenges.

Keywords: Extreme sea level rise, coastal protection, hybrid modeling, risk perception, North Sea, islands

1 Introduction

Coastal risks rank among the most severe natural hazards and are expected to escalate, increasing pressure on coastal populations (Kopp et al. 2014, Vousdoukas et al. 2018). Since around 1900, global sea levels (GSL) have risen by approximately 20 cm (Hauer et al. 2020). Currently, sea levels are rising at a rate of 3 to 4 mm per year on a global average (Ablain et al. 2019, Vitousek et al. 2017). Sea level projections vary depending Representative Concentration Pathways (RCPs): under RCP 2.6, an increase of 0.35–0.56 m by 2100 is anticipated; RCP 4.5 estimates a rise of 0.45–0.67 m; RCP 6.0 predicts 0.46–0.71 m; and the most severe scenario, RCP 8.5, forecasts a rise of 0.65–0.97 m (Nauels et al. 2017). As might be expected, uncertainties in these projections increase with the severity of the scenario and over time (Burgess et al. 2023). However, even if greenhouse gas emissions are drastically reduced and global average temperatures stabilize, sea levels will continue to rise due to the inertia of the system. Deep-ocean warming and ice sheet melting will continue, resulting in sea levels remaining elevated relative to pre-industrial sea levels for thousands of years (Lee et al. 2023).

While SLR poses a significant long-term challenge, extreme sea-level rise (ESLR) is often of much more immediate relevance for planning local coastal defense infrastructure. The term extreme sea level (ESL) refers to the highest recorded sea levels during extreme weather events, such as storms, that affect coastal regions (Jevrejeva et al. 2023, Vousdoukas et al. 2017). These events result from a combination of factors, including mean sea level (MSL), tides, and climate-induced increases in wave energy (Vitousek et al. 2017, Vousdoukas et al. 2017).

ESL events can drastically exceed mean water levels. They can lead to significant morphological changes, coastal erosion, defense failures, and subsequent flooding (Boettle et al. 2016, Kopp et al. 2014, Vousdoukas et al. 2017). Moreover, they pose serious risks to infrastructure and, in extreme cases, to the loss of human lives, making them a critical environmental threat to many low-lying coastal regions (Ganske et al. 2018). For risk assessment and coastal

https://doi.org/10.3112/erdkunde.2025.03.05 ISSN 2702-5985 (Online)

defense planning, understanding extreme events and their development is crucial, as coastal defenses are typically designed to withstand ESL events of specific intensities tied to their frequency of occurrence or return periods (Ganske et al. 2018, Kopp et al. 2014, Vousdoukas et al. 2018).

Rising sea levels elevate the baseline for ESL, and with extreme weather events becoming more frequent and intense, both the occurrence and magnitude of ESL events are projected to increase (Boettle et al. 2016, Boumis et al. 2023, Ganske et al. 2018, Jevrejeva et al. 2023, Paulik et al. 2020, Vitousek et al. 2017). Along European coastlines, present-day 100-year events are projected to occur as frequently as every 1 to 10 years by the year 2100. At the regional level, the intensity of extreme events is also likely to rise. For instance, in Northern Europe, the height of extreme events under RCP 8.5 could increase by nearly 20 cm (Vousdoukas et al. 2018). Furthermore, high tide water levels are expected to increase over time and under higher RCP scenarios (Vousdoukas et al. 2018). Coastal risks, already among the most severe natural hazards, are expected to escalate significantly, placing immense pressure on coastal populations, settlements, and infrastructure. Without additional measures, the current coastal defense infrastructure will likely become largely inadequate.

Nonetheless, projections of sea-level rise often assume that factors contributing to ESL – such as tides, waves, and storm surges – remain roughly constant over time (Vousdoukas et al. 2018, Wahl et al. 2017). This assumption fails to account for the complex interactions between these elements and their potential variations due to climate change, which could lead to an underestimation of future ESL risks (Vousdoukas et al. 2017). This is problematic, as extreme events pose the greatest risk to coastal areas, with the potential for significant economic damage and loss of life (Jevrejeva et al. 2023, Lam-González et al. 2021, Morss et al. 2024, Pycroft et al. 2016). In any case, the protection infrastructure must be designed to withstand all conceivable extreme events.

The necessary and efficient adaptation of the infrastructure requires the willingness of local and regional actors, and in particular their adequate perception of future challenges. The prevention of hazards has to be high enough up on their list of preferences to enable adequate action to be taken. This applies equally to larger-scale technical and structural protection measures, such as raising dikes, and spatial development and infrastructure planning by the government, as well as to small-scale individual adaptation strategies. Preference systems and the insight into necessary action strategies also depend on the potentially affected economic values, the specific local or regional economic base, or other important problem constellations in a particular region or locality.

When dealing with sea-level rise and associated extreme events, a short-term feeling of (still) relative security can arise, or the issue can be overshadowed by more pressing challenges, so that the urgency to act is not sufficiently perceived (Hornsey & Fielding 2020). Moreover, positive illusions, cognitive dissonance, in-group/out-group biases, and other psychological biases can restrict unbiased and rational assessment of future challenges (Johnson & Levin 2009). This study, therefore, aims to link the localized modeling of local ESLR with the perceptions and assessments of local actors. To this end, we have empirically selected two East Frisian islands in the Wadden Sea in the northwest of Germany – Norderney and Borkum – that may be severely affected by an increase in extreme sea levels in the coming decades. Both islands are strongly shaped by tourism in terms of economy and settlement patterns but differ markedly in form: Borkum's artificial land connection sets it apart from the barrier island shape of Norderney and the other East Frisian Islands, enabling a comparison of ESL impacts under slightly different morphological but comparable socio-economic conditions. The strong focus on tourism – according to our thesis – leads to a situation in which, despite the considerable pressure of rising sea levels, the shorter-term interests of tourism development could have a significant impact on perception and the willingness to act.

Against this background, our study has two main objectives: Firstly, we present ESLR projections for Norderney and Borkum, which significantly improve existing larger-scale projections for 2050 and 2100. To achieve this, our projections are carried out at a higher resolution of 1 m x 1 m. Moreover, the results of site inspections and ground checks are incorporated into the projections to include small and mobile protective infrastructure. Secondly, the problem perception, willingness to act, and prioritization of action by various local and regional stakeholders are examined based on semi-structured interviews.

The following sections of this paper are organized as follows: In section 2, we briefly discuss the state of previous projections of sea level rise for the East Frisian coast and their limitations, before moving on to the existing research on the perception of the processes and the barriers for the willingness to act in section 3. Section 4 presents our methods of investigation and data sources, Section 5 presents

our results, first our ESLR projections for 2050 and 2100 (5.1), then our findings from the stakeholder interviews (5.2). The paper concludes in Section 6 with a summarizing discussion of our empirical findings.

2 Modeling ESLR on the German North Sea coast and its limitations

Accurate and spatially explicit projections of ESLR are essential for effective coastal defense infrastructure planning (Boettle et al. 2016, Vitoussek et al. 2017). Various modeling approaches are used to project ESLR, each with strengths and limitations. The existing ESLR projections are typically developed on a global or continental level (e.g., Boumis et al. 2023, Pycroft et al. 2016, Vousdoukas et al. 2018, Walsh et al. 2012). The components contributing to ESLR, and consequently its impacts, vary considerably by region, with parts of Europe, the North American east coast, the West African coast, parts of Southeast Asia, and South Asia being particularly vulnerable (Pycroft et al. 2016). Furthermore, global or continental projections often lack the precision needed to assess the consequences for specific coastal regions, such as the German North Sea coast, and to inform tailored mitigation measures. While there are already comprehensive studies on SLR and current ESL for the coasts of Germany (see e.g. Hafencity Universität Hamburg 2020, Niedersächsisches Ministerium für Umwelt, Energie und Klimaschutz 2020), research specifically addressing ESLR in the particularly vulnerable East Frisian islands region remains rather limited. At the European level, however, the LISCOAST project provided critical analyses and projections of extreme sea levels (European Commission 2018), constituting the foundation for the model applied in this study.

Overall, since the early 2000s, three major projects have assessed ESL along the German North Sea coast: the MUSE project (*Modellgestützte Untersuchungen zu Sturmfluten mit sehr geringen Eintrittswahrscheinlichkeiten*/ Model-based Investigations of Storm Surges with Very Low Probabilities of Occurrence; Jensen et al. 2006, Rudolph et al. 2019), the XtremRisK project (*Extremsturmfluten an offenen Küsten und* Ästuargebieten/ Extreme Storm Surges on Open Coasts and Estuary Areas; Rudolph 2012), and the EXTREME-NESS project (*Extreme North Sea Storm Surges and Their Consequences*; HZG et al. 2019, Rudolph et al. 2019). These projections of potential extreme events offer valuable insights into rare maximum scenarios, which are critical for coastal defense planning. However, these predictions are limited to individual gauge stations and therefore do not offer a comprehensive view of the broader regional impacts, such as the extent of affected land in a region. Moreover, existing models of the North Sea coast and the East Frisian Islands have a relatively low spatial resolution and are mainly designed to address larger sections of the coastline. This makes them prone to errors when applied to smaller areas, such as specific East Frisian Islands. The integration of statistical extreme value analyses with highly data-intensive physical models also makes adapting these findings to other regions challenging and resource-intensive. To address these limitations, this study uses a hybrid modeling approach, combining physical, statistical, and geostatistical components, to enable more precise, small-scale predictions and impact assessments. Our model approach has the advantage that the necessary data is relatively easy to obtain, and the calculations do not require excessive resources, even with high spatial resolution. This makes it relatively easy to replicate for different time horizons and/or study areas.

3 Perception and valuation of ESLR risks

An understanding of local perceptions of change, of adaptation to this change, and of existing conflicts is key to gaining deeper knowledge on how local communities adapt or do not adapt to climate change (Klöck 2019). Reasons for maladaptation are, for example, psychological distancing in terms of space, such as perceptions of distant climate change impacts as more serious than local ones (Spence & Pidgeon 2010), or temporal aspects, such as the perception of SLR still being distant in time (Shao et al. 2020). While an increase in the awareness of causes for climate change is often seen as a prerequisite for enhancing public support to adaptation policies, a higher awareness does not necessarily lead to higher risk perceptions due to a process of 'risk normalization', wherein "individuals more exposed and aware of hazards minimize their risk perception to psychologically cope with hazards" (Luis 2018: 1). Yet, this effect is moderated by the individuals´ environmental concern (Luis 2018). Although risk perception is widely regarded as essential for motivating preparedness, experiencing natural hazards and perceiving high risk do not necessarily result in greater preparedness (Cisternas et al. 2024). Yet, identified priorities, needs, and values may vary within a community and in comparison to assessments from external actors (Klöck 2019). Also, understanding

the social construction of individually perceived risk through shared ideas and representations proves to be essential in the case of risk perception (Bertoldo et al. 2021). Three strategies of optimistic argumentation when describing vulnerability to coastal risks by local inhabitants have been identified: social comparison (other geographical locations are seen as more vulnerable), risk comparison (other risks being more pressing) and so-called fatalism (the problem is perceived as too challenging to solve on an individual or local level; Bertoldo et al. 2021). A better understanding of factors and motivations influencing how individuals perceive threats and deal with risks is seen as one key for policymakers in order to generate effective responses in cooperation with the community (Parreira & Mouro 2023). Studies on anticipatory coastal adaptation suggest that expanding an individual framing by applying, e.g., an intergenerational justice narrative might be a useful way for policy-makers to enhance sensitization for a collective preparation of transition plans regarding future coastal change (Cotton et al. 2024).

Regarding the Wadden Sea region, a reaction to emerging challenges such as conflicting uses and an expected increasing vulnerability to environmental and societal risks makes a shift away from the prevalent technical risk management paradigm towards an understanding of risk management as a social process necessary (Gerkensmeier et al. 2018). For the North Frisian part of the Wadden Sea islands, controversies regarding climate adaptation have been identified in terms of human-environment-relations (e.g. sometimes diverging aims of protecting natural versus cultural habitats), the role of different actors and knowledge types (e.g. regarding local knowledge versus 'expert' knowledge from the mainland) and the objectives of adaptation measures (e.g. regarding questions of the social desirability of technical feasible adaptation options; Klöck 2019). Similar controversies and discussions exist on the East Frisian islands, which are elaborated on in this article.

4 Study areas, data, and methodology

4.1 Study site selection: Borkum and Norderney

Norderney and Borkum were selected for this study for multiple reasons. The East Frisian Islands form a highly dynamic and complex system, influenced by strong tides and their predominantly sandy composition. Consequently, they are significantly impacted by tidal forces, currents, and related processes of sand erosion and sediment transport. Before the existing coastal defense infrastructure was introduced, sediment transport caused the islands to gradually shift eastward (ErdmannN et al. 1995, Niedersächsischer Landesbetrieb für Wasserwirtschaft, Küsten- und Naturschutz 2010). As a result, the necessity of coastal protection measures is well recognized by local inhabitants. Additionally, the East Frisian Islands act as natural barriers, shielding the main coastline from wind and waves, which predominantly come from a northerly and northwesterly direction (Kerber 2018).

In terms of size, population, and tourism, Borkum and Norderney are the most important among the German East Frisian Islands. Borkum, the westernmost of the German Frisian islands, is also the largest at 35.9 km², while Norderney, covering 26.2 km², has the highest population, with approximately 5,900 permanent residents (Landesamt für Statistik Niedersachsen 2024, Wasserstrassen- und Schifffahrtsverwaltung des Bundes 2013).

Since 1986, the Wadden Sea along the North Sea coast of Lower Saxony has been designated as a national park. Covering approximately 3,450 square kilometers, it ranks as the second-largest national park in Germany. It is recognized as a UNESCO biosphere reserve and is included in the UNESCO Wadden Sea World Heritage Site. These different designations influence how the relationship between nature and society, including land use developments and conflicting interests on the islands of Borkum and Norderney, is negotiated between different stakeholder groups (Nationalpark Wattenmeer 2023).

4.2 ESLR modeling

To assess how Norderney and Borkum could be affected by ESLR in the future, a multi-layered modeling approach was applied for the RCP 4.5 and RCP 8.5 scenarios through 2050 and 2100. This was a two-step process: First, the ESLR was modeled for two gauge stations on each of the islands, Norderney and Borkum, based on a hybrid model. Second, these results were used in a geostatistical model and spatially extrapolated across the islands of Norderney and Borkum.

In the first modeling step, the LISCOAST projections by Vousdoukas et al. (2018) were used as a database. These projections used hourly data from about 5000 gauge stations along the European coast and the Mediterranean coast of Africa to estimate future MSL and ESLR (European Commission

2018, Vousdoukas et al. 2018). This was done with a Monte Carlo simulation to estimate the different likelihoods of ESL events of varying severity for the scenarios RCP 4.5 and RCP 8.5, assuming a normal distribution of the variables, as is common in climate projections (see also Vousdoukas et al. 2018). With the Monte Carlo simulation, three levels of occurrence probability for an ESL event were calculated: the fifth percentile, the 50th percentile, and the 95th percentile. The fifth percentile represents the least severe outcome, with only a 5% chance that future ESLR will be smaller or equal to this value. The 50th percentile reflects a moderate severity, with a 50% chance that future ESL will be smaller or equal to this level, making it the most likely scenario. The 95th percentile predicts the most severe ESLR, but there is a 95% chance that the actual future ESL will be smaller than or equal to this value. Therefore, the 50th percentile is considered the most probable scenario (IBM n.d., Vousdoukas et al. 2018).

Since the projections are based on data from gauge stations, the results are limited to individual coastal points, leaving the impact of ESLR on specific land areas unclear. To address this limitation, the second step of the modeling process involves spatially extrapolating the point data to estimate impacts on broader regions. This spatial extrapolation, which is the primary focus of this study, follows the methodology outlined by Martellozzo et al. (2024a), who applied it to all European coastlines (excluding Scandinavia) and the Mediterranean coast of Africa at a 30m x 30m resolution. Similar geostatistical approaches have been widely used in coastal and environmental studies (e.g., Anderson et al. 2018, Martellozzo et al. 2024b, Wu et al. 2014), which demonstrates the robustness of this method in handling large-scale spatial datasets. This stage of the model uses geostatistical techniques, specifically the Thiessen polygon interpolation. Thiessen polygons are geometrical constructs that define areas of influence around each sample point, ensuring that any location within a polygon is closer to its corresponding sample point than to others (ESRI, n.d.). This approach is effective for converting point data into spatial data, enabling more comprehensive analyses, such as assessing the effects of rising ESL on entire coastal regions rather than isolated measurement points. While this approach is comparatively simple and results in a rather coarse spatial representation, it has the advantage of being transparent, reproducible, and free from additional assumptions that more sophisticated interpolation techniques (e.g., kriging) would require. For the large-scale coastal application of this study, these characteristics are particularly valuable, as they ensure that uncertainties stem primarily from the input data rather than from the interpolation procedure itself.

The resulting Thiessen polygons now show the effect of ESL events on coastline sections instead of just gauge stations. To determine the affected land area, the polygons must be combined with data on the coastal geomorphology. For this, a Digital Elevation Model (DEM) for Norderney and Borkum with a 1 m x 1 m resolution, provided by the Federal Waterways and Shipping Administration, was used (Wasserstrassen- und Schifffahrtsverwaltung des Bundes 2013). The high resolution of the DEM ensures that coastal defense infrastructure, which is very important for the estimation of the expected flooding during an ESL event, shows up in the projections. To ascertain that all important defense infrastructure was considered in the model, additional field studies were conducted on the two islands. For Norderney, all coastal defense infrastructure showed up in the DEM. For Borkum, however, a mobile floodgate was found during the field study, which was not included in the DEM data. The floodgate was added manually in the DEM data. As Figure 1 shows, this led to a significant difference in the projections of the flooded area for Borkum depending on whether the floodgate is included in the model or not. Additionally, the General Plan for Coastal Defense (Niedersächsischer Landesbetrieb für Wasserwirtschaft, Küsten- und Naturschutz 2010) was referenced to identify planned improvements to protective structures. While no further elevation of the defenses is planned for Borkum, an elevation of the dikes on the southern side of Norderney is scheduled. Given that these adjustments are expected to be completed by 2050, the affected areas were updated in the DEM to reflect the planned changes in height.

The adjusted DEMs and the Thiessen polygons were then combined to identify areas affected by ESL events. This calculation results in a raster with values of 0 and 1, where 1 represents flooded areas, and 0 represents non-flooded areas. Consequently, the raster does not say anything about the flood height. Furthermore, in this step, any area with a DEM value below the ESL for the respective scenario was considered flooded, even if there was no way for the water to reach this area. To improve accuracy, pixels without a possible hydrological connection to the coast were subsequently excluded, resulting in the final set of projections.

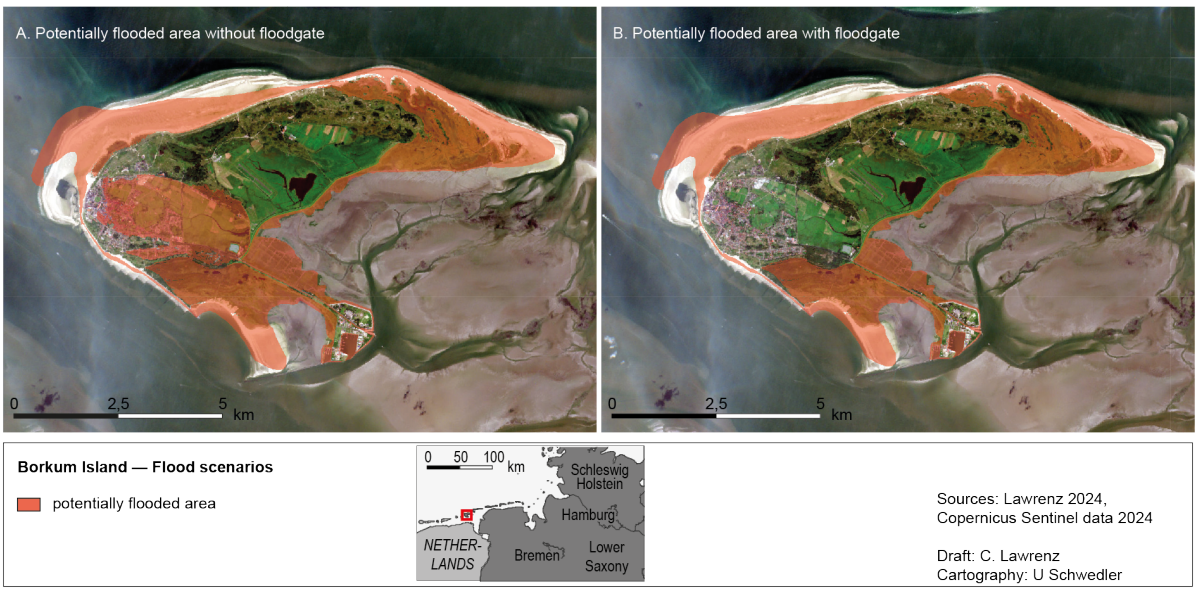

Fig. 1: Potentially flooded area on Borkum with and without consideration of a floodgate

In total, this modeling process was done five times for each island: the baseline scenario for the year 2015 and projections for RCP 4.5 and RCP 8.5 for the years 2050 and 2100. For each scenario, the three different occurrence probabilities were modeled, resulting in 15 different projections overall.

Although the model includes various physical components, it does not account for future changes in North Sea currents and sediment transport. This affects the maintenance of protective dunes and beaches. Without countermeasures, this could even lead to the island's relocation. These complex processes, however, lie beyond the study's scope.

Here, this dynamic process is treated as static, with the protective dunes representing a snapshot. However, since they are crucial for storm surge defense, they are regularly maintained through sand replenishment, planting, and other stabilizing measures. As this practice is expected to continue, the snapshot remains valid for future scenarios – unless extreme storm surges compromise the dunes, rendering the model ineffective and possibly leading to the island's abandonment. Whether this occurs cannot be determined without integrating current and sediment modeling.

4.3 Qualitative interviews

In relation to KLÖCK (2019), we understand risk management as a social process with impacts on different knowledge types and adaptation objectives for different actor groups. To gain further insights into the perception of ESLR, existing conflict lines, and perceived problems in these contexts among different actor groups, 28 semi-structured qualitative interviews (cf. Tab. 1) were analyzed. The data were collected in two rounds. The first set of interviews consisted of 19 expert interviews on land use conflicts in the context of tourism, climate adaptation, and governance aspects conducted between March 2023 and June 2024 (online and in person). Interviewees included stakeholders from the island of Borkum (8 interviews), the island of Norderney (7 interviews), and representatives from the mainland who provided a superordinate view, either knowledgeable of both islands or from the district level (4 interviews). In particular, seven respondents came from the political and administrative sphere (local and regional level), seven from the tourism sector (both services and administration, and marketing), and five from environmental organizations (national park administration, coastal protection, environmental education, etc.). To assess the consequences of ESLR for the livelihood and economic situation on the islands, in the second set of interviews, consisting of nine interviews with tourism actors, the sea level rise projections for the most probable scenario (50th percentile) were shown and explained to the respondents at the beginning of the interviews. This was done to assess whether the ESLR projections change the perception of SLR and ESLR - presumably negatively - and to see how the increase in extreme events

Tab. 1: List of interviews

Interview code	Date	Place	Main stakeholder area
Borkum - Interviews without projection shown			
Interview 1	21.03.2023	Borkum	Politics & administration
Interview 2	21.03.2023	Borkum	Politics & administration
Interview 3	22.03.2023	Borkum	Environment
Interview 4	22.03.2023	Borkum	Touristic services
Interview 5	23.03.2023	Borkum	Tourism administration & marketing
Interview 6	23.03.2023	Borkum	Tourism administration & marketing
Interview 7	23.03.2023	Borkum	Touristic services
Interview 8	30.03.2023	online	Politics & administration
Norderney - Interviews without projection shown			
Interview 9	09.10.2023	Norderney	Politics & administration
Interview 10	10.10.2023	Norderney	Environment
Interview 11	10.10.2023	Norderney	Touristic services
Interview 12	10.10.2023	Norderney	Tourism administration & marketing
Interview 13	11.10.2023	Norderney	Politics & administration
Interview 14	11.10.2023	Norderney	Touristic services
Interview 15	02.11.2023	online	Environment
Regional level - Interviews without projection shown			
Interview 16	01.06.2023	online	Environment
Interview 17	29.02.2024	online	Environment
Interview 18	01.03.2024	online	District level Aurich (Norderney)
Interview 19	10.05.2024	online	District level Leer (Borkum)
Borkum – Interviews with projections shown			
Interview pro_1	04.06.2024	online	Tourism administration & marketing
Interview pro_2	20.06.2024	online	Environment & Tourism services
Interview pro_3	23.07.2024	online	Touristic services
Interview pro_4	14.08.2024	online	Touristic services
Interview pro_5	22.08.2024	online	Politics & administration
Interview pro_6	03.09.2024	online	Touristic services
Interview pro_7	11.09.2024	online	Touristic services
Regional level – Interviews with projection shown			
Interview pro_8	22.05.2024	online	Tourism management
Interview pro_9	05.09.2024	online	Tourism management

could affect tourism. Furthermore, the projections helped to make ESLR a less abstract topic. The second set of interviews was conducted between June and September 2024. Respondents for both sets of interviews were selected through purposeful sampling, identifying key stakeholders from different sectors through desk research and stakeholder mapping. Since not all of the potential interviewees responded to the authors, a potential response bias might exist. This was addressed in the research process through snowballing and recommendations of further respondents by interviewees, after building trust in the research team. One respondent of the first set of interviews also took part in the second set. All respondents were informed about data protection and guidelines regarding good scientific

practice and gave their written consent to be part of the study. Most interviews lasted around an hour and were recorded and later transcribed using F4X and analyzed with MaxQDA.

Qualitative content analysis of all interviews was conducted according to the framework of KUCKARTZ and RÄDIKER (2023). In general, the first set of interviews covered a relatively broad range of topics, including positive and negative aspects of island life, governance issues such as transparency, planned and already implemented measures, decision-making processes, level of participation, as well as tourism-related issues such as tourism acceptance or past, present, and future tourist development. A further important topic was climate change adaptation, including the general perception of the issue, perceived present and future impacts of climate change, the personal assessment of measures, and questions of responsibility for their implementation. Additionally, conflicts of use (mainly concerning the limited availability of space on the islands) and positive interactions between the described thematic fields were identified. Within this frame, the specific text passages dealing with SLR and coastal protection were identified and analyzed in the specific context of risk perception and valuation of the issue in comparison to other mentioned problems and challenges, both within the context of climate change adaptation and a broader problem definition taking into account other negative aspects listed by the interviewees. Topics regarding SLR concern, e.g., the perception of urgency, the evaluation of past and present measures, and questions regarding who bears responsibility to act. The second set of interviews specifically focused on the perception of SLR and ESLR and their importance for the tourism industry. The coding scheme for the qualitative content analysis is summarized in Appendix A. Anchor examples for tendencies of risk perceptions among different actor groups are shown in Appendix B.

5 Results

5.1 ESLR projections for Borkum and Norderney

Table 2 shows the projected heights of ESL events. Due to the use of Thiessen polygons, there are slight variations in the maximum water levels between the northern and southern sides of Borkum, as well as between the western and eastern sides of Norderney. However, these differences are minimal. The slightly higher values on Borkum's northern side and Norderney's western side reflect the actual flow conditions. When compared to historical records, the measured level for Norderney is 4.09 m, which is slightly lower than the projected maximum water lev-

Tab. 2: ESL height for each scenario

		Borkum		Norderney	
Scenario	**Percentile**	**North**	**South**	**West**	**East**
Baseline	**5th**	4.02 m	4.02 m	4.21 m	4.21 m
	50th	4.20 m	4.20 m	4.41 m	4.41 m
	95th	4.51 m	4.51 m	4.75 m	4.41 m
RCP4.5 2050	**5th**	4.33 m	4.32 m	4.55 m	4.55 m
	50th	4.69 m	4.69 m	4.86 m	4.86 m
	95th	5.10 m	5.10 m	5.37 m	5.37 m
RCP4.5 2100	**5th**	4.64 m	4.64 m	4.90 m	4.90 m
	50th	4.95 m	4.95 m	5.24 m	5.24 m
	95th	5.49 m	5.49 m	5.83 m	5.82 m
RCP8.5 2050	**5th**	4.32 m	4.32 m	4.52 m	4.52 m
	50th	4.57 m	4.57 m	4.79 m	4.79 m
	95th	5.00 m	5.00m	5.24 m	5.24 m
RCP8.5 2100	**5th**	4.87 m	4.87 m	5.19 m	5.17 m
	50th	5.25 m	5.25 m	5.52 m	5.52 m
	95th	6.38 m	6.39 m	6.68 m	6.66 m

el of 4.208 m for the current 5th-percentile extreme event. For Borkum, the highest recorded water level of 3.86 m is also below the projected maximum of 4.02 m for the fifth percentile. By 2100, under an RCP 8.5 scenario, the maximum projected water levels are 6.391 m for Borkum and 6.681 m for Norderney. In total, the ESL is expected to increase by at least 84 cm on Borkum and 92 cm on Norderney, and could rise by as much as 2.36 m on Borkum and 2.47 m on Norderney by 2100. Consequently, the current dike height of SL + 6 m on the islands' eastern sides may no longer provide sufficient protection by 2100.

In the baseline scenario for Borkum, even during a 95th percentile ESL event, the developed areas of the island are fully protected by the coastal infrastructure in the southern part of the island. Minor variations in the affected areas can be seen around the harbor and at the edges of the protective dunes across all three probability levels. 16.04 km² (44.7%) are affected in a fifth percentile event, 16.42 km² (45.8%) in a 50th percentile event, and 16.93 km² (47.2%) in a 95th percentile event (see Fig. 2).

Looking at future projections for Borkum, the current coastal defenses appear to offer sufficient protection for the time being. In the RCP 4.5 scenario up to 2050, the island remains secure during both the 5th and 50th percentile events. However, in a 95th percentile event, the southern infrastructure would prove inadequate, resulting in flooding of the developed areas. Notably, the RCP 4.5 projection for 2050 seems to contradict other projections, as it predicts higher water levels than the RCP 8.5 scenario for the same year. Although sea level rise is generally higher under RCP8.5, projections for extreme sea levels around 2050 may locally appear higher under RCP4.5. This is due to the nonlinear nature of extreme sea level events, which depend not only on mean sea level but also on short-term factors like storm surges and waves. These components introduce statistical variability, meaning small differences in conditions can lead to disproportionately large shifts in projected extremes. By 2100, in the RCP 4.5 scenario, the coastal defense infrastructure would still be sufficient for events up to the 50th percentile. However, during a 95th percentile event, the defenses would no longer provide adequate protection, and 31.30 km² (87.2%) of the island would be flooded (see Fig. 2). The remaining areas without flooding would mostly consist of the protective dunes above the flood level, though these dunes would also be susceptible to overwash, affecting the freshwater lenses. The projected dike height of at least 6.2 meters would still be sufficient against an ESL event of 5.49 meters. The main vulnerability would be the southern dunes, which could become weak points.

In the RCP 8.5 scenario up to 2050, Borkum's settlements and infrastructure remain well protected in all ESL events considered. However, by 2100, the

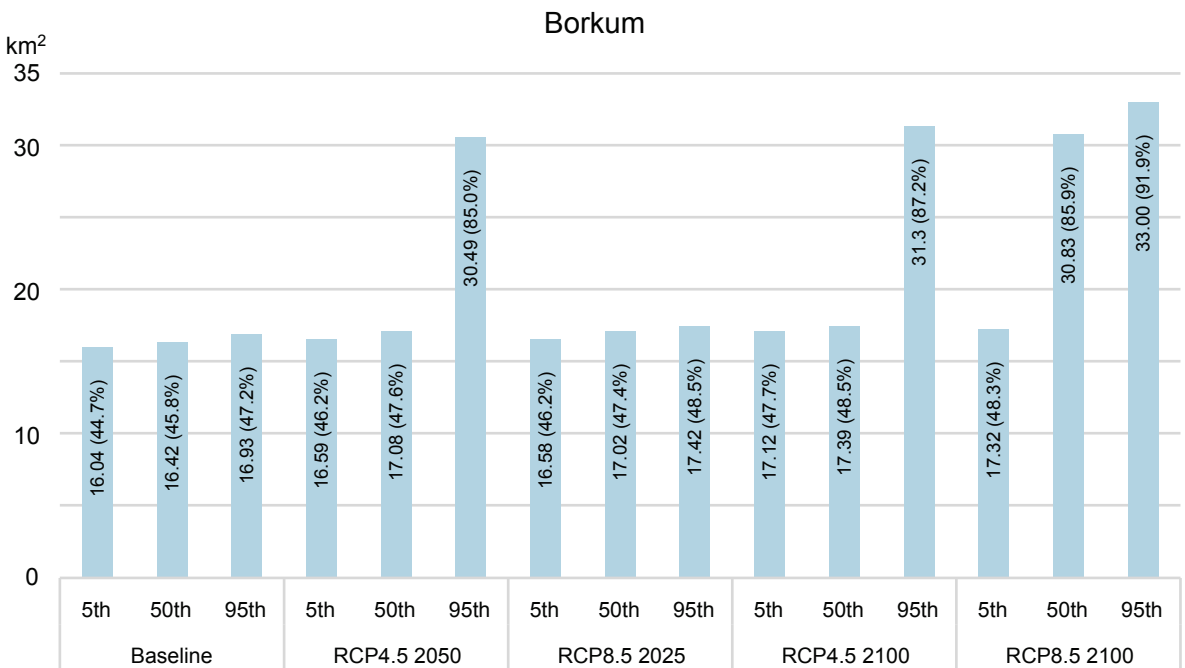

Fig. 2: Flooded area for different RCP scenarios – Borkum

island would no longer be adequately protected, even during a 50th percentile event. In the case of a 95th percentile ESL event, between 30.83 km² (85.9%) and 33 km² (91.9%) of the island would be flooded (see Fig. 3). The freshwater lenses would again be impacted by overwash in both cases. To protect Borkum in these future scenarios, reinforcement of the southern dunes would be necessary, and the dikes would need to be raised to withstand an ESL event possibly reaching 6.39 meters in the RCP 8.5 scenario. It is also important to note that the frequency of ESL events is expected to increase dramatically, with events potentially occurring annually by 2100. In these scenarios, the effectiveness of the protective dunes could be compromised due to erosion from repeated overwash. While dunes can be replenished, the available time to do so will decrease. In the later scenarios, consideration should be given to whether the islands can be better protected with harder protection measures like a ring dike, and whether the livelihood can still be secured on these islands.

In the baseline scenario for Norderney, where the existing dikes on the southern side of the island are considered, these structures effectively protect the settlement areas. For all three probability percentiles, the affected area ranges from 12.37 km² to 12.66 km². However, by 2050, this level of protection will no longer be sufficient except for a 50th-percentile ESL event. In both the RCP 4.5 and RCP 8.5 scenarios, large portions of the settlement area in the southwest will be flooded during a 50th-percentile ESL event, with 15.84 km² (60.4%) flooded in the RCP 4.5 scenario and 15.8 km² (60.2%) in the RCP 8.5 scenario (see Fig. 4). By 2050, ESL events would also start to affect Norderney's freshwater supply. In the case of a 95th-percentile ESL event, 22.02 km² (83.9%) would be flooded in the RCP 4.5 scenario, and 21.88 km² (83.4%) in the RCP 8.5 scenario. Apart from large portions of the protective dunes, almost the entire island would be submerged. The problem is not that the dikes, with a minimum height of 5.75 meters, are too low – since the ESL events would only reach about 5 meters (see Tab. 2) – but rather that the southern protective dunes appear to be the weak points (see Fig. 5).

By 2100, in both the RCP 4.5 and RCP 8.5 scenarios, the coastal infrastructure will still provide adequate protection for a 5th-percentile ESL event. However, during a 50th-percentile ESL event – the most likely scenario – 21.88 km² (83.4%) of Norderney would be flooded in the RCP 4.5 scenario, and 22.17 km² (84.5%) in the RCP 8.5 scenario. The flooded area would increase only slightly during a 95th-percentile

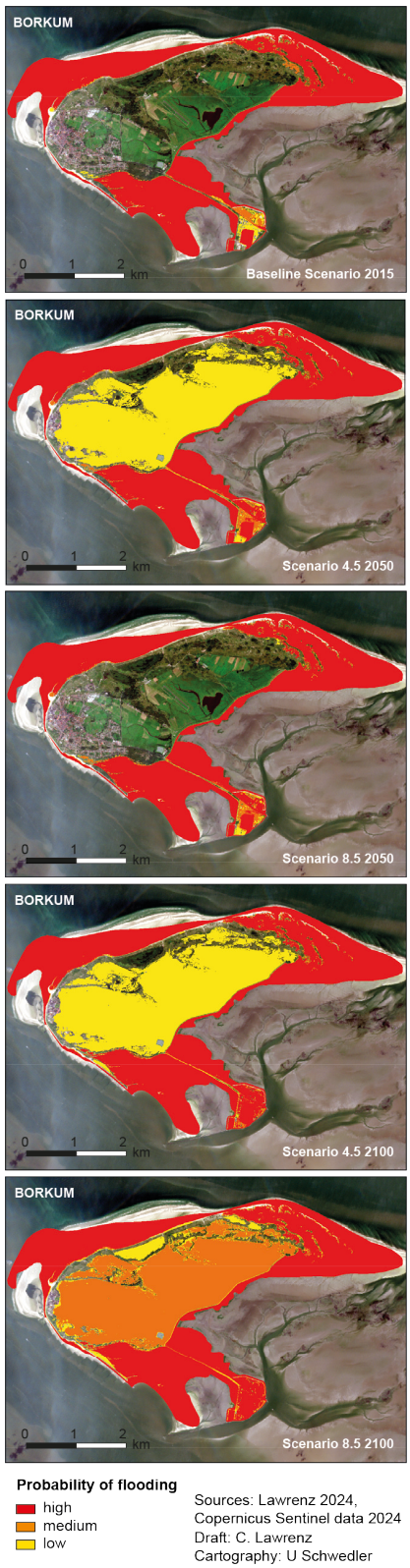

Fig. 3: Borkum - Flooded areas according to different RCP scenarios

event (see Fig. 5). To fully protect Norderney in these scenarios by 2100, the dikes would need to be raised to at least 5.9 meters in the RCP 4.5 scenario and to at least 6.7 meters in the RCP 8.5 scenario, as the current lowest dike height is 5.75 meters. Additionally, the protective dunes would need reinforcement or replacement with a sufficiently high dike.

5.2 Results of stakeholder interviews

This section will first present results from the interviews with local stakeholders on both islands, pointing to differences and similarities within and between actor groups and islands. These results are then complemented by findings from our interviews with representatives on the regional (district and state) level.

5.2.1 Borkum and Norderney

One of the stakeholder groups interviewed on Borkum was people working in the environmental sphere. These actors stress the need to create good harmony between nature, tourism, and the local population. Climate adaptation is regarded as highly necessary despite the fact that resources for funding might be limited. The islands are considered to be the first who be affected by climate change due to rising sea levels in Germany. Consequently, respondents see the need for a rising awareness that things cannot continue in the way they used to be. At the same time, the awareness of already implemented coastal protection measures is high among this actor group. They are also very clear on the question of who is responsible for funding respective measures, since the small island communities are not seen as capable of carrying protection costs alone. In this context, the importance of the East Frisian islands as a coastal defense bulwark for the mainland, as well as the responsibility of the state and federal levels to contribute to its maintenance, are emphasized. On Norderney, this view is complemented by environment-related interviewees who draw a larger picture around the need to give up the privileges of a society profiting from a rather consumerist culture to avoid collapse. Yet they are rather pessimistic that these changes will happen voluntarily and at a time when worse consequences can still be prevented.

For the actors from the political and administrative sphere on Borkum, the issue of SLR is framed as leading to insecurity and fear on the one hand, and something not yet readily perceptible and an issue

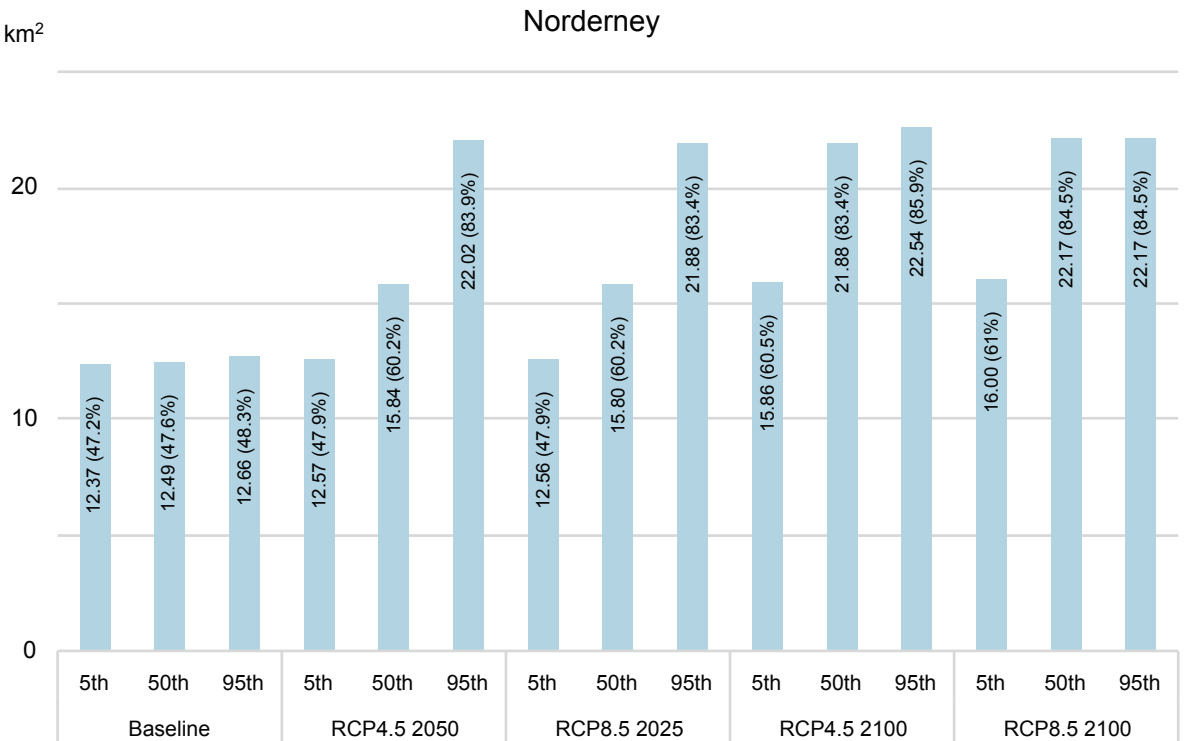

Fig. 4: Flooded area for different RCP scenarios – Norderney

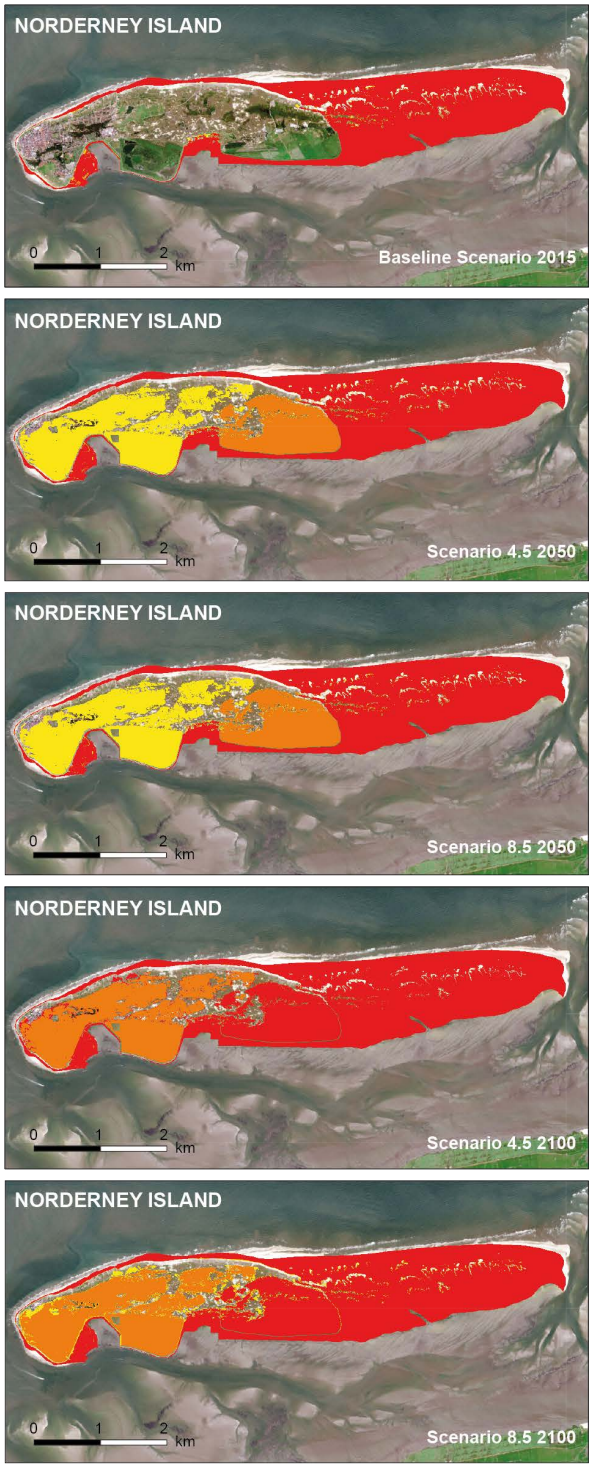

Fig. 5: Norderney - Flooded areas according to different RCP scenarios

that is momentarily far away from the islanders' daily realities on the other hand:

> "So, of course it will become an issue at some point. But as I said, so far I think other issues are more important to us than climate change." (Interview 2, translated by authors from German original)

On Norderney, the building plans for the beaches developed by the municipality in cooperation with the district and the coastal protection authority to mitigate conflicts between recreational use, coastal, and environmental protection are mostly seen in a positive light. Yet, similar to Borkum, questions regarding financial issues evolve. Usually, there is a strict distinction between measures needed for coastal protection and those merely securing attractiveness to tourists.

This view is rather similar among the actors in the local tourism sector, who display a diverse range of urgency perceptions. On the island of Borkum, especially, a possible intrusion of salt water into the sweet water lens, an increase of storm surges, and necessary changes of the infrastructure stabilizing the island against the consequences of SLR are major concerns. One interviewee from the tourism sector stated:

> "When you replace a protective dune with a concrete wall, like we´ve done on the west side of the island, it may secure the area, but it risks making the island less appealing to visitors. People come here expecting to experience nature, not to be faced with concrete structures. This concern is something that really matters to me. Honestly, I can´t imagine how life here will continue as it is now by the year 2100. I just don´t see how it could work." (Interview 5, translated by authors from German original)

For other actors in the tourism industry, the problem of SLR is important, yet based on their opinion, it is hard to fully assess the situation and notice ongoing changes in the natural system. Hence, they see the necessity to trust in institutions and people dealing with the issue of SLR professionally. Another factor making the issue difficult to grasp is the fact that severe impacts are expected by interviewees to happen in a distant future. Yet on Borkum, the question of intergenerational justice is also touched upon as a motivator to act. e.g., through reflecting on the need to think about coastal protection measures for the sake of future generations, even if one might not experience severe events in one's own life span.

The rather unconcerned perspective on extreme sea level rise (ESLR) remained largely unchanged, even when interviewees were presented with projections at the outset of the interviews. Although awareness of rising sea levels and the potential for more frequent ESL events is growing, the expected timeline for significant impacts on the tourism sector was perceived as too far in the future to warrant immediate action. Since ESL events are projected to have only relatively minor effects by 2050 – and tourism planning typically operates on a 15- to 20-year horizon – the anticipated increase in such events is not currently viewed as a pressing issue. Consequently, this diminishes the urgency to take proactive measures. Overall, tourism stakeholders who reviewed the projections maintained a positive outlook on the future of Borkum, as well as tourism development on the island. There was a high level of trust in the authorities responsible for coastal protection. This optimistic perspective is also linked to the expectation that, at least in the short to medium term, the East Frisian Islands may benefit from climate change – particularly due to investments in the energy transition (e.g., wind turbines) and a possible shift of traditionally Mediterranean-oriented beach tourism to northern Europe. Such developments could enhance the economic viability of tourism, supporting its continued growth. However, the most frequently mentioned concern remained the risk of drinking water salinization.

For Norderney, there were no interview partners found for this set of interviews. Since the overall outlook on Norderney was less concerned about SLR and ESLR compared to Borkum, it could be assumed that the perception of tourism development would not be affected negatively by the projections. In the first set of interviews, positive examples of collaboration between tourism and coastal protection are emphasized, e.g., the new revetment, which also serves as a promenade. At the same time, actors from tourism expect conflicts to aggravate through SLR, e.g., between ground-nesting birds and tourism under the conditions of decreasing land availability.

5.2.2 Beyond local

Moving beyond the local level, one interviewee from coastal protection in the federal state administration of Lower Saxony emphasized the fact that the Lower Saxonian coastal protection strategy prepares for developments to be expected over the next 100 years, allowing for a SLR of one meter in the construction of the massive structures. The issue of nature-based solutions, e.g., through sand replenishment, is expected to play a larger role on the islands, also in response to an increased perception of sustainability within society. Future viability is seen as highly dependent on how the consequences of climate change will actually materialize, which is the reason for pursuing a strategy of maximizing flexibility, including principles of sustainability and precaution (including risk minimization) as essential general conditions. A complete change of the Lower Saxonian coastal protection framework is not regarded as necessary, also not in the context of climate adaptation.

The national park authority sees SLR as one of the main challenges for the Wadden Sea ecosystem, alongside rising temperatures and a different distribution of precipitation, with the danger of reaching a tipping point when the Wadden is no longer able to grow as fast as the sea level is rising. The higher pressure on coastal and island protection infrastructure through rising sea levels is seen as challenging not only natural systems but also the reliability for human use of the islands in the long term.

At the district level, the interviewee from Aurich (responsible for Norderney) stated that the topic of climate adaptation receives relatively little political resonance due to the perception that the coast is less affected by climate change impacts than other regions in Lower Saxony. Yet, SLR plays a certain role, and the district has supported local projects related to storm surges and SLR. When it comes to the islands´ initiatives, climate adaptation is perceived to mainly play a role concerning tourism. For the district of Leer (responsible for Borkum), the issue of collaboration between different levels is emphasized, as well as climate adaptation as a cross-sectoral task with single solutions such as heightening the dykes not being sufficient, whereas funding is also seen as a prerequisite to enhance action. In the short term, the island of Borkum is perceived as benefiting from climate change compared to other destinations, e.g., the Mediterranean.

5.2.3 Summary of interview results

In general, perception and valuation of SLR vary considerably both between and within actor groups. On both islands, the range of perceptions regarding SLR impacts and related urgency is rather wide. While for some interviewees it is important to stress that climate change-related issues are not discussed different-

ly than on the mainland, others emphasize that the problem of rising sea levels is not being realized or sometimes even denied by many islanders. This was explained by the interviewees with expected short-term positive effects on tourism (e.g., a result of warmer summers), economic interests being prioritized over rather intrinsic ecological values, or a general fear of change. Still others emphasize the need to adapt to climate change impacts for the next 20 to 30 years, often combined with not seeing a real chance for the islands to survive for the next 100 years or more. The threat of future non-availability of drinking water through saltwater intrusion and an accompanying decrease in quality of life were mentioned, as well as the unnatural character of coastal protection measures.

In sum, except for environmental and coastal protection actors, sea level rise is not yet perceived as the most pressing issue that needs to be addressed urgently on both islands. Trust in technical solutions is high, and short-term issues (such as affordable housing for the local population) are perceived as problems that are more urgent[1]. These rather contradictory perceptions also apply to the actors in the local tourism sector to whom our projections for ESLR were presented at the beginning of the interview. Although there is a growing awareness of rising sea levels and the potential for more frequent ESL events, the timeline in which they are expected to significantly impact the tourism industry was deemed too distant. ESL events are projected to have only a relatively minor impact by 2050, and with a planning horizon of approximately 15 to 20 years, the anticipated increase in ESL events is not currently viewed as a major concern for tourism planning, dampening the motivation to take immediate action. Additionally, some interviewees even expect that climate change might have a positive impact on local tourism, as rising temperatures could drive tourists away from increasingly hot regions, such as the Mediterranean, to cooler destinations like Borkum. This was also the case for the interviewees outside the local tourism sector, who saw climate change and SLR as a pressing issue but also confirmed that it is not the main concern for people working in the tourism industry.

[1] Other short-term problems considered urgent included mobility/connection to the mainland (on Borkum, for example, monopoly/cooperation with AG Ems), the feeling of not being able to decide on land use (state-owned land, as national park or coastal protection infrastructure), effects of seasonality (provision of infrastructure in winter, weighing up the need for touristic businesses for seasonal expansion in order to continue to cover costs and maintain jobs versus the need for holidays/recreational breaks for both the local population and seasonal staff).

Finally, we need to acknowledge that our study only provides insights from two of the affected East Frisian islands, and our interviews did not include, for example, voices from civil society, residents, or tourists. We suggest that further research could include these groups for an even more holistic understanding of perceived SLR urgency. It could also explore how (perceived) agency to address SLR challenges can be improved at the local/island community level. It could build on recent work on anticipatory coastal adaptation that indicates that policy-makers can improve awareness and collective preparation for future coastal changes by using broader narratives, such as intergenerational justice (Cotton et al. 2024). Other further pathways of research could ask how notions of degrowth are considered/perceived to be viable options for island communities for the tourism sector in light of pressing SLR challenges.

6 Conclusions

Projections of extreme events offer crucial insights for risk assessment and according effective adaptation of coastal protection infrastructure, which is very likely to become inadequate without additional measures. However, projections at a global or continental scale often lack the precision needed for protecting smaller areas like the islands along the German North Sea coast. For the East Frisian islands of Borkum and Norderney, this study therefore employed a high-resolution hybrid model combining physical, statistical, and geostatistical components to increase the precision of small-scale predictions and impact assessments. Additional semi-structured interviews allow for a better understanding of how local and regional actors, particularly in the public and tourism sectors, perceive the risks of SLR and derive effective short- and long-term measures. This can provide more comprehensive insights into effective mitigation and adaptation strategies for policymakers (see also Parreira & Mouro 2023).

Our SLR/ESLR projections indicate a dramatic impact on the North Sea islands by 2100. Both Borkum and Norderney face significant challenges due to projected rises in ESLs, with potential increases of up to 2.36 meters for Borkum and 2.47 meters for Norderney by 2100. These increases threaten current coastal defense measures and suggest that the existing infrastructure may become inadequate, particularly during high percentile ESL events. For Borkum, the current defense structures, including infrastructure around the southern areas, may not withstand events beyond the

50th percentile by mid-century. The southern dunes are particularly vulnerable, requiring reinforcement to prevent erosion that could compromise both land and freshwater lenses. Similarly, for Norderney, while present dikes and defense structures are sufficient for now, they may fail to protect all settlement areas by mid-century. The dune belts are also identified as weak points, at risk of overwash and subsequent freshwater lens compromise. Both islands will need to take significant protective measures. Borkum may need to elevate dikes to at least 6.4 meters and consider installing a ring dike for comprehensive protection. For Norderney, reinforcing the southern dunes is essential, and the dikes will need to be raised to a minimum height of 5.75 meters to maintain the integrity of freshwater resources and ensure long-term resilience. The increased frequency of ESL events poses a common risk for both islands, likely requiring more sustained and strategic coastal management efforts in the future.

Our interview results support previous work by Klöck (2019) in that SLR threats – including their assessment and prioritization of necessary measures – are viewed very differently by different actor groups at community, district, and federal state levels. Interestingly, presenting our projection maps to interview partners from the tourism sector had very little impact on their overall assessment of the SLR risk. Perhaps not surprisingly, we found a higher risk perception and sense of urgency mainly among environmental and coastal protection interviewees. At the same time, our results at the community level revealed that some respondents from both tourism and the political/administrative sectors perceived SLR as a distant future concern, pointing to the prevalence of psychological distancing in temporal terms (Shao et al. 2020). while other short-term challenges are perceived to be more pressing at the local level. The lack of affordable housing for staff and residents (in competition with accommodation for tourists) was clearly ranked first as the most pressing current challenge. In part, this is likely due to the tourism industry's planning horizons typically not exceeding 20 years and communities prioritizing short- to medium-term local economic development, anticipating immediate benefits such as warmer summers boosting tourism in Northern European destinations. A 'coolcation' trend - where tourists deliberately choose cooler destinations such as in Nordic or Baltic countries - is already starting to emerge as more 'traditional' holiday destinations in the Mediterranean experience more extreme heat waves in the summer months, making them less attractive (Karaferi et al. 2025). We also found cases of 'risk normalization' on the islands, as interview partners highlighted that many islanders, particularly on Norderney, do not recognize or sometimes even deny the problem of rising sea levels, attributing this to either a lack of sensitization to climate impacts or an extreme fear of change in general. This could support findings that individuals more exposed to hazards – such as those living on islands – downplay their risk perception to psychologically manage their fears (see also Luis 2018). The findings could also reflect path dependencies, which act as a barrier to fundamental changes to individual behavior and institutional structures in climate change adaptation (e.g., van Buuren et al. 2016). Insights from the district level suggest that climate adaptation garners little political attention because the coast is perceived as less affected by climate change than other regions in Lower Saxony. That said, political programs and their stance on environmental issues at the district, state, and national levels can change with the political parties that come into power.

Overall, even though projections objectively indicate that ESLR poses a serious threat to the livelihoods of the islands, our interview data show that these threats are not regarded by everyone as an urgent concern requiring immediate action. The interviewed actor groups employ all three strategies of optimistic argumentation when discussing vulnerability to coastal risks (cf. Bertoldo et al. 2021): Social comparison (other geographical locations are seen as more vulnerable), risk comparison (other risks being more pressing) and even fatalism (the problem is perceived as too challenging to solve at an individual or local level). The latter also concerns the question of (perceived) agency and who is responsible for making decisions on how to address the obvious threat through future ESLR on the East Frisian islands (also in the sense of multi-level governance). We found some evidence from Borkum, which suggests that the tourism industry is partly driven by a sense of responsibility towards intergenerational justice. At the same time, while there are some positive examples of joint endeavors to implement SLR-related-measures between the local tourism industry and the State of Lower Saxony coastal protection agencies, many actors from the tourism sector perceive themselves as 'laypeople', i.e. incompetent regarding SLR and hence refer to overarching State authorities as 'experts' responsible for handling coastal protection. These authorities, in turn, must balance the probable SLR risks, financial resources, economic development opportunities on the islands, and the islands' function as a protective barrier for the mainland, which currently results in a policy of maximizing flexibility.

Finally, our study implies that conflicts of interest related to land use are likely to become more challenging in the coming decades as SLR pressures increase, particularly where competing economic and environmental priorities intersect. The medium-term trajectory of coastal protection appears to rest predominantly with State-level authorities, since local community actors – especially those in the tourism sector – often lack either the perceived capacity or the authority to meaningfully engage in or influence higher-level decision-making processes. Recent literature has argued that adaptation pathway approaches are popular but insufficiently operationalize path dependencies in climate adaptation contexts (Hanger-Kopp et al. 2022). Drawing on this, future research could explore how far both entrenched institutional path-dependencies and dominant risk narratives, and newer understandings of climate governance in (coastal) Lower Saxony influence the development and implementation of more decentralized coastal management strategies with higher local and regional participation levels.

Acknowledgments

We would like to express our gratitude to the editors and the two anonymous reviewers for their constructive feedback, which greatly improved this manuscript. We also thank the interviewees for their time and valuable insights. The projection components of the case study were funded by an EUniWell Research Incubator Grant awarded to the Universities of Florence, Murcia, and Cologne for a joint project on "Sea-Level Rise and Societal Adaptation to Climate Change." Interviews were conducted in the context of the research project '4N – Nordwest Niedersachsen Nachhaltig Neu' which is funded by the Ministry of Science and Culture of the State of Lower Saxony (Ministerium für Wissenschaft und Kultur - MWK), Germany.

References

Ablain M, Meyssignac B, Zawadzki L, Jugier R, Ribes A, Spada G, Benveniste J, Cazenave A, Picot N (2019) Uncertainty in satellite estimates of global mean sea-level changes, trend and acceleration. *Earth System Science Data* 11: 1189–1202. https://doi.org/10.5194/essd-11-1189-2019

Anderson T R, Fletcher C H, Barbee M M, Romine B M, Lemmo S, Delevauy J M S (2018) Modeling multiple sea level rise stresses reveals up to twice the land at risk compared to strictly passive flooding methods. *Scientific Reports* 8: 14484. https://doi.org/10.1038/s41598-018-32658-x

Bertoldo R, Guignard S, Dias P, Schleyer-Lindenmann A (2021) Coastal inconsistencies: Living with and anticipating coastal flood risks in southern France. *International Journal of Disaster Risk Reduction* 64: 102521. https://doi.org/10.1016/j.ijdrr.2021.102521

Boettle M, Rybski D, Kropp J. P (2016) Quantifying the effect of sea level rise and flood defence – a point process perspective on coastal flood damage. *Natural Hazards and Earth System Sciences* 16: 559–576. https://doi.org/10.5194/nhess-16-559-2016

Boumis G, Moftakhari H, Moradkhani H (2023) Coevolution of extreme sea levels and sea-level rise under global warming. *Earth's Future* 11: 1–14. https://doi.org/10.1029/2023EF003649

Burgess MG, Becker SL, Langendorf RE, Fredston A, Brooks CM (2023) Climate change scenarios in fisheries and aquatic conservation research. *ICES Journal of Marine Science* 80: 1163–1178. https://doi.org/10.1093/icesjms/fsad045

Cisternas PC, Cifuentes LA, Bronfman NC, Repetto PB (2024) The influence of risk awareness and government trust on risk perception and preparedness for natural hazards. *Risk analysis* 44: 333–348. https://doi.org/10.1111/risa.14151

Cotton I, Forster j, Lorenzoni I, Tolhurst, TJ (2024) Challenges to anticipatory coastal adaptation for transformative nature-based solutions. *Global Environmental Change* 88: 102893. https://doi.org/10.1016/j.gloenvcha.2024.102893

Erdmann K-H, Lange H, Mayerl D, D'Oleire-Oltmanns W, Spandau L (1995) Biosphärenreservate in Deutschland. Berlin, Heidelberg.

ESRI (n.D.): GIS Dictionary. Thiessen polygon. https://support.esri.com/en-us/gis-dictionary/thiessen-polygon

European Commission (2018) Large scale integrated sea-level and coastal assessment tool. Joint Research Center. https://data.jrc.ec.europa.eu/collection/LISCOAST

Ganske A, Fery N, Gaslikova L, Grabemann I, Weisse R, Tinz B (2018) Identification of extreme storm surges with high-impact potential along the German North Sea coastline. *Ocean Dynamics* 68: 1371–1382. https://doi.org/10.1007/s10236-018-1190-4

Gerkensmeier B, Ratter BM, Vollmer M, Walsh C (2018) Managing coastal risks at the Wadden Sea: A societal perspective. *Disaster Prevention and Management* 27: 15–27. https://doi.org/10.1108/DPM-04-2017-0074

Hafencity Universität Hamburg (2020) Prognosen zum Meeresspiegelanstieg 2100. Hamburg. https://sealevel-rise.hcu-hamburg.de/#/map

Hanger-Kopp S, Thaler T, Seebauer S, Schinko T, Clar C (2022) Defining and operationalizing path dependency for the development and monitoring of adaptation pathways. *Global Environmental Change* 72: 102425. https://doi.org/10.1016/j.gloenvcha.2021.102425

Hauer M. E, Fussell E, Mueller V, Burkett M, Call M, Abel K, Mcleman R, Wrathall D (2020) Sea-level rise and human migration. *Nature Reviews Earth & Environment* 1: 28–39. https://doi.org/10.1038/s43017-019-0002-9

Hornsey MJ, Fielding KS (2020) Understanding (and reducing) inaction on climate change. *Social Issues and Policy Review* 14: 3–35. https://doi.org/10.1111/sipr.12058

IBM (n.D.) Was ist die Monte-Carlo-Simulation? https://www.ibm.com/de-de/topics/monte-carlo-simulation

HZG (Institut Für Küstenforschung - Helmholtz-Zentrum Geesthacht), DWD (Deutscher Wetterdienst), BAW (Bundesanstalt Für Wasserbau), FWU (Forschungsinstitut Wasser und Umwelt - Universität Siegen), UNI-HH (Institut Für Geografie - Universität Hamburg) (eds) (2019) Extremeness: Extreme North Sea storm surges and their consequences. Schlussbericht. https://ms.hereon.de/imperia/md/images/mw/03f0758a-e_schlussbericht_extremeness.pdf

Jensen J, Mudersbach C, Müller-Navarra S, Bork I, Koziar C, Renner V (2006) Modellgestützte Untersuchungen zu Sturmfluten mit sehr geringen Eintrittswahrscheinlichkeiten der deutschen Nordseeküste. *Die Küste* 71: 123–168.

Jevrejeva S, Williams J, Vousdoukas M, Jackson L (2023) Future sea level rise dominates changes in worst case extreme sea levels along the global coastline by 2100. *Environmental Research Letters* 18: 1–10. https://doi.org/10.1088/1748-9326/acb504

Johnson D, Levin S (2009) The tragedy of cognition: Psychological biases and environmental inaction. *Current Science* 97: 1593–1603.

Karaferi E, Chatzidaki A, Solstad J, Vamvatsikos D (2025): Quantitative assessment of the impact of climate change to the tourism of Tønsberg, Norway. *International Journal of Disaster Risk Reduction* 120: 105351. https://doi.org/10.1016/j.ijdrr.2025.105351

Kerber G (2018) Klimawandel hautnah. Wenn das Meer kommt - Wie Inselbewohner mit den Veränderungen umgehen. Berlin.

Klöck C (2019) Dealing with climate change in the German Wadden Sea: Perceptions, measures, and contestation on Hallig Hooge. *Ocean & Coastal Management* 179: 104864. https://doi.org/10.1016/j.ocecoaman.2019.104864

Kopp R, Horton R, Little C, Mitrovica J, Oppenheimer M, Rasmussen D, Strauss BH, Tebaldi C (2014) Probabilistic 21st and 22nd century sea-level projections at a global network of tide-gauge sites. *Earth's Future* 2: 383–406. https://doi.org/10.1002/2014EF000239

Kuckartz U, Rädiker S (2023) Qualitative content analysis: Methods, practice and software. Thousand Oaks.

Lam-González YE, Galindo CG, Hernández MMG, León CJ (2021): Understanding the heterogeneity of tourists' choices under climate change risks: A segmentation analysis. *Atmosphere* 12: 1–22. https://doi.org/10.3390/atmos12010022

Landesamt Für Statistik Niedersachsen (2024) Bevölkerung nach Geschlecht; Fläche, Bevölkerungsdichte (Gemeinde). https://www1.nls.niedersachsen.de/statistik/html/default.asp

Lee H, Calvin K, Dasgupta D, Krinner G, Mukherji A, Thorne P et al. (2023) IPCC 2023: Climate Change 2023: Synthesis report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change IPCC, Geneva, Switzerland.

Luís S, Vauclair CM, Lima ML (2018) Raising awareness of climate change causes? Cross-national evidence for the normalization of societal risk perception of climate change. *Environmental Science & Policy* 80: 74–81. https://doi.org/10.1016/j.envsci.2017.11.015

Martellozzo F, Dalle Vaglie M, Randelli F, Falaguasta C, Van Tongeren P, Negacz K (2024a) Rising tides, sinking crops: Assessing the impact of extreme sea level rise on coastal agriculture in Europe and North Africa. *Research Square*. https://doi.org/10.21203/rs.3.rs-4950906/v1

Martellozzo F, Randelli F, Dalle Vaglie M, Falaguasta C (2024b): Projections: Risk and impacts on populations in the mediterranean Basin. Bonora L, Catelani M, De Vincenzi M, Matteucci G (eds) *Tenth international symposium "Monitoring of Mediterranean Coastal Areas: Problems and Measurement Techniques":* 420–428. Florence. https://doi.org/10.36253/979-12-215-0556-6

Morss RE, Ahijevych D, Fossell K, Kowaleski AM, Davis CA (2024) Predictability of hurricane storm surge: An ensemble forecasting approach using global atmospheric model data. *Water* 16: 1523–1541. https://doi.org/10.3390/w16111523

Nationalpark Wattenmeer (2023) Nationalpark Niedersächsisches Wattenmeer. https://www.nationalpark-wattenmeer.de/nds/

Nauels A, Meinshausen M, Mengel M, Lorbacher K, Wigley T (2017) Synthesizing long-term sea level rise projections – the MAGICC sea level model v2.0. *Geoscientific Model Development* 10: 2495–2524. https://doi.org/10.5194/gmd-10-2495-2017

Niedersächsischer Landesbetrieb Für Wasserwirtschaft, Küsten- Und Naturschutz (2010) Generalplan Küstenschutz Niedersachsen - Ostfriesische Inseln. Norden.

Niedersächsisches Ministerium Für Umwelt, Energie Und Klimaschutz (2020) Umweltkarten Niedersachsen. Hannover. https://www.umweltkarten-niedersachsen.de/Umweltkarten/?topic=Hochwasserschutz&bgLayer=TopographieGrau&lang=de&catalogNodes=&layers=WassertiefenKuesteHWextrem

Parreira N, Mouro C (2023) Living by the sea: place attachment, coastal risk perception, and eco-anxiety when coping with climate change. *Frontiers in Psychology* 14: 1-15. https://doi.org/10.3389/fpsyg.2023.1155635

Paulik R, Stephens S, Bell R, Wadhwa S, Popovich B (2020) National-scale built-Environment exposure to 100-year extreme sea levels and sea-level rise. *Sustainability*12: 1513–1529. https://doi.org/10.3390/su12041513

Pycroft J, Abrell J, Ciscar J-C (2016) The global impacts of extreme sea-levelrRise: A comprehensive economic assessment. *Environmental and Resource Economics* 64: 225–253. https://doi.org/10.1007/s10640-014-9866-9

Rudolph E (2012) XtremRisK - Extremsturmfluten an offenen Küsten und Ästuargebieten: Modellierung von Extremsturmflutszenarien im Elbeästuar. FuE-Abschlussbericht A 3955 03 70165. Karlsruhe.

Rudolph E, Brodhagen T, Fery N, Gaslikova L, Grabemann I, Meyer E, Möller T, Tinz B, Weisse R (2019) Analyse extremer Sturmfluten an der deutschen Nordseeküste und ihrer möglichen Verstärkung. *Die Küste* 87: 47–73. https://doi.org/10.18171/1.087111

Shao W, Moftakhari H, Moradkhani H (2020) Comparing public perceptions of sea level rise with scientific projections across five states of the US Gulf Coast region. *Climatic Change* 163: 317–335. https://doi.org/10.1007/s10584-020-02893-1

Spence A, Pidgeon N (2010) Framing and communicating climate change: The effects of distance and outcome frame manipulations. *Global Environmental Change* 20: 656–667. https://doi.org/10.1016/j.gloenvcha.2010.07.002

Van Buuren A, Ellen G J, Warner JF (2016) Path-dependency and policy learning in the Dutch delta: Toward more resilient flood risk management in the Netherlands? *Ecology and Society* 21: 43. https://doi.org/10.5751/ES-08765-21044

Vitousek S, Barnard P, Fletcher C, Frazer N, Erikson L, Storlazzi C (2017) Doubling of coastal flooding frequency within decades due to sea-level rise. Scientific reports 7: 1–9. https://doi.org/10.1038/s41598-017-01362-7

Vousdoukas M, Mentaschi L, Voukouvalas E, Verlaan M, Feyen L (2017) Extreme sea levels on the rise along Europe's coasts. *Earth's Future* 5: 304–323. https://doi.org/10.1002/2016EF000505

Vousdoukas M, Mentaschi L, Voukouvalas E, Verlaan M, Jevrejeva S, Jackson L, Feyen L (2018): Global probabilistic projections of extreme sea levels show intensification of coastal flood hazard. *Nature Communications* 9: 1–13. https://doi.org/10.1038/s41467-018-04692-w

Wahl T, Haigh ID, Nicholls RJ, Arns A, Dangendorf S, Hinkel J, Slangen ABA (2017) Understanding extreme sea levels for broad-scale coastal impact and adaptation analysis. *Nature Communications* 8: 1–12. https://doi.org/10.1038/ncomms16075

Walsh KJE, MCinnes KL, MCbride JL (2012) Climate change impacts on tropical cyclones and extreme sea levels in the South Pacific – A regional assessment. *Global and Planetary Change* 80–81: 149–164. https://doi.org/10.1016/j.gloplacha.2011.10.006

Wasserstrassen- Und Schifffahrtsverwaltung Des Bundes (2013) Download der Geodaten - Auswahl: Portal Tideems. DGM-W 2015 Unter- und Außenems. Cuxhaven, Tönning. https://www.kuestendaten.de/Tideems/DE/Service/Kartenthemen/Kartenthemen_node.html

Wu G, Liu Q, Xu H, Wang J (2024) Modelling the combined impact of sea level rise, land subsidence, and tropical cyclones in compound flooding of coastal cities. *Ocean & Coastal Management* 252: 107107. https://doi.org/10.1016/j.ocecoaman.2024.107107

Authors

Christiane Lawrenz
lawrenz@gmail.com
christiane.lawrenz@uni-hamburg.de
ORCID: 0009-0000-3160-7145
University of Hamburg
Sustainability and Global Change
Grindelberg 5
20144 Hamburg
Germany

Gesa Witt
gesa.witt@uni-vechta.de
ORCID: 0009-0001-9891-7348
Prof. Dr. Amelie Bernzen
amelie.bernzen@uni-vechta.de
ORCID: 0000-0002-9494-3645
Universität Vechta
Vechta Institute of Sustainability
Transformation in Rural Areas (VISTRA)
Driverstraße 22
49377 Vechta
Germany

Prof. Dr. Boris Braun
boris.braun@uni-koeln.de
ORCID: 0000-0003-3863-2153
Universität zu Köln
Geographisches Institut
Zülpicher Str. 45
50674 Köln
Germany

Appendix

Appendix A: Coding scheme for qualitative content analysis

Code	Description	Anchor example
Perception of climate change	Perceptions of impacts, urgency, and importance of the topic.	„So, there is already a high level of awareness and sensitivity on Borkum for the issue of climate change. Because I think the vast majority of people are now aware that scenarios such as the one presented here can occur.“ – Interview pro_1
Impacts on the island	Stated examples of climate change impacts related to (extreme) sea level rise and its consequences for human use (e.g., with regard to sweet water supply).	“Well, I would see a strengthening of the dynamic. Of course, terrestrial habitats will most likely be lost. Just as the dunes are now depicted in the east of Norderney. They won’t stay there.” – Interview pro_2 „If you read the word Borkum, on the right-hand side to the east, there are about 2/3 of our drinking water areas. We have two freshwater lenses. So we have fresh water everywhere under the island. But we take our drinking water from two freshwater areas. One is the Waterdelle drinking water area and the other is the Ostland drinking water area.“ – Interview pro_5
Current situation	Descriptions of recent developments. E.g., regarding coastal protection infrastructure.	„Exactly. Yes, the west of the island, roughly where the hook is, has been stabilized for ages. I don‘t know how long there‘s been a really massive coastal protection structure there, because that‘s also the direction of weather attack from the west, while everything to the north and south is essentially natural coastal protection, with protective dunes.“ – Interview pro_1
Measures	Past, present, and future measures to protect the island against rising sea levels.	„What I still know now, what is probably planned: I was talking about the path on the south beach. There is also a path on the promenade in the other direction on the upper beach promenade towards Seeblick and Sturmeck. That‘s the side where we have this extremely wide beach.“ – Interview pro_4
Conflicts of interest	Conflicts mentioned regarding the implementation of measures, e.g., between different sectors or actors, or related to the (non-) availability of space.	„I know enough people for whom this is a thorn in their side. I also know that the city or the NWG has sought contact with the NLWKN at this point, but that the reference is quite uncompromising due to this high-ranking task of coastal protection at the site. That‘s what I heard, but I wasn‘t involved in the discussions.“ – Interview pro_4
Challenges	Mentioned challenges regarding the implementation of measures, communication of risks, or strategies to cope with current and future climate change impacts.	„Yes, yes, I see challenges simply because we can already see that storm surges are increasing in frequency and severity. And we are less and less able to simply say: Well, there was a storm surge. We coped with that quite well.“ – Interview pro_1
Tourism	Aspects related to the tourism sector, its development, and the impacts of climate change.	„If the island is no longer attractive to tourists, then there will no longer be any employment opportunities for locals. Then you can basically give up the island as a location.“ – Interview pro_1
Future prospects	Outlooks into possible futures, e.g., with regard to prioritization of development perspectives.	„And I believe that every investment that is made is good and necessary and must also be pursued in order to simply protect and preserve these habitats, these tourist areas, and to develop them further in the best possible way. So that should actually be the goal, that we not only preserve what is there, but that we also develop it further and make it better, so to speak.“ – Interview pro_8

Additional codes for interviews with projections

Code	Code description	Anchor example
Accuracy of projections	Content related to the accuracy of projections, e.g., confirmation, critique, or suggestions for improvement.	„It doesn‘t even need a major storm surge for this to be flooded. And then such a storm surge does not yet come over the edge of the dune, and in this respect, everything is definitely shown correctly at the top. Yes, and at the bottom, at the bottom in the south-east, if you like, is the district of Reede. Exactly where you are with your cursor. That would be interesting again. I think it would work differently there.“ – Interview pro_1
2050 RCP 4.5	Statements referring to the RCP 4.5 scenario for the year 2050.	“So now we have a scenario for 2050 with 4.5 and 8.5. In both scenarios, this would virtually call into question the habitability of the Reede district down there, at the bottom right, in the south-east” – Interview pro_1
2050 RCP 8.5	Statements referring to the RCP 8.5 scenario for the year 2050.	„If we really have such a massive collapse that the island is flooded in large areas/so if the protective dunes really break, and you can see in the 2050 scenario that the layer is already very, very thin/then the eastern part of the island will be completely flooded.“– Interview pro_5
2100 RCP 4.5	Statements referring to the RCP 4.5 scenario for the year 2100.	„Then I can also follow this, because I have the feeling that the left scenario logically leaves a little more area available, and the area is already reduced in the 2100 scenario. However, I assume that if the protective dunes remain stable, then our drinking water supply will also remain stable.“ – Interview pro_5
2100 RCP 8.5	Statements referring to the RCP 8.5 scenario for the year 2100.	„Yes, and that‘s the end of the line. Nevertheless, you have to think about it; I‘m looking at it through my glasses. Residential areas here would be completely flooded in the one on the right.“ – Interview pro_1
Reactions to projections	Reactions to and valuations of the projection, both positive and negative.	„It‘s a bit scary at this point. I‘m going to say/ it used to be the case, especially in East Frisia and on the islands, that everyone was always very aware of it. And the local people mainly took care of coastal protection themselves. But now that it‘s more or less national history, or sovereign, and coastal protection has become so good, it‘s, yes, a story from the past.“ – Interview pro_4

Appendix B: Anchor examples for tendencies of risk perceptions among different actor groups on Borkum and Norderney

	Borkum (with projections shown)	**Borkum** (without projections shown)	**Norderney** (without projections shown)
	High risk perception/level of urgency		
Respondents from the tourism sphere	"It is a bit unsettling at this point. You know, in the past - especially in East Frisia and on the islands - people were always very aware of the importance of coastal protection. It was something very present in their daily lives. Back then, the local communities largely took care of it themselves. But since coastal protection became a state responsibility and has improved so much, it has started to feel like an issue of the past. However, with rising sea levels, this reality is catching up with us again." (Interview pro_4)	"So, with the island locations, I would go so far as to say that the real issue here is whether the islands will still be viable as a habitat in 20 or 30 years' time. I simply assume that there will be a/ that it won't take a rise in sea level for not a grain of sand to peek out of the top. It doesn't have to come to that. The central issue is whether the drinking water supply, in particular, can be maintained for so long. All of the East Frisian islands have a freshwater lens beneath them." (Interview 5)	"And I think many people have now realised this, because you can actually say that there has been erosion every year due to the storm surges. Not so much in the actual coastal protection measures near the city, but in the eastern part of the island. *Kugelbake* near the *Weiße Düne*, for example. I think many people are aware that, at some point, it will become difficult to absorb all of this. If you think about it, every two or three years this has to be flushed up, at the beach alone." (Interview 11)
	Low risk perception/level of urgency		
		"Well, as I said, if you're always talking about rising sea levels, that's not exactly favourable for an island like us. How that really affects us now/ I don't know if I'll even live to see it in the time I'm here. I actually don't think so. Of course, it's a situation that you have to think about. For the next generations. Yes, of course, I always find that difficult too. That's why people find it so difficult: When it's so far ahead of you." (Interview 7)	"You would actually think that it would be more important for islanders who live on an island in the middle of the North Sea and are perhaps affected differently than someone who lives in Bavaria. But I don't actually perceive it in that way. I have to be fair and say that. This may be due to the fact that, as islands, we have, of course, been dealing with the issue of coastal protection here for centuries, for as long as the island has existed, and not just since climate change was consciously recognised. And there is always talk of sea level rise. This is also one of the core issues of climate change and the people of Norderney are relatively well equipped to deal with it." (Interview 12)

	Borkum (with projections shown)	**Borkum** (without projections shown)	**Norderney** (without projections shown)
	High risk perception/level of urgency		
Respondents from the political sphere	"And if you go back and look at the images for 2050, you can still clearly say: Hey, there's still a chance. And if we now really tackle the energy transition with full force and manage to stay on the RCP 4.5 path instead of heading toward RCP 8.5 — and if we actually succeed in making Germany fully climate-neutral by 2045 — then we still have a real chance of maintaining a status quo that allows life on Borkum to remain viable in the long term, along with tourism as its main economic sector." (Interview pro_5)	"What does this do to our drinking water? Protecting the freshwater lens is certainly also a major challenge. That's not so urgent now. Everyone says everything is fine. But if the sea level rises and we lose dunes, then this fragile balance, which is what makes the freshwater lens physically possible, is quickly broken. And when it comes to a mix of fresh and salt water, then you're quickly at the end." (Interview 1)	"Yes, of course it [the topic of climate adaptation] is of huge importance. It's not for nothing that the dykes here will ultimately be raised. The only question is: over what period of time do you look at the issue? So, if you say now, for the next 20 or 30 years, I think it's enormously important to adapt in order to protect this area from a climatic point of view. Both for us and for the other species that live here and need and require this space. And I think that sooner or later, of course, we won't necessarily make the effort, and in 100 years' time, only the top of the water tower will perhaps still be peeking out. I can see that we will have other coastlines and the islands will primarily be there as bulwarks for the mainland, you could almost say." (Interview 9)
	Low risk perception/level of urgency		
		"It's a recent topic that brings with it a bit of uncertainty and also a bit of fear as to whether something could happen. But I will say that sea levels are rising, and we will have problems at some point. That's still a long way off for many people. Maybe in the back of some people's minds. But it's actually an issue that doesn't really affect you." (Interview 2)	"I would say we have a climate problem with sea level rise, which I think is still denied or not seen on the island." (Interview 13) "I have the impression that this has not yet been properly recognised. Or at the moment, there are also tendencies to welcome the fact that, apart from this summer perhaps, but otherwise we have had more [warm] summers in recent years, or however you want to put it. This will benefit domestic tourism and, therefore, also Norderney tourism, because many guests will come. I don't have the impression that we are seriously thinking about what a sea level rise of one metre, one metre ten in eighty years would mean." (Interview 13)

	Borkum (with projections shown)	**Borkum** (without projections shown)	**Norderney** (without projections shown)
	High risk perception/level of urgency		
Respondents from the environmental sphere		[Key for future proof Borkum] "that we create a good harmony between nature, tourism, and the local inhabitants, and that there is an awareness that we also have to make climate adaptations. So, that is simply the case. That we also have to do something with the limited resources that we may have available, because as an island we are of course also the first to be affected by climate change due to rising sea levels, etc., and that there is simply an awareness that things can perhaps not continue the way they used to be." (Interview 3)	"I also find this non-inclusion (of climate-related topics into the implementation of the living habitat concept) problematic because the groups that are active in nature conservation here are all warning: 'People, watch out a bit. We will experience climate change directly here on the islands, and we will experience it very harshly." (Interview 10)
	Low risk perception/level of urgency		
	"That's true — the eastern end is outside the protective dunes. There will be changes there, and depending on how sediment transport develops, some areas might naturally build up again over time. That's part of the process. And since we're talking about an extreme event projected for the year 2100, I don't find that particularly dramatic at this point." (Interview pro_2)	-	"I don't think the awareness is there yet. So, we have a lot of climate change deniers on the island who simply say: 'Sea level rise is not real. Temperature changes are not real. There is no such thing as man-made climate change. It's always been the case that the climate has changed.' And I believe that the explosive nature of the issue or the urgency of the issue has not yet really reached the decision-makers." (Interview 15)