



Free and Hanseatic City of Hamburg
Senate Chancellery

**Regional Analysis of Coastal Zone Management
of the Free and Hanseatic City of Hamburg**

- Dr. Heike Markus-Michalczyk

for the Senate Chancellery of Hamburg –

16.11.2018



Summary

Executive Summary	3
Integrated Coastal Zone Management	4
Hamburg Climate Plan	6
Storm flood defence	8
Actions implemented	10
Outlook	12
References	



Executive Summary

Hamburg is a water-shore-city with more than half of the area located in the Elbe estuary and the Nationalpark “Hamburgisches Wattenmeer” which is located in the outer delta of the Elbe estuary. Hamburg is connected with the coast and sea in many ways with its sea port and the maritime structure. Thus, sustainable coastal zone management is crucial for the city’s economic, ecologic and social development.

Climate change may particularly affect coastal zones in addition to natural hazards like storm surges. Sea level rise accompanied by extreme weather events like heavy rainfalls and drought may lead to increasing risks including flooding and affect coastal communities.

For some economic sectors like tourism, the direct consequences of climate change are expected to be mostly positive in the North Sea region which will be able to compete better with other major destinations. As the demand for tourism is expected to increase and will further affect the function of coasts, mitigation options are necessary. Destinations can seek to deal with climate change through adaptation measures and thereby lessen potential impacts.

Integrated coastal zone management (ICZM) promotes human well-being and economic viability on the long term and aims to enhance the protection of coastal resources whilst increasing the efficiency of their uses. Coastal activities such as fishery and industry, shipping and tourism shall be managed regarding mitigation and adaptation to climate change by respecting the limits of natural resources by an 'ecosystem-based approach'.

Hamburg is conscious of its global and regional responsibility and has released the Hamburg Climate Plan (HCP; 2015) bringing together climate change mitigation and adaptation to climate change. It is aimed to become a “Climate Smart City” by urban development and cross-sectoral measures at all levels of municipal policy and involving private urban stakeholders by 2050. Storm surge protection as well as flooding protection shall have been put in place in order to avoid damage from effects of climate change to the greatest degree possible.

The HCP aims to link technical flood protection with area-related and behavioural precautions. Hamburg developed a mix of innovative strategies to manage flood risks. The HafenCity in front of the main dyke will be protected by a “Warftenkonzept” where buildings have been placed on dwelling mound stepwise to keep them protected, even in the event of severe floods. Hamburg is implementing multi-purpose flood protection infrastructures for both citizens and tourists as public spaces, e.g. the Harbour-Promenade that enriches the city shape at the “Niederhafen” and “Binnenhafen”. The forecasting and flood warn systems called WADI and FLUTWARN are implemented for informing the public and businesses in the area as behavioural precautions.

A cross-sectoral action regarding the ecosystem-based approach is the Pilot-Project Kreesand. A shallow water area in a former flushing field in the foreland of the Elbe estuary reduces the tidal action and thus optimizes the sediment management whilst valuable tidal habitats evolve. Public relations that aim to enhance public awareness of tidal dynamics e.g. by the installation of the dyke booth attract citizens, tourists and expert-groups to learn from this pilot project.



Integrated Coastal Zone Management

Coastal zones offer a variety of valuable habitats and an environment with diverse ecosystems services that have led to dense population and intensive coastal exploitation by humans. The natural and cultural heritage and high productivity of coasts have further made them important business zones and travel destinations. Today, more than 200 million European citizens live near coasts, stretching from the North-East Atlantic and the Baltic to the Mediterranean and Black Sea.

This intensive human impact puts enormous pressure on coastal ecosystems and causes biodiversity loss, habitat fragmentation and pollution that also affects tourism. Various demands on the environment are leading to user conflicts among different coastal stakeholder groups.

Moreover, climate change may particularly affect coastal zones in addition to natural hazards. Sea level rise accompanied by extreme weather events like heavy rainfalls and drought may lead to increasing risks including flooding, coastal erosion, and salinization. These impacts are already changing the lives and livelihoods of coastal communities.

At the same time, coastal zones are and may even become more important popular tourist destinations. Coastal zones offer locations for recovery of health and relaxation particularly in times of increasing temperature that contribute to cause e.g. urban heat islands.

Integrated coastal zone management (ICZM) intends to promote a good environmental status of coastal zones to ensure human well-being and economic viability on the long term. Thus, ICZM aims to enhance the protection of coastal resources whilst increasing the efficiency of their uses. Contrary to sectoral approaches that may lead to disconnected decisions that risk undermining each other, ICZM provides opportunities for sustainable coastal development.

The sustainable coastal development that the ICZM is promoting includes the coordinated application of the different policies affecting the vulnerable coastal zone. Regarding nature and biodiversity protection the EU Birds Directive 2009/147/EC and Habitats Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora have to be properly applied. Regarding actions in the field of water policy the Water Framework Directive 2000/60/EC and in the field of marine environmental policy the Marine Strategy Framework Directive 2008/56/EC have to be applied whereas the Floods Directive 2007/60/EC aims on the assessment and management of flood risks, to be mentioned as some relevant directives amongst others.

According to the ICZM, all coastal activities such as agriculture and aquaculture, fisheries, industry, off shore wind energy, and shipping shall be managed regarding mitigation and adaptation to climate change. With this, the ICZM will contribute to sustainable development of coastal zones by the application of an approach that respects the limits of natural resources and ecosystems, the so-called 'ecosystem-based approach'.

A sustainable coastal tourism should similarly be based on this ecosystem-based approach.



Free and Hanseatic City of Hamburg
Senate Chancellery

To support the implementation of management strategies corresponding to the ICZM, all stakeholders across the different sectors have to be involved and the whole management cycle including data collection, planning, decision-making, management and monitoring of implementation and evaluation have to be applied.

Along German coasts, the ICZM should be implemented by good communication and participation in a crossover coordination in order to harmonise the social and economic development with the protection of the coastal environment. Although the city of Hamburg has a small territorial coverage along the coast, it is a water-shore-city being with 80% of the city area being located in the Elbe estuary. Moreover, Hamburg contributes to the protection of the unique Waddensea by the Nationalpark "Hamburgisches Wattenmeer". This Nationalpark is located 105 km outside of the main territory of Hamburg on the outer delta of the Elbe estuary. Furthermore, with its sea port and the maritime economic structure, Hamburg is connected with the coast and sea in many ways.

In Hamburg, the ICZM concept is reflected by a diversity of administrative and private actions.

The "Tideelbekonzept" developed by the Hamburg Port Authority (HPA) together with the Waterways and Shipping Directorates (WSA), the „Integrated Management Plan Elbe Estuary" (IMP Elbe Estuary) and the INTERREG IVB-project TIDE as well as the INTERREG IVB-project Clean North Sea Shipping should be mentioned as concrete examples.

The "Tideelbekonzept" was launched in 2006 and focusses on (i) damping the tidal energy in particular in the estuary mouth, (ii) creating room for retention in the tidal freshwater and brackish section and (iii) optimising the sediment management in the whole system based on the hydrodynamic changes during the last decades.

The IMP Elbe Estuary was established in 2012 as a joint state plan by voluntary commitment of all stakeholder groups along the Elbe estuarine stretch. The IMP aims to sustainably develop the Elbe estuary as part of the European Natura-2000 network. Two hundred measures are proposed and many of them have already been implemented.

The Tidal-Elbe concept and the IMP Elbe Estuary were created by regional administration and stakeholders. Within the Interreg IVB-project TIDE international representatives of four North Sea Region estuaries including the Elbe estuary worked together to improve the management of European estuaries by developing concrete tools which enable stakeholders to take the whole estuary into account (ecology, economy, society). Ecosystem function, governance and measures were selected as work areas that delivered the "Tide Tool Box" based on an ecosystem service approach comprising tools for effective governance and communication.

Recently, the Forum Tideelbe was initiated in 2016 as cooperation among the northern German *Länder* Hamburg, Lower, Saxony and Schleswig-Holstein, the federation, municipalities and NGO's. The forum is coordinated by HPA, aiming to sustainably develop the tidal Elbe by cross-sectoral major projects.



Furthermore, the HPA together with the Helmholtz Centre Geesthacht for Material and Coastal Research participated in the research project THESEUS (2009-2013) that aimed to develop innovative technologies and strategies for coastal protection in changing climatic conditions.

Issues like water management, storm water protection and coastal issues are particularly tackled in the Hamburg Climate Plan. “Sustainable water management” means for the City of Hamburg – being with 80% of the cities area in the Elbe estuary – Coastal Zone Management.

Hamburg Climate Plan

Following Kyoto, the world community assigned the climate agreement in Paris. One hundred and ninety-five states committed themselves to combat the impact of climate change and to reduce greenhouse gas emissions. Against this background the Senate of the Free and Hanseatic City of Hamburg released the Hamburg Climate Plan (HCP) in 2015. With this, Hamburg intends to send a signal how large cities can develop strategies and take action for climate mitigation and adaptation to the effects of climate change.

Aim of the HCP was to further develop the “Climate Action Masterplan” and the “Adaptation of Climate Change Action Plan” released in 2013 in terms of methods and content, bringing together climate change mitigation and adaptation to climate change.

Hamburg is conscious of its global responsibility and has thus been promoting climate mitigation for many years. At the same time, Hamburg has to adapt to climate change as a city and measures are being put in place.

One of the main reasons to develop the HCP has also been to tackle the challenges Hamburg is facing as a city where the Elbe estuary passes right through the city. The Elbe estuary is connecting Hamburg with the North Sea. Thus, Hamburg is at risk of severe storm surges. Sensitized through severe storm surges which already hit the city, especially the one in 1962, one of the major aims of the Senate is flood protection of the urban area and the city’s inhabitants.

With this experience in the past, flood protection is a constant issue in Hamburg until today and will be for the near and more distant future. To keep the citizens and the city protected, the Senate decided in response to the expected climate change and the forecasts for the rising sea-level which can have a direct impact on Hamburg to introduce a “climate allowance” of 50 cm for measuring the public flood defences.

In further response to the upcoming challenges in relation to the climate change Hamburg has set itself some aims for actions on the long-term perspective to 2050 as e.g.:



- Using the instruments of urban development and cross-sectoral measures at all levels of municipal policy and involving private urban stakeholders, Hamburg will have developed into a renewable city adapted to climate change.

- The measures needed for storm surge protection as well as flood protection on inland waters have been put in place in order to avoid damage from effects of climate change to the greatest degree possible.

The HCP reflects the opinion that Hamburg will be adapted to the climate change in 2050, so that damages to the city will be avoided as far as possible. To reach this goal in time, there are diverse topics that need to be taken into account. One of the major tasks is to keep the private sector and the stakeholders interested in the topic and to outline why they are in need to participate and act. Furthermore, it is an urgent task to keep the initiated process running, even if the government might change.

On the road to the “Climate Smart City Hamburg” systematic changes are needed. This requires also the support of a cross-sectoral approach plus synergies between individual action areas. Strategic clusters show how partners can spur each other on and of how a positive trend can be initiated in Hamburg. The four aggregated strategic clusters selected are: (1) Transformation of urban spaces: city and neighbourhood development; (2) Green economy; (3) The city as a role model; (4) Climate communication. Moreover, the 2020/2030 action programme defines targets and steps in 14 action fields with the focus on achieving the objectives for 2050 plus “management and monitoring”.

First actions have been undertaken since the release of the “Climate Action Masterplan” and the “Adaptation of Climate Change Action Plan” in 2013. In view of the accelerated rise in sea level and the need for adapted coastal protection, public flood protection systems were newly designed. The goal is to create a climate allowance of 20 cm by 2050 and 50 cm by 2100. With these measures it is intended to keep the city safe for the near future and beyond.

“The remit of coastal flood protection is to reduce the flood risk for Hamburg and to protect the municipal area of Hamburg from storm surges in the long term. Strategically the aim is to link technical flood protection with area-related and behavioural precautions.” (HCP, 2015 p. 79)

One of the key projects is reinforcement of the public flood protection structures to achieve the goal of HPCs` action area “Coastal Flood Protection”. This is to be combined with an adaptation in the field of private flood protection, especially in the harbour area which is permanently at risk at the event of a storm flood. The Hamburg Port Authority (HPA) is the harbour administration of Hamburg. They are responsible for a wide range of duties related to the harbour, e.g. maintaining of the waterways, pilot services and dock railway.

Two measures to increase the flood protection in the harbour area are implemented by the HPA with the development and implementation of forecasting and flood warn systems for informing the public and businesses in the area, called WADI and FLUTWARN. The WADI-System is constantly evaluating the water levels and weather data to produce an accurate weather forecast for the affected area. The FLUTWARN-System is a warning system. The responsible



Free and Hanseatic City of Hamburg
Senate Chancellery

authority, the HPA, is using it to contact those who might be affected when a storm surge is at risk via SMS and e-mail.

With the reported actions, mentioned above, the city of Hamburg is actively working on the challenges which will occur in the near future. As a water bound city Hamburg is in need to constantly work and improve the storm water protection measures due to the displayed reasons. With the HCP, which is also taking care of many other climate related topics, the tracks are laid to keep the municipality and public safe from storm floods in the upcoming years.

Storm flood defence

Hamburg is geographically located in an area of constant flood danger. As Hamburg has suffered from a severe storm flood in 1962 storm flood defence is one of the major responsibilities for the Hamburg Senate. So most of all dykes for storm flood protection are in public property and maintained from public authorities.

The body responsible for the direct storm flood defence in Hamburg is the “Landesbetrieb Straßen Brücken Gewässer” (LSBG) accountable for building, inspection and maintaining roads, bridges and water related structures. The city owned company is responsible for structures like e.g. dykes, flood protection walls and further flood protection buildings in the public space.

Over the last decades the Senate spend around 1.7 Milliard Euro for measures related to flood protection. The flood protection for Hamburg consists mainly of three parts: (i) mostly there are dykes with a length in total of 78 kilometres; (ii) in addition there are flood protection walls of around 25 kilometres length in use and individual buildings (e.g. sluices and flood gates); furthermore (iii) private flood protection has become a topic over the recent years.

To ensure an easy shipping access to the Hamburg harbour, the Elbe estuary is not protected by a surge barrier, and hence the city of Hamburg is sensitive to tidal dynamics. The semidiurnal tides cause changes in water level of about 3.5 to 4 metres up to a high tide water level of +2.1 m NN (mean sea level). Hamburg occasionally experiences storm surges particularly during winter, in which case the high tide water levels might increase up to +5 to +6 m NN. The major flood of 1962 with a peak of +5.70 m NN caused a huge loss of human life, and material loss. Still, about 20 % of the Hamburg citizens are living in low lying areas, and with 342 km² about 45 % of the city’s area is lying deeper than the valid storm surge “Bemessungswasserstände”.

The city of Hamburg has increased its flood protection levels by implementing a major dyke improvement program. Furthermore, the city is constantly adapting the dyke heights and flood protection walls to the requirements. These are redefined at intervals of a few years, most recently in the parliamentary publication Drucksache 20/5561 "Flood protection in Hamburg"



(2012). The reinforcement of public protection structures is a key storm flood protection project according to the HPC, because these are what provide Hamburg with permanent protection from the expected local effects of climate change with its – anticipated – increased storm surge risk and rising sea level. The LSBG calculated with an additional 80 cm in the “Bemessungswasserstand” to take a rising sea level up the year 2100 in account, soon to be upgraded from +7.30 m NN to + 8.10 m NN (Pegel St. Pauli) resulting from recent research on expected local sea level rise.

Not just in relation to the companies located in the harbour area, but also for private housing as the city is growing in areas formerly used as harbour areas, e.g. the HafenCity, coastal flood protection is indispensable. Both companies and residential area are built in front of the cities flood protection constructions. Therefore, new ways of flood defence had to be developed and to be included in the planning of new buildings and infrastructure.

The HafenCity, a part of the former harbour being transformed into a new residential, office and retail area, is one of Europe’s largest urban regeneration projects. According to the master plan, the HafenCity will be an attractive living environment in the heart of the city closely connected to the water. In an area with around 5.800 flats, 12.000 inhabitants and 45.000 jobs the flood defence structures are an urgent need. Especially in the HafenCity there has been a new approach for buildings in the flood prone areas within the city. Rather than building a dyke around the HafenCity, Hamburg developed a mix of innovative strategies to manage flood risk. The HafenCity will be protected stepwise by a “Warftenkonzept” (Drucksache 20/5561, 2012). Buildings have been placed on dwelling mound to keep them protected, even in the event of severe floods.

In addition to public flood protection, the private flood protection in the port was strengthened after the so far highest storm surge on 3rd January 1976. About 118 km private flood protection systems were built in the harbour and today approx. 100 km private flood protection systems enclose 40 polders with an aerial of about 2.200 ha.

Included in the considerations on innovative flood protection, the Senate is following an additional approach. Flood protection buildings in the centre of the public attention should not only be designed as pure protection. They should also enrich the cityscape. Hamburg is committed to sustainable urban development which means making more efficient use of the scarce spaces within the existing built-up environment. Flood protection infrastructure should also be designed to fit in the public space and work as public space. Thus, Hamburg aims to implement multipurpose flood protection infrastructure where the inhabitants and tourists have access. Urban planning solutions for such a kind of construction are the flood protection systems on the Elbe island Finkenwerder and Wilhelmsburg, and the multi-purpose flood protection infrastructure in the “Niederhafen” and “Binnenhafen” at the Hamburg harbour. These flood protection systems have been new designed and reconstructed over the last years and are widely accepted by the public as public space. Moreover, thousands of tourists as well as Hamburg citizens are attracted by this infrastructure within the city in order to visit the harbour and do sightseeing on an elevated save Harbour-Promenade.



Actions implemented

According to the Integrated Coastal Zone Management (ICZM) and the Hamburg Climate Plan (HPC), a diversity of administrative and private actions is being implemented, managed and monitored and evaluated. Four outstanding examples are described next. Corresponding to a focal point of the EU Floods Directive, provision of information to increase the public awareness about tidal processes and their risks are integral part of all mentioned flood protection actions.

Pilotproject “Kreetsand” – Development of a shallow water area

A cross-sectoral key project that combines economy with ecology, coastal flood protection and education is the creation of a shallow water area in a former flushing field in the foreland of the Elbe estuary in Hamburg.

The project is aimed to safeguard the seaward accessibility of the Port of Hamburg under changing hydrodynamic conditions in the tidal Elbe. Since the future sustainability of the harbour depends on sediment management strategies, the sediment load has to be stabilized in order to reduce the quantities and costs for dredging. An optimised sediment management that lessens the tidal action and the upstream transport of sediment which this causes will be implemented.

On the Elbe island Wilhelmsburg, an approx. 42 ha shallow water area where the tide can rise and fall freely is being created jointly by the HPA and the German Waterways and Shipping Administration (WSV). Due to the additional tidal volume of approx. 1 million cubic metres, the tidal processes are reduced and the harbour benefits from a reduction in sedimentation. At the same time protected habitat types, e.g. Tidal White Willow Softwood Forests (91E0*) and species e.g. the Elbe water dropwort (*Oenanthe conioides*) according to the Habitats Directive, are expected to evolve and will benefit from the restored tidal dynamics in the Elbe foreland.

Public relations that aim to enhance public awareness of tidal dynamics is being implemented e.g. by the installation of the dyke booth, an information location that is being frequently visited by locals and tourists. Moreover, expert-groups are visiting the site frequently in order to learn from the experience gained in this pilot project.

Ecological preservation that serve for both nature and human

According to the HPC actions to maintain biodiversity, to ensure the productive and functional capacity of the environment and to maintain the diversity, uniqueness and beauty of nature and the landscape have to be implemented. These actions shall also buffer climate changes and weather extremes and guarantee human relaxation and recreation in the long-term.

Some of the actions taken are the restoration of the tidal flow in some structures of the Biotop-Network Hamburg. According to the Integrated Management plan Elbe estuary (IMP) the



revetments are lowered at some locations to allow tidal flow in the foreland for fish nursery and tidal wetland and tidal forest restoration e.g. Obergeorgswerder, Wrauster Bogen, Zollenspieker.

A large action implemented is the restoration of the tidal flow in the Borghorster Elblandschaft (224 ha). This area is located in front of the main dyke line but has been disconnected from the tidal flow due to the construction of a frontline dam during building the upstream tidal Elbe barrier in Geesthacht. The frontline dam was slotted and a sluice has been installed in order to allow a controlled tidal flow up to 4.5 m into the Borghorster Elblandschaft for the recovery of tidal habitats like worldwide unique tidal freshwater mudflats, reed stands and tidal forests.

This protected area has been restored as an outstanding example for the representation of the habitat's that are characteristic for the Tidal Elbe landscape. Thus, an information platform has been installed to increase the public understanding for tidal processes and habitats. Furthermore, many pathways cross the area and serve for recreation and recovery of visitors' health which may like to escape the increasing heat stress and hot summer days in the city.

Hafencity "Warftenkonzept"

The HafenCity is located south of the main Hamburg dyke that is thus not protecting the district against flooding. To maintain the districts charm at immediate proximity to water combined with flood protection, all new buildings stand on artificial bases eight meters above sea level - out of reach of the most extreme flooding what is referred to as the "Warftenkonzept". The private developers of buildings are responsible to put these artificial compacted bases in place, so their number is growing as the number of buildings increases.

By elevating the buildings on dwelling mounds made of compacted fill ("Warften", german: traditional flood-secure dwelling mound used along the coast), it has been possible to connect HafenCity with the existing city area and develop it step by step. All roads and bridges are similarly built above the flood-line. Thus, the HafenCity can continue to function even during flooding despite its "island" situation.

The HafenCity also serves as a prominent tourist destination. The historic quays have been restored and a strip up to 15 m wide is down at the existing 4,5 to 5.5 m level of the HafenCity area and provides 10.5 km of waterside walks. This is part of a lot of public urban space like squares and promenades right next to the water. Thus, the "Warftenkonzept" is also allowing a new topography to take shape which contributes to the character and quality of the district.

Multi-purpose flood protection structure – the Harbour-Promenade

Newly built multi-purpose quay walls along the harbour including architectonical accents with conical stairs to sit down and enjoy the atmosphere serve as Hamburg's popular Harbour-Promenade for both citizens and tourists. There is also added value like a parking level and places designated e.g. for restaurants, cafes and kiosks.



The multi-purpose structure is the flood protection wall (1.2 km long; heightened from +7.2m to +8.6-8.9m) that was redesigned by an award-winning architect office and constructed by the LSBG. In order to manage various needs of different stakeholders in spatial planning and flood risk management (e.g. harmonisation of the Water 2000/60/EC and Floods Directive 2006/60/EC) rural and urban areas like the Hamburg harbour are increasingly designed as multi-purpose and public spaces.

Outlook

Recently, the IPCC Special Report (2018) shows that “Human activities are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels” and “Global warming is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate”. The climate-related risks also depend on the geographic location and on the implementation of adaptation and mitigation options. The risks from global warming of 1.5°C call for system transitions by adaptation and mitigation, policy instruments, and the accelerated technological innovation and behaviour changes.

The harbour city Hamburg, located along the Elbe estuary closely connected with North Sea, is conscious of its global and regional responsibility and aims to become a “Climate Smart City”. To both mitigate and adapt to climate change the Hamburg Climate Plan (HPC 2015) as the city’s policy instrument was created. On the long-term up to 2050, it is aimed to develop the city into renewable city adapted to climate change by participation of all stakeholders, and by implementing flooding protection to avoid damage from the effects of climate change to the greatest degree possible.

The rising sea level, further increases in the tidal range and the predicted lower water volumes from upstream during summer will cause a rising upstream sediment transport that may threaten the existence of the Hamburg port. Shallow water areas are being created for both more sustainable sediment management and ecological valuable water retention room as an ecosystem-based approach to adapt to effects of climate change. The related Pilotproject Kreetsand is already implemented whereas another large measure, the managed realignment Ellerholz on the Elbe island Wilhelmsburg, is recently discussed and may be implemented in the further future.

Future coastal management in Hamburg requires multiple benefits in particular where space is scarce as in the city centre and ports boundaries. As suggested by the IPCC special report (2018), more technological innovations have to be implemented, e.g. like the multi-purpose flood protection walls that serve as public space and tourist attraction in the Hamburg Niederhafen and similarly with the Klütjenfelder Hauptdeich, a space to rest and chat in Wilhelmsburg.



Overall, communication and information exchange among planning parties and residents plus involvement of external stakeholders in areas with various spatial requirements including tourism are crucial for future coastal management to adapt to climate change. Tourism is one of the most highly climate-sensitive economic sectors including sun-and-beach tourism and nature-based tourism that play a major role in the North Sea region. To sustain tourist activities in the North Sea region which occur mainly in the coastal zones that are highly vulnerable to the impacts of climate change future coastal management should be based on an integrated ecosystem-based approach. It is suggested to integrate tourism as an action area in the Hamburg Climate Plan particularly since coastal tourism is the largest component of the tourism economy worldwide.

References

1. Hamburg Climate plan – Report by the Senate to the Hamburg Parliament; 2015; <https://www.hamburg.de/contentblob/9051304/754a498fcf4e4bbf9516e1f9a99e2bfe/data/d-21-2521-hamburg-climate-plan.pdf>
2. Integriertes Küstenzonenmanagement in Deutschland; <http://www.ikzm-strategie.de/>; accessed at latest 9.11.2018
3. IPCC Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and sectoral aspects. Working Group II Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Field, C.B., Barros, V.R., Dokken, D.J., Mach, K.J., et al. (eds). Cambridge University Press
4. Kreise, E., von Bergner, N.M., Maukamp, C.; 2016; Socio-economic Impacts - Recreation. In: M. Quante and F. Colijn (eds.), North Sea Region Climate Change Assessment, Regional Climate Studies, DOI 10.1007/978-3-319-39745-0_17
5. Natura 2000 – Management Planning for the Elbe Estuary; <https://www.natura2000-unterelbe.de/english.php>
6. Integrated Management Plan for the Elbe Estuary; https://www.natura2000-unterelbe.de/media/downloads/IBP_engl_mit_Titel_72dpi_RGB.pdf
7. Tideelbekonzept; Meine, M.; 2009; https://www.iba-hamburg.de/fileadmin/contentdateien/beteiligungsgremium/091124_tideelbekonzept_M_Meine.pdf
8. Mitteilung des Senats an die Bürgerschaft; Drucksache 20/5561; 2012; <https://www.landtag.nrw.de/portal/WWW/dokumentenarchiv/Dokument/GGD20-5561.pdf>
9. Neubau der Hochwasserschutzwand Niederhafen; LSBG; <https://lsbg.hamburg.de/gewaesser-und-hochwasserschutz/4484680/niederhafen/>
10. Sturmflutschutz in Hamburg; Report LSBG; 2012; <https://www.hamburg.de/contentblob/3286388/1822cf666737349331ec6e88b8e2ce58/d/ata/sturmflutschutz-broschuere.pdf>



11. IPCC; 2018; Summary for Policymakers. In: Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [V. Masson-Delmotte, P. Zhai, H. O. Pörtner, D. Roberts, J. Skea, et al. (eds.)]. World Meteorological Organization, Geneva, Switzerland, 32 pp.
12. Entwicklungen im Küstenschutz aus technischen und gesellschaftlichen Gesichtspunkten; Müller, O.; LSBG/TUHH; 2017;
https://www.wasserverbandstag.de/fileadmin/user_upload/Intern/Tagungen/Mitgliederversammlung/2017-11-13_MV_Entwicklung_Kuestenschutz_-_Dr._Olaf_Mueller.pdf
13. HafenCity Hamburg Concepts Infrastructure Flood Protection; Flood-secure bases instead of dikes: safe from high water in HafenCity;
<https://www.hafencity.com/en/concepts/flood-secure-bases-instead-of-dikes-safe-from-high-water-in-hafencity.html>; accessed at latest 12.11.2018