Climate Change Adaptation Strategy

Bremen.Bremerhaven.

Summary

BREMEN
BREMERHAVEN
TWO TOWNS. TOGETHER!

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Imprint

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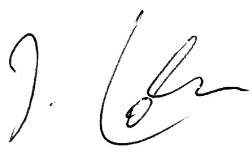
Preface

Dear readers,

The global climate is changing. Changes are also being felt in the State of Bremen and its two urban communities of Bremen and Bremerhaven. Difficult international climate negotiations highlight just how important it is to take independent and responsible action at a local level. It is for this reason that we have been pursuing a very ambitious climate protection policy for many years. In this way, the State of Bremen and its cities are contributing towards the mitigation of global warming. Extreme weather events, which we have all experienced in the media or at first-hand, are one example of the consequences of climate change. In addition to extreme weather phenomena, however, we can also expect to see subtle, gradual changes, such as wetter autumns and winters and longer dry spells in the summer. We need to systematically prepare ourselves for these consequences. The Bremische Bürgerschaft (state parliament) therefore adopted the Bremen Climate Protection and Energy Act in 2015. This legislation enshrined the commitment to develop a strategy for adapting to the consequences of climate change.

The climate change adaptation concept set out here provides a specific programme of action for policymakers and administration that seeks to ensure that our state and its urban communities can develop resilience to the consequences of climate change and reinforce the personal protection of our population. The key measures described represent the main courses of action. Protection of the population by means of healthcare provision, flood protection and protection against heavy rainfall, as well as the long-term improvement of the amenity value in our cities through open space planning and urban green areas are important action areas in this context. Some measures have already been set in motion. We now need to continue to build on these efforts and resolve to implement the measures set out in this document over the coming years. All activities that serve to mitigate the unavoidable consequences of climate change will yield long-term dividends. They reduce the risk presented by the consequences of climate change for all citizens, help to maintain high-quality living and working conditions in the State of Bremen and seek to preserve the competitiveness of the region.

Sincerely yours,



Dr. Joachim Lohse
Senator for Environment, Urban Development and Mobility

Dr. Susanne Benöhr-Laqueur
City Councillor and Head of the
Bremerhaven Environmental Protection Authority

Introduction

Fig. 03

BACKGROUND AND STARTING POINT

Climate change is measurable – between 1881 and 2016, the mean annual air temperature in Bremen and Bremerhaven rose by around 1.3 °C. Analyses by the Deustcher Wetterdienst predict mean regional warming of around 3.6 °C (range of increase: 2.5–4.9 °C) by the end of the century.[1]

It is also very likely that higher extreme temperatures will occur with greater frequency in future. Moreover, it can be assumed that the frequency and intensity of extreme precipitation events will increase in Bremen and Bremerhaven. Growing seasons and thus phenological seasons are also changing. In the Bremen region, spring, summer and autumn already start much earlier today than they did 30 to 40 years ago. This trend is likely to continue, while winter will shorten. Sea levels are rising, resulting in higher storm-surge water levels and other effects on the coastal water regime.

Fig. 04

Climate protection/climate change adaptation
Climate protection refers to activities that aim to reduce the human impact on climate and thereby prevent further climate change. These measures seek, first and foremost, to reduce the consumption of fossil fuels and the emission of greenhouse gases.

Strategies and measures for climate change adaptation seek to avert or at least mitigate the inevitably negative consequences of climate change. At the same time, these measures also aim to exploit the potential resulting from climate change.

With a view to risk prevention and guaranteeing the provision of essential public services, it makes sense to tackle these long-term challenges early on. The Federal Government has already established a comprehensive framework for strategic development at a state, regional and municipal level, with its adoption of the German Strategy for Adaptation to Climate Change (DAS) in 2008 and the subsequent Adaptation Action Plan. In 2012, the Deutscher Städtetag (Association of German Cities) clearly set out the challenges presented by climate change adaptation in its position paper entitled “Adaptation to climate change – recommended measures to be taken by and for cities”. Like many federal states and large cities, the State of Bremen and its two municipalities have developed a strategy for adapting to climate change. This created a strategic framework with a long-term focus, setting out how both the gradual and sudden consequences of climate change can be addressed.

In the long term, our goal is to preserve favourable living and working conditions and ensure that the region remains competitive even in the face of the climate-related changes that may potentially occur. Addressing concerns specific to the region, the climate change adaptation strategy defines a set of key measures for taking preventive action to mitigate all major consequences of climate change in Bremen and Bremerhaven.

In developing the strategy, it was possible to draw on various project results, experiences and approaches at a local, regional and municipal level (see infobox, right). The knowledge acquired over the course of these projects was incorporated into the overall strategic approach, which encompasses all relevant action areas for both municipalities, based on their individual concerns and scope for action.

Adapting to the consequences of climate change is a long-term challenge for society as a whole. The climate change adaptation strategy for Bremen and Bremerhaven is aimed primarily at public-authority stakeholders. It focuses on what those in the political and administrative sector can do to improve the resilience of the state and municipalities in the face of climate change and to enhance their ability to adapt. This also includes reinforcing personal protection for the population.

FIG. 05

Climate change adaptation activities to date

In developing the adaptation strategy, it was possible to draw on various project results and on the experiences and approaches of various sectors at a local, regional and municipal level. These include, in particular, the results of research projects and pilot projects conducted in the region, for example:

- the KLIMZUG Project nordwest2050 in the metropolitan region of Bremen-Oldenburg, funded by the Federal Ministry of Education and Research (BMBF),
- the projects “Umgang mit Starkregenereignissen in der Stadtgemeinde Bremen” (“Dealing with Heavy Rainfall Events in the Municipality of Bremen”), funded by the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) with the participation of Bremerhaven (KLAS) and the Interkommunale Koordinierungsstelle Klimaanpassung (Intermunicipal Coordination Unit for Climate Adaptation, InKoKa),
- Metropolregion Bremen-Oldenburg im Nordwesten e.V. (Association of the Metropolitan Region of Bremen-Oldenburg),
- urban climate analyses conducted during the creation of the Landscape Programme (LAPRO) for the municipality of Bremen
- the functional specification published by The Senator for Environment, Urban Development and Mobility, entitled “Klimawandel in Bremen – Folgen und Anpassung” (“Climate Change in Bremen – Consequences and Adaptation”)
- the “Climate City Bremerhaven” initiative
- the “aqua-add” INTERREG project, and
- many initiatives by local and regional research institutes and other institutions

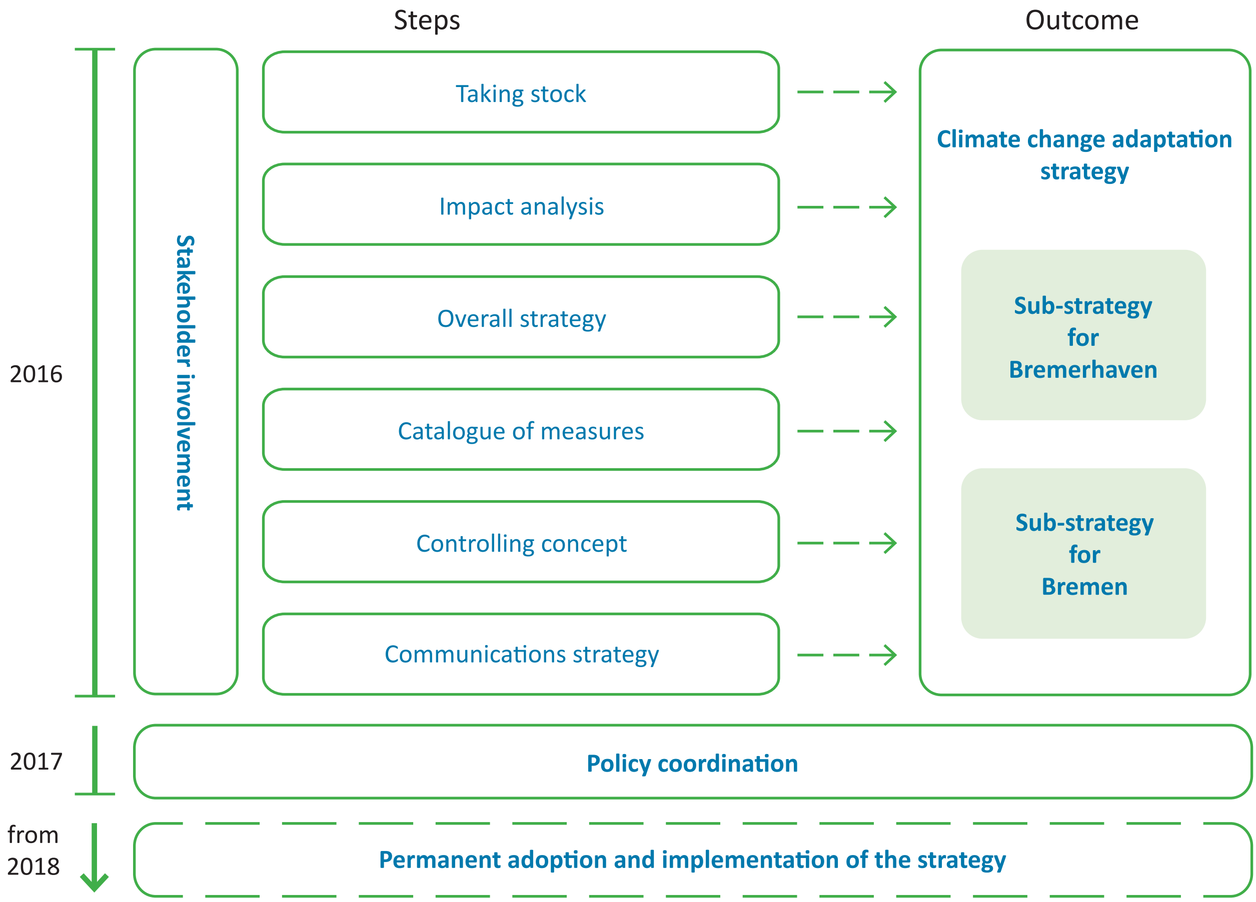


FIG. 06 Project modules and process workflow

ACTION AREAS FOR ADAPTATION

Climate change has many effects on the environment, buildings and communal infrastructures, the economy and urban society. One facet of strategy development was to investigate the sectors in which special challenges are presented by long-term climate changes and the expected increase in extreme weather events. A point of reference was provided by the German Strategy for Adaptation to Climate Change (DAS) from 2008, which defines 13 thematic areas of relevance, in addition to providing a policy framework for actions forming part of climate change adaptation.[2]
The adaptation strategy for Bremen and Bremerhaven centres around the themes of the German Strategy for Adaptation to Climate Change, modifying some of these in accordance with the municipal context. In total, 12 sectors were scrutinised. These are all sectors that could potentially be impacted directly by the effects of climate change (e.g. water management and transport). Alongside these, four cross-cutting sectors were examined, in which there is a higher-level need for provisioning and action in order to adapt to climate change.

Individual sectors

- Construction and real estate
- Traffic and mobility
- Health
- Nature conservation and species protection
- Agriculture and forestry
- Economy
- Soil
- Green areas and open spaces
- Tourism and leisure
- Energy
- Water management
- Ports

Cross-cutting sectors

- Urban and landscape planning
- Disaster control/civil protection
- Education and research
- Development cooperation

FIG. 07

Process and stakeholders

Strategy development was funded as a joint municipal project as part of the Federal Government's National Climate Initiative (NKI). The Senator for Environment, Urban Development and Mobility assumed the leadership role in strategy development and subsequent implementation, working in close cooperation with the Bremerhaven Environmental Protection Authority (Climate City Office). A team of experts, comprising MUST Städtebau (Amsterdam/Cologne), BPW baumgart+partner (Bremen), GEO-NET Umweltconsulting (Hanover) and Dr. Pecher AG (Erkrath), was tasked with providing technical and organisational support.

The strategy process was also supported by the Deutscher Wetterdienst (DWD) in the context of an administrative arrangement with the State of Bremen, as well as by the Alfred-Wegener-Institut (AWI) and the North German Climate Office at the Helmholtz-Zentrum Geesthacht. In terms of administration, both Bremen and Bremerhaven were provided with technical support by an interdepartmental project group.

Building on the experiences of other municipalities and research projects, a process of extensive stakeholder involvement was undertaken as part of strategy development. At the start of the project, a network of stakeholders was identified and assembled. This network represents, as far as possible, all stakeholders with an interest in climate change adaptation, in particular the sectors identified by the impact analysis (e.g. health, water management, nature conservation, urban planning etc.). For this extended circle of stakeholders, various participation formats were developed over the course of the project. A concept for a further communication process for public participation forms part of the strategy.

FIG. 08

FIG. 09

Climate change and its consequences for Bremen and Bremerhaven

FIG. 10

The emission of greenhouse gases and large-scale changes in land use are two examples of how humans have interfered with the Earth's natural climate system. Scientists have used climate models to calculate the consequences of this interference for the global and regional climate, based on various scenarios. Depending on the chosen scenario, an increase in Germany's mean annual temperature of at least 1 °C and potentially more than 4 °C is predicted to occur over the next 100 years. According to climate models, limiting the increase to just 1 °C is only possible if the emission of greenhouse gases is significantly reduced. If economic growth continues in association with high levels of greenhouse gas emissions, we can expect to see an increase in the range of 3 °C to over 4 °C. An increase in temperature will be accompanied by a continued decline in the number of cold and very cold days, while the number of hot and very hot days will rise significantly.

Another probable effect is a continued increase in annual precipitation figures, and thus also a rise in the number of days of extreme precipitation. An increased air temperature is also associated with a rise in sea water temperature. As a result, the water will expand, leading to rising sea levels. The future rise in sea levels along the German coast cannot be adequately quantified at present because it is subject to a significant degree of uncertainty due to the melting of mountain glaciers and continental ice sheets. Recent estimates assume that the North Sea could potentially rise by up to 1 meter or more by the end of the century, based on the "business as usual" scenario.[3]

Weather and climate

In meteorology and climatology, these terms are used to describe processes that unfold in the Earth's atmosphere over varying lengths of time. Weather describes occurrences in the atmosphere in a specific place at a specific time or over a period of several days or weeks. Climate, meanwhile, describes the weather over a period of months, years, decades and longer, including geological ages. The World Meteorological Organization (WMO) defines climate as the "synthesis of weather conditions in a given area, characterized by long-term statistics of the meteorological elements in that area." It is generally understood that these statistics will be recorded over a period of at least 30 years.

Various climate conditions prevail within the individual regions of Germany. The area around Bremen and Bremerhaven – and indeed all of northern Germany – currently experiences cool summers and mild winters, as well as adequate precipitation throughout the year due to its mid-latitude location, characterised by prevailing westerly winds. The weather is changeable due to the frequently alternating high-pressure and low-pressure areas. If a longer period of high pressure were to occur, this would produce warmer, drier weather during the warmer half of the year, and, depending on the location of the high-pressure area, either cold and dry or cloudy and foggy weather during the colder half of the year. The climate is modified locally by climate factors (latitude and longitude, distance from the sea, relief, topography, etc.).

FIG. 11

FIG. 12

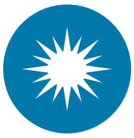
The north-western part of Germany down to the central mountain ranges constitutes a climate region characterised by proximity to the sea, low-lying terrain and only slight differences in altitude.

The following pages provide an overview of climate changes that have occurred in Bremen and Bremerhaven in the past and of future developments, based on the measurements made for the region by the Deutscher Wetterdienst and on climate projections created as part of climate research. The following climate parameters and changes are examined in detail:

- rising temperatures and heat
- heavy precipitation
- shifting precipitation patterns
- storms and storm surges

Climate projections
If a global climate model is used to calculate potential climate change based on a scenario, this is done as part of a climate projection calculation. This is not to be confused with a climate forecast or prediction. It is, rather, a "what-if" calculation based on the chosen scenario. Climate projection calculations for the various climate scenarios help to order the expected climate changes in a spectrum.

Observed climate-related changes



- Increase in average annual temperatures
- More summer days (≥ 25 °C) and tropical nights (≥ 20 °C)
- Longer-lasting and more frequent hot spells

- Increase in the intensity and frequency of heavy precipitation (esp. during the warmer half of the year)

- Drier summers and damper winters
- Longer and more frequent dry spells during summer

- More storms (esp. in winter)
- Higher storm-surge levels (in connection with rising sea levels)

FIG. 13 Summary of the climate-related changes examined as part of the strategy

Rising temperatures and heat

WHAT CHANGES CAN WE EXPECT CLIMATE CHANGE TO BRING?

A definite warming trend can be observed in the cities of Bremen and Bremerhaven. The long-term mean temperature has risen significantly in recent decades (see Fig. 14). This is associated with an increase in the number of summer days (Tmax ≥ 25° C), hot days (Tmax ≥ 30 °C) and tropical nights (Tmin ≥ 20° C).

Despite the fact that Bremerhaven enjoys good ventilation thanks to the prevailing conditions in the North-German lowlands, urban heat islands still develop in the centre of the city. While Bremen is experiencing more hot days and summer days than Bremerhaven, Bremerhaven has recorded a higher number of tropical nights. In both cities, warming during the summer months goes hand-in-hand with a decrease in the number of frost days (Tmin ≤ 0 °C) and ice days (Tmax ≤ 0 °C) during the colder half of the year.

The cities of Bremen and Bremerhaven experience relatively moderate temperatures by German standards. In both cities, the number of temperature threshold days (see Tab. 01) was below the average for Germany as a whole, with approx. 28 summer days and approx. 9 hot days. However, a further increase in temperature is expected for both cities, based on the results of current climate-model calculations. In Bremerhaven, for example, the number of summer days experienced annually is set to triple over the next 50 years.[4]

Urban climate

The climate within a city is markedly different from that which prevails in the open countryside. One particularly well-known result of this is the formation of urban heat islands, caused by dense development and a higher consumption of energy by transport, industry and households than in the surrounding areas. Mean annual temperatures in German cities are significantly higher (by approximately 0.5 °C to 2.0 °C) than in rural regions. This urban-rural divide is most noticeable on clear, sunny days with little wind. Temperature differences in excess of 8 °C are possible in isolated cases. Even in the city, however, different forms of urban heat islands occur, depending on the patterns of construction and usage.

Heatwave

Based on climate models, we can expect to see a rise in the number of heatwaves occurring during the warmer half of the year. In Europe, the term "heatwave" is normally used when the daily maximum temperature exceeds 30 °C for several days in succession.[5]

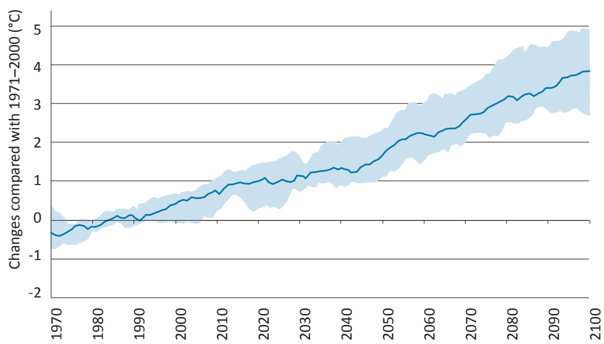


FIG. 14 Bremerhaven: Increase in annual average temperature*

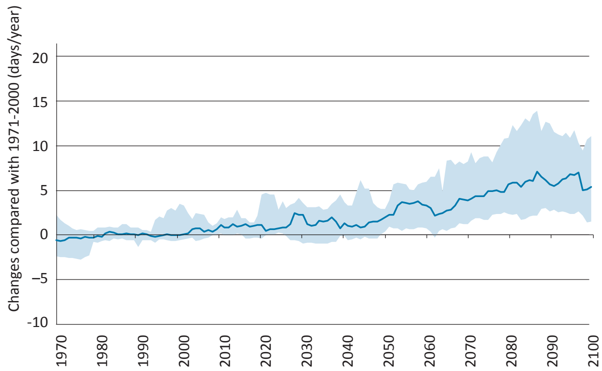


FIG. 15 Bremerhaven: Number of hot days (number of days with maximum temperatures ≥ 30°C)*

*Analyses of eight model chains based on the "business as usual" scenario" RCP8.5 (CNRM-CM5_RCA4, EC-EARTH_HIRHAM5, EC-EARTH_ RACMO22E, EC-EARTH_RCA4, HadGEM2-ES_RCA4, IPSL_RCA4, MPI-ESM_CCLM, MPI-ESM_RCA4)

Days on which weather events occurred	1971-2000		2001-2015	
	HB	BHV	HB	BHV
Summer days (T_{max} ≥ 25 °C)	25.7	16.5	31.2	21.3
Hot days (T_{max} ≥ 30 °C)	4.5	2.4	5.7	3.7
Tropical nights (T_{min} ≥ 20 °C)	0.3	0.9	0.3	1.9
Frost days (T_{min} < 0 °C)	68.5	48.1	68.3	46.7
Ice days (T_{max} < 0 °C)	14.2	13.7	13.4	12.2

TAB. 01 Long-term mean number of event days per year

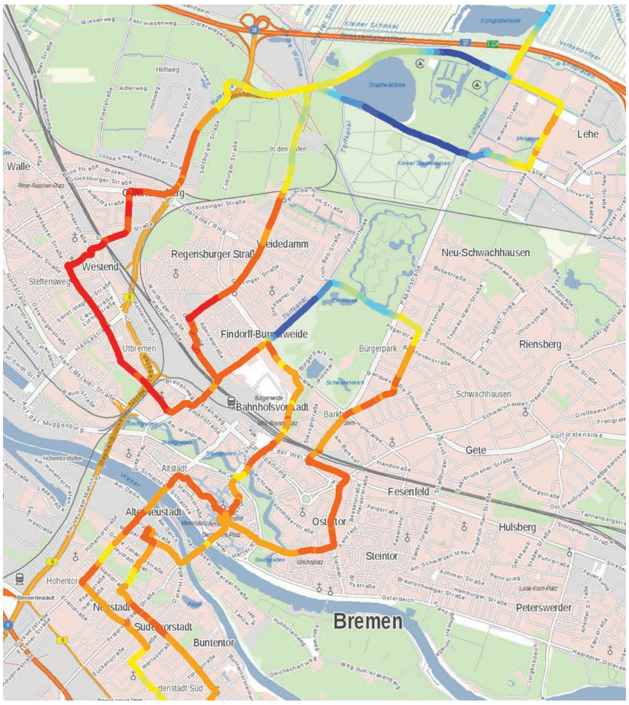


FIG. 16 Profile measurement run in Bremen on 18 August 2012 (evening)

FIG. 17 Profile measurement run in Bremerhaven on 25 August 2016 (evening)

Air temperature at 2.0 m in °C

18.1-18.5, 18.6-19.0, 19.1-19.5, 19.6-20.0, 20.1-20.5, 20.6-21.0, 21.1-21.5, 21.6-22.0, 22.1-22.5, 22.6-23.0, 23.1-23.5, 23.6-24.0, 24.1-24.5, 24.6-25.0, 25.1-25.5, 25.6-26.0

Measurement runs

The urban climate can be analysed by taking stationary or mobile meteorological measurements at various locations around the city and in the surrounding rural areas, or on the basis of model calculations. Establishing a stationary measurement network in the city is associated with a certain degree of cost. As an alternative, temporary or mobile measurement stations are often used to record urban climatological data at selected points in time. The urban climate of Bremen and Bremerhaven has been investigated using meteorological measurements. In the summer of 2012, temporary and mobile measurements were collected to study the urban climate in Bremen. Then, in the summer of 2015, a measurement campaign was undertaken over several months in Bremerhaven, and was enhanced with profile measurement runs in August 2016.

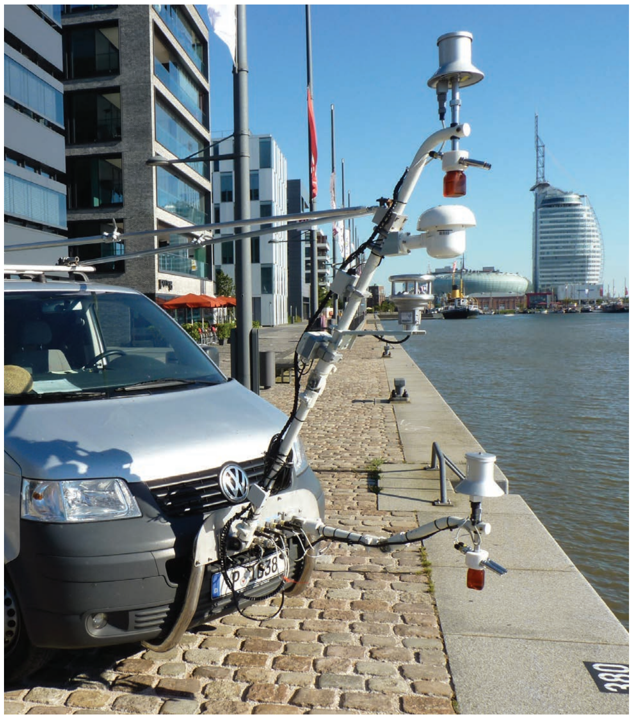


FIG. 18 Measurement-recording vehicle in Bremerhaven

Rising temperatures and heat

WHICH LOCATIONS WILL BE MOST IMPACTED BY THE CHANGES?

At present, city-centre temperatures are higher than those in surrounding areas, and climate change is expected to elevate these temperatures to an even higher level. The municipal area of Bremen currently exhibits a relatively low thermal load at night. Approximately 82% of the general residential building area exhibits favourable or very favourable human bioclimatic conditions (see Fig. 21). If we look at the entire municipal area of Bremen, less favourable or unfavourable human bioclimatic conditions are to be found in 11% of the total area. Highly sealed, commercial and industrial areas in particular are most likely to have the least favourable or unfavourable human bioclimatic conditions.

A climate analysis map of Bremerhaven was created as part of the adaptation strategy, showing the various climatopes in the city. This map was subsequently used as a basis for estimating the areas that experience the greatest thermal loads. The areas that fall into the following climatope categories are particularly affected by thermal load: "urban climate", "city-centre climate" and "commercial and industrial climate". In Bremerhaven, such areas represent 18% of the entire urban area. Measurements recorded by the Deutscher Wetterdienst during the summer months of 2015 confirmed this heat island effect that is at play in the city compared with the surrounding areas. For example, the average difference in the daily maximum temperature amounts to +0.4 °C, while the equivalent night-time value is +1.7 °C.

FIG. 19

FIG. 20

WHAT ARE THE POTENTIAL CONSEQUENCES OF THESE CLIMATE CHANGES?

Changes in climate will have a very wide range of effects. In the heavily populated centres of both urban areas in particular, sealed surfaces with no shade and little vegetation will become very hot, thus negatively impacting amenity value. While the impact of a gradual increase in temperature is felt most strongly by the urban ecosystem (soils, bodies of water, flora and fauna), the most significant effect of the expected rise in hot days and tropical nights will be an increased human-bioclimatic impact due to heat stress. This will place an added burden on the healthcare sector to manage heatwaves in terms of the provision of essential public services (e.g. emergency and nursing services or support for vulnerable members of the population who live alone). In addition, greater demands will be made of the construction sector in relation to maintaining a comfortable indoor climate in heat-exposed buildings and public spaces.

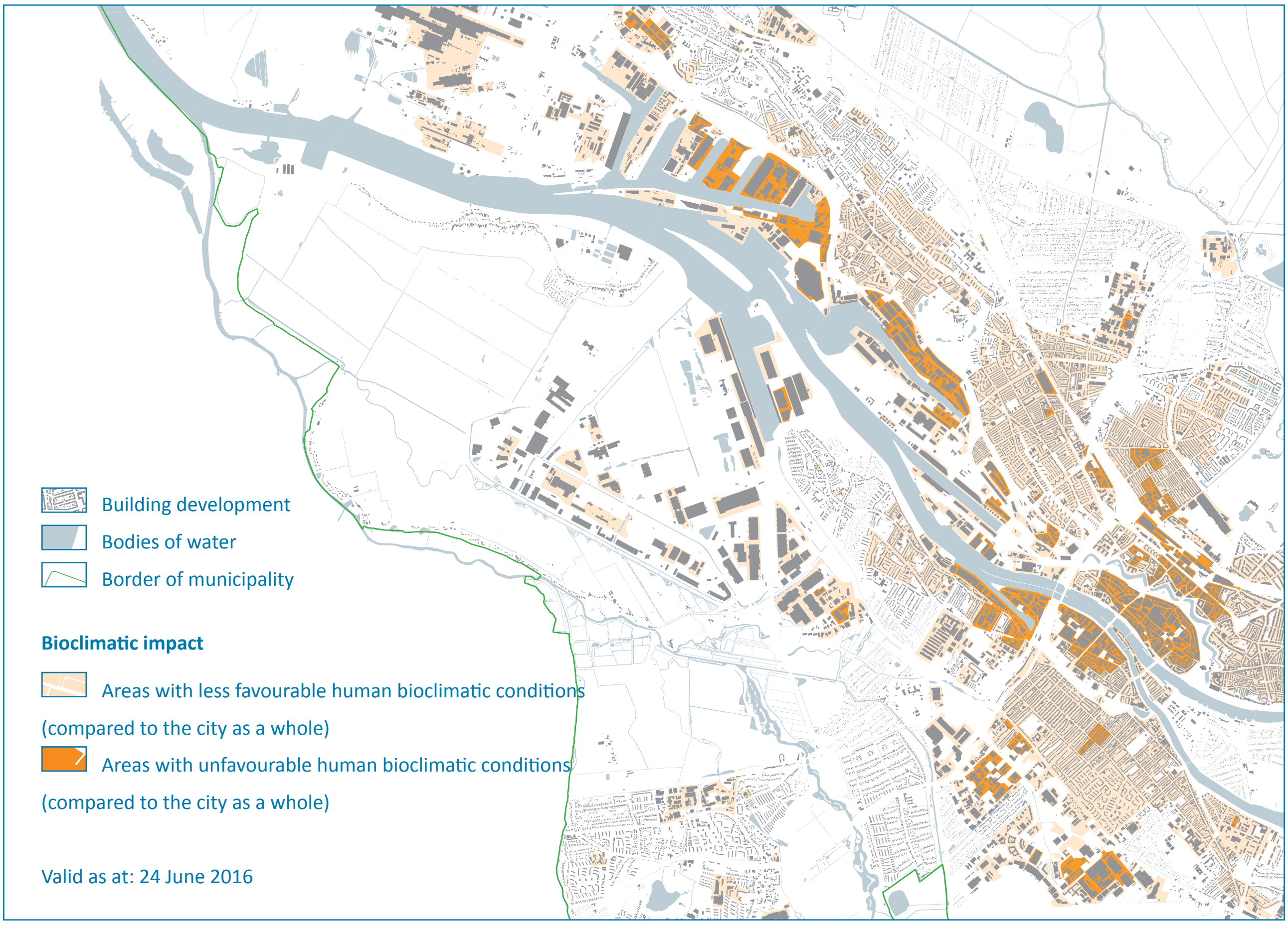


FIG. 21 Potential load on hot days within the municipality of Bremen (map section)

POSSIBLE EFFECTS OF INCREASING TEMPERATURES

- Reduced amenity value in the municipal area, as well as heating-up of traffic areas and open spaces due to increased solar irradiation
- Increasing physical strain and risk of accidents due to heat stress and a reduced ability to concentrate
- Establishment of new and spread of existing pathogenic agents and disease carriers
- A growing demand for energy to cool buildings, equipment and vehicles, with a simultaneous decline in heating requirements
- Wear and tear on green spaces and recreation grounds due to increased solar irradiation and intensive usage
- Increased material stress and damage to transport routes due to heat and temperature fluctuations
- Heat-related damage to goods (storage and transport) and to technical equipment
- Increased odour emissions due to decomposition processes in the sewage system
- Warming and impairment of the physiochemical status and quality of bodies of water
- Shifting species diversity/spread of invasive thermophilic animal and plant species
- Increasing, earlier pest infestations following mild winters
- Damage (e.g. protein coagulation) to heat-stressed vegetation
- Impairment/loss of soil functions due to increased soil temperature
- Growing demand on resources for waste disposal, green waste, monitoring, sewer flushing and irrigation
- A rapidly increasing burden on the healthcare system and funeral services during heatwaves

Heavy precipitation

WHAT CHANGES CAN WE EXPECT CLIMATE CHANGE TO BRING?

Under the climatic conditions that prevail at present, localised heavy precipitation is already causing repeated flooding resulting in significant damage. The particular relevance of this type of damaging event is highlighted by the damage reports produced by the insurance industry.[6] As a result, planning requirements for water drainage systems explicitly specify that the effects of climate change must be taken into account.[7] Measures to make municipal areas more resilient to the effects of heavy rainfall events therefore constitute an important component of this climate change adaptation strategy. Short-term predictions of the locations where heavy rain is to occur are almost impossible. Trend statements based on climate models for individual heavy rain events cannot be made as extensively as for extremes in air temperature, for example. However, an increase in the number of heavy rain days (days on which total rainfall amounts to 20 mm or more) in the medium- to long-term can be inferred for the State of Bremen, based on the underlying climate projection. The latest research indicates that large portions of Germany will experience an increase of more than 30% in the number of heavy rain days with daily rainfall totals exceeding 25 mm by around 2050.[8] This result is robust for the coastal regions along the North Sea.

Heavy precipitation

Heavy precipitation, whereby a large volume of rain falls within a relatively short space of time, is not a frequent occurrence. As well as duration and frequency, the size of the area affected by a heavy precipitation event is also significant.[9] Heavy precipitation may occur in summer or winter. In summer, the precipitation is often convective (heat thunderstorms), with a high volume of rain falling on a small area, usually for a short time only. These events are often associated with heavy gusts of wind and, in some isolated cases, with hailstorms and tornadoes. Cyclonic precipitation, on the other hand, usually lasts several days and normally affects large areas. It also occurs predominantly during the colder half of the year and, depending on the temperature, can also take the form of heavy falls of snow.[10]

The DWD issues two different levels of warnings in advance of heavy precipitation if it expects that the following thresholds are going to be exceeded: Rainfall depth ≥ 10 mm/1h or ≥ 20 mm/6h (significant weather warning) or rainfall depth ≥ 25 mm/1h or ≥ 35 mm/6h (severe weather warning).[11] In climate research, the total precipitation per day is normally analysed. If defined threshold values (e.g. precipitation depth of ≥ 20 mm/d) are exceeded, this is indicative of heavy precipitation.

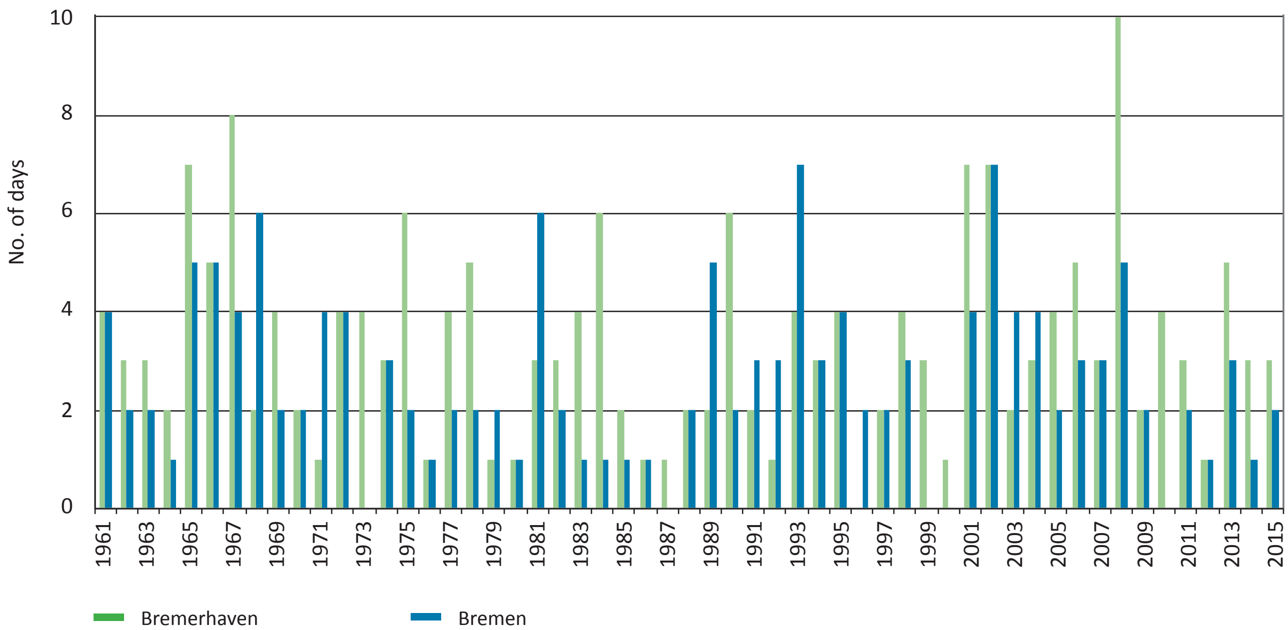


FIG. 22 Number of days with precipitation levels ≥ 20 mm

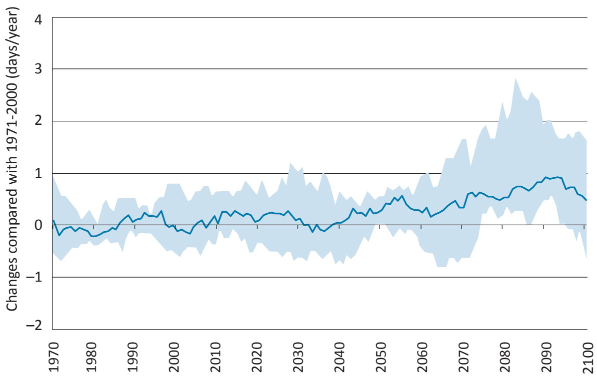


FIG. 23 Bremen: Number of days with P ≥ 20 mm/d*

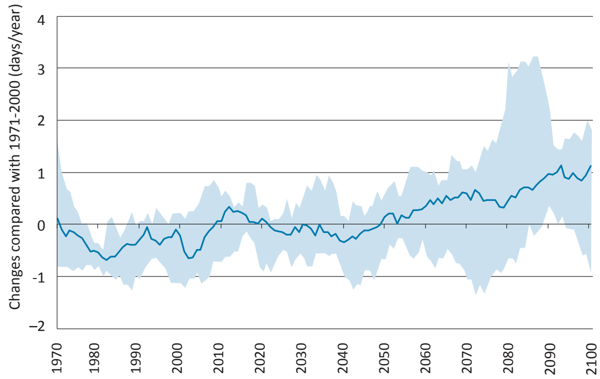


FIG. 24 Bremerhaven: Number of days with P ≥ 20 mm/d*

*Analyses of eight model chains based on the "business as usual" scenario" RCP8.5 (CNRM-CM5_RCA4, EC-EARTH_HIRHAM5, EC-EARTH_ RACMO22E, EC-EARTH_RCA4, HadGEM2-ES_RCA4, IPSL_RCA4, MPI-ESM_CCLM, MPI-ESM_RCA4)

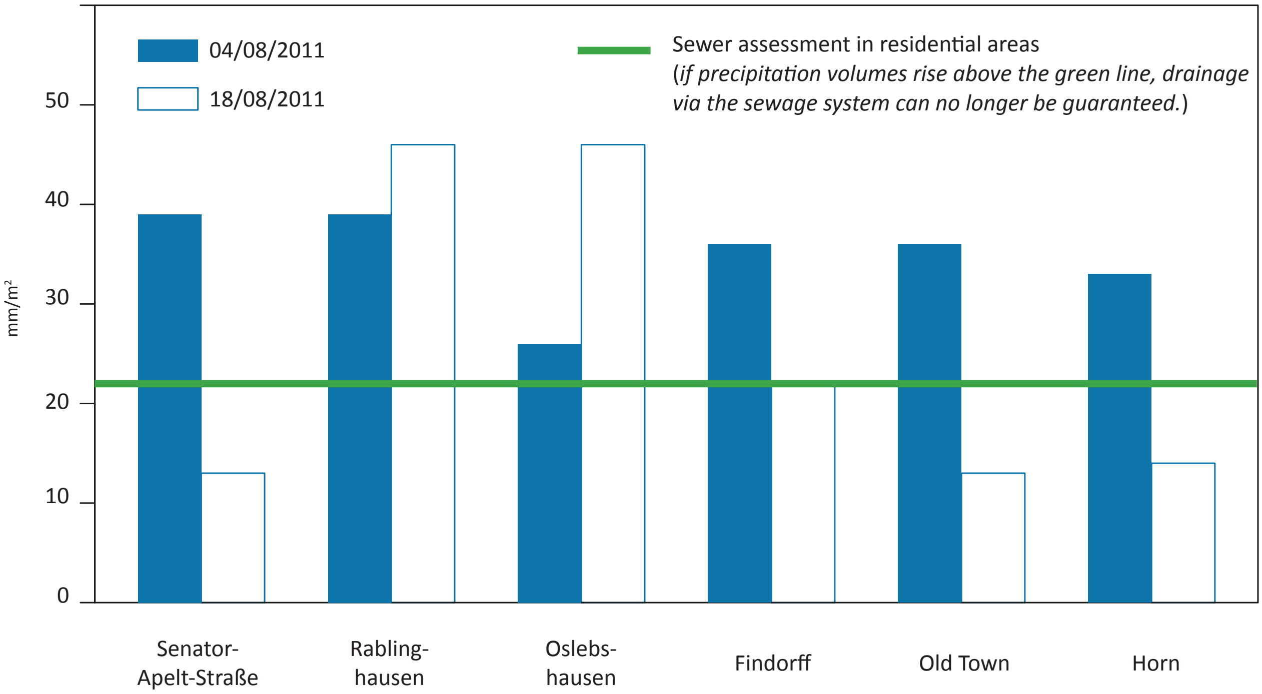


FIG. 25 Heavy precipitation for 90 minutes during storms in Bremen in August 2011 (Cyclone René and Cyclone Xaver)

FIG. 26 Flooded streets in Bremen

Heavy precipitation

FIG. 27

FIG. 28

FIG. 29

WHICH LOCATIONS WILL BE MOST IMPACTED BY THE CHANGES?

The effects of a heavy rainfall event can, in principle, be felt in every part of the city. It is not currently possible to pinpoint precise areas of impact with precision. However, the results of flooding analyses (see Fig. 30) at least enable a relative classification of potential flood damage due to heavy rainfall. As the municipalities of Bremen and Bremerhaven are located in a low-gradient region, they are exposed to a potential risk of flooding in low-lying urban areas, rather than a risk of storm surges. Surface runoff simulations provide valuable information when the results of these are superimposed on the location of structures that are particularly sensitive (e.g. hospitals, power supply installations) or low-lying (e.g. underpasses or garages). Such risk analyses have already been initiated in the municipal area of Bremen. Surface runoff analyses were also conducted for Bremerhaven as part of the impact analysis for the climate change adaptation strategy. Further analyses and measures based on theses are already in the pipeline.

WHAT ARE THE POTENTIAL CONSEQUENCES OF THESE CLIMATE CHANGES?

The expected rise in the frequency and intensity of heavy rainfall events increases, in particular, the risk of flood damage to buildings, commercial property and infrastructure. The energy sector in particular, but also traffic infrastructure, are particularly vulnerable in this context because supply shortages and disruptions to traffic flow may occur in areas of both cities as a result of flooding. Rising average temperatures and altered precipitation patterns have an effect on all dimensions of the water cycle. Via the water balance, the resulting increase in evaporation and the impact on surface runoff affect groundwater increase. Rising volumes of heavy precipitation also increases the risk that soils and bodies of water will be contaminated due to the entry of pollutants and nutrients, as well as by erosion. For example, flooding of agricultural areas, storage tank facilities or industrial sites may result in hazardous substances being released into the environment.

FIG. 30 Potential flooding in connection with heavy rainfall in the municipality of Bremerhaven (map section)

POSSIBLE EFFECTS OF HEAVY PRECIPITATION

- Congestion of the sewage network as a result of heavy precipitation exceeding the established thresholds
- Flooding and damage of private and public buildings and property
- Damage to and failure of vehicles and traffic management systems due to flooding or undermining
- Outage of supply facilities and networks (energy, water, heat and telecommunications)
- Damage to an outage of industrial and commercial property due to flood damage
- Loss of and damage to equipment or assets due to flooding or hail
- Increased demand on resources for the maintenance of bodies of water and for municipal cleaning
- Increased runoff into bodies of water
- Release and distribution of hazardous substances due to flooding and the displacement of suspended matter
- Damage to and loss of soil functions due to erosion and the entry of pollutants
- Personal injury due to water entering buildings or deep pooling
- Risk of accidents caused by aquaplaning and displaced manhole covers
- Increased demand on resources and increased strain on rescue services and fire brigade
- Impairment of the physiochemical status of bodies of water due to hydraulic, biological or material contamination
- Damage to vegetation/crops due to increased waterlogging
- Increase in pump output and in energy consumption by pumping stations

Shifting precipitation patterns and drought

WHAT CHANGES CAN WE EXPECT CLIMATE CHANGE TO BRING?

As in many other regions of Germany, mean annual precipitation totals have been on the rise in Bremen and Bremerhaven in recent decades (see Fig. 31). Precipitation volumes in winter and autumn in particular have increased. Future projections point towards a continued, slight increase in annual precipitation totals. In terms of seasonal variations, it is assumed that precipitation will continue to rise during autumn and winter but will decline during the summer months (see Fig. 32 and 33).

Shifting precipitation patterns and increasing dry spells will have a noticeable effect on the local water balance in Bremen and Bremerhaven. Wetter winter months, in conjunction with rising temperatures, will lead to increased runoff into bodies of water. During the summer months, in contrast, higher rates of evaporation and the expected change in precipitation patterns (less frequent but more intense precipitation events) are associated with a decrease in natural water resources. Longer and more frequent dry spells are expected.

Drought

Generally speaking, drought refers to an extended absence or significant shortage of precipitation or a sufficiently long period of extremely dry weather, such that the lack of precipitation causes a serious hydrological imbalance.[12]

The term "dry day" is used to describe a day on which total precipitation is less than 1 mm.[13] However, there is no standard specification of how many days of very little to no precipitation must occur in succession before this can be described as a "drought". This depends on the water requirements of the region in question and therefore may begin after just a few days during the warm season. In winter, lower air and soil temperatures result in significantly reduced evaporation, so that it is difficult for a genuine drought to take hold despite low levels of precipitation persisting for a month. Groundwater levels and water levels in rivers must also be taken into account. If these levels are sufficiently high prior to a period of little to no precipitation, it will, accordingly, take longer for a period of drought to take hold.

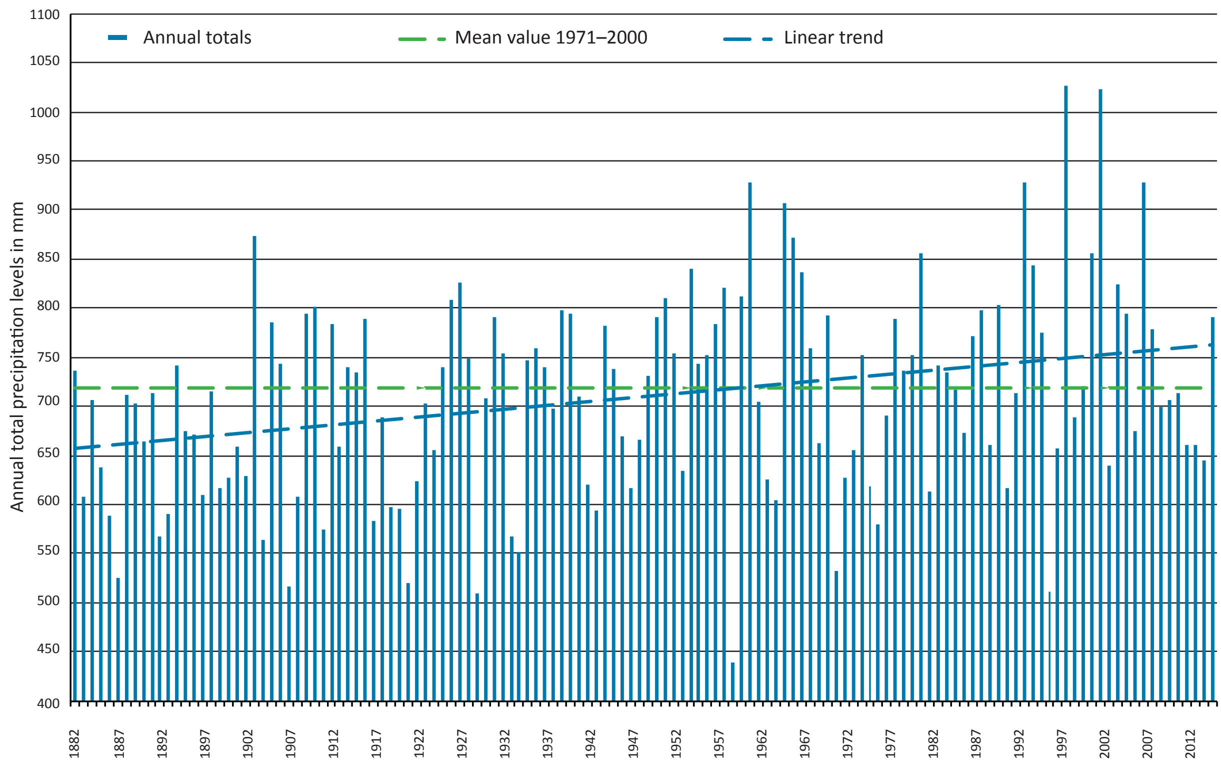


FIG. 31 Mean annual total precipitation level (area average for the State of Bremen)

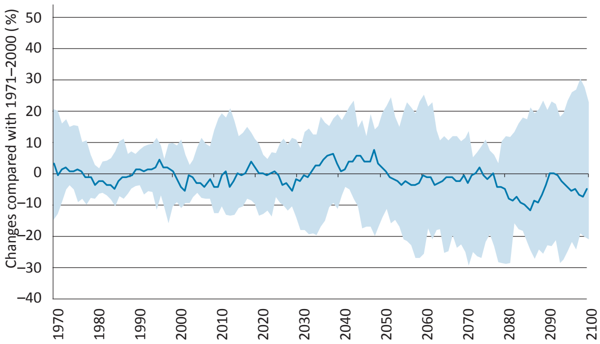


FIG. 32 Bremen: Change in mean total precipitation in summer*

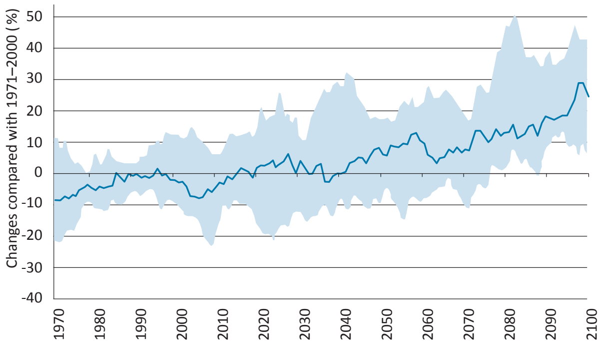


FIG. 33 Bremen: Change in mean total precipitation in winter*

*Analyses of eight model chains based on the "business as usual" scenario" RCP8.5 (CNRM-CM5_RCA4, EC-EARTH_HIRHAM5, EC-EARTH_ RACMO22E, EC-EARTH_RCA4, HadGEM2-ES_RCA4, IPSL_RCA4, MPI-ESM_CCLM, MPI-ESM_RCA4)

FIG. 34

FIG. 35

FIG. 36

WHICH LOCATIONS WILL BE MOST IMPACTED BY THE CHANGES?

Bremerhaven faces a particular challenge in light of these altered conditions in terms of the drainage of coastal lowlands. Seasonally, however, the volume of water to be drained can also swell considerably within much shorter periods of time due to heavy precipitation. In Bremerhaven, this applies in particular to the River Geeste, but also to the Weser river system. On the other hand, longer and more frequent dry spells during the summer months can lead to a temporary reduction in runoff.

Climate change is also expected to impact groundwater levels. The Geologischer Dienst für Bremen (the Geological Service for Bremen, GDfB) has made initial calculations based on forecasting data relating to groundwater recharge up to the year 2100. The first model results predict that the remainder of the 21st century will see only small changes in groundwater levels, on average, for the urban area of Bremen that was modelled (excluding the Bremen-Nord area). However, these results do not take account of the potential influence of rising sea levels. In Bremen-Nord, it is expected that the lower groundwater recharge rates will result in reduced groundwater levels, in particular on the higher-lying geest ridge. However, it is expected that this will be compensated for by a rise in the level of the Weser. The influence of river water on the groundwater level will increase in this area.

In the municipality of Bremerhaven, the rise in sea levels has already been taken into account in groundwater model calculations. These indicate that the influence of sea water on groundwater levels is likely to extend further inland in future (see Fig. 38).

Further analyses are required in order to yield more detailed information about future groundwater levels and the consequences of these. This is particularly true in relation to the potential effects of rising sea levels on groundwater levels in the municipality of Bremen and the calculation of the minimum and maximum seasonal groundwater levels for both Bremen and Bremerhaven.

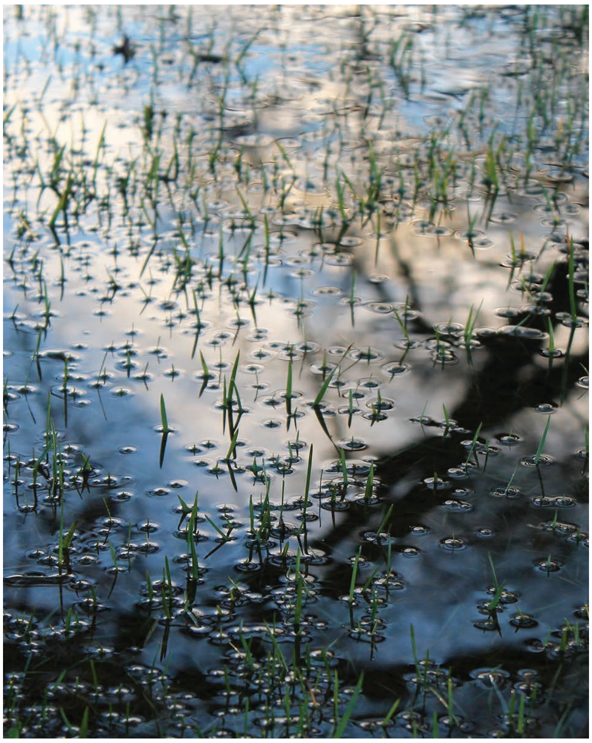


Fig. 37

WHAT ARE THE POTENTIAL CONSEQUENCES OF THESE CLIMATE CHANGES?

Stronger fluctuations in groundwater levels may have negative consequences, above all for building ground and constructions, in the form of subsidence and moisture penetration. The altered groundwater balance presents new challenges, in particular in terms of soil protection and water management (especially in areas of moor and marshland). Finally, the rise in the low-tide water level due to climate change will reduce the difference between the water levels of the North Sea and lower Weser and the water levels on the inland side of the tide gates. As a result, less water can be drained by means of natural inland runoff, meaning that more water will need to be pumped.

The potential increase in drought periods and their influence on irrigation also has implications for farming and for urban green spaces. More prolonged periods of drought, together with the general rise in temperatures, represent the main causes of a long-term deterioration in growth and survival conditions for native urban vegetation. Therefore, tree and plant species with a greater tolerance of heat and drought will need to be selected in future.

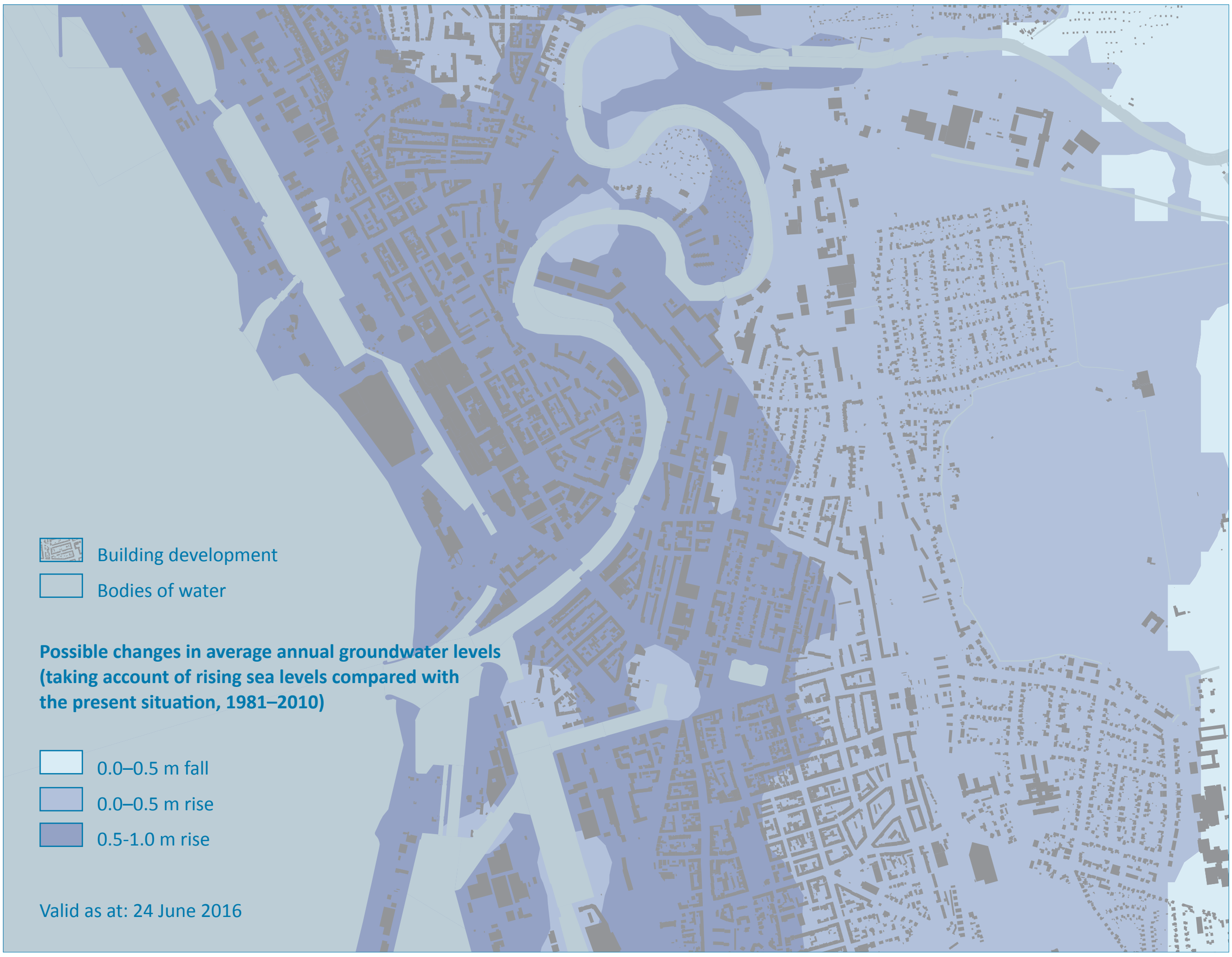


FIG. 38 Potential fall and rise in groundwater levels in the municipality of Bremerhaven for the scenario 2017-2100 (map section)

POSSIBLE EFFECTS OF SHIFTING PRECIPITATION PATTERNS

- Damage to buildings and infrastructure due to changes in soil and groundwater levels in conjunction with rising sea levels
- Corrosion and buildup of deposits in the sewage system, as well as odour pollution from sewers during periods of drought
- Declining water quality due to lengthy periods of drought and low water levels
- Damage to and loss of green spaces and trees due to drought stress and waterlogging
- Risk of fire and falling branches due to drought
- Pest infestations and fungal diseases affecting trees due to increased humidity
- Spread of invasive thermophilic animal and plant species
- Increased requirements for watering, monitoring and care of green spaces and city trees
- Eutrophication of bodies of water due to the erosion of dry soils (esp. in areas on the urban fringe)
- Establishment of new and spread of existing pathogenic agents and disease carriers
- Reduced output by power plants arising from restricted access to cooling water due to drought
- Restrictions on inland waterway transport due to high and low water levels
- Negative impact on industrial/agricultural production due to water shortages
- Changes to the filtering, buffering, habitat and production functions of soils due to fluctuating water balances
- Hydrochemical changes (salinisation) of groundwater in connection with rising sea levels

WHAT CHANGES CAN WE EXPECT CLIMATE CHANGE TO BRING?

Bremen and Bremerhaven have already borne the brunt of severe storm events several times in the past. Bremen is at particular risk if flood waves on inland bodies of water coincide with heavy storm surges after heavy rainfall.

Although there has not yet been any systematic change in the wind climate over the North Sea, climate calculations for the future indicate that North Sea storms could become more severe in winter. Current climate projections do not allow us to draw clear conclusions about future changes to the frequency and intensity of storm events.

However, a further rise in sea levels in future seems to be relatively certain (see Fig. 42). In the long term, water levels will primarily be determined by the melting of inland glaciers, the great ice sheets in Greenland

STORMS AND STORM SURGES

Storms

In meteorology, the term “storm” includes air currents that exceed a strength of 8 on the Beaufort Scale (approx. 17-21 m/s).[14] These are also known as “gales” and may be caused by areas of low pressure with high wind speeds and, in some cases, intense precipitation, or by high winds in conjunction with thunderstorms. The insurance industry defines storms as weather-related movements of air that must reach speeds of at least 60 km/h at the insured location.[15]

Storm surges

A storm surge is a temporary rise in sea level caused by a storm with onshore winds. Storm surges occur more frequently in coastal regions during spring and autumn, resulting from an increased water level due to wind surges and high waves.[16]

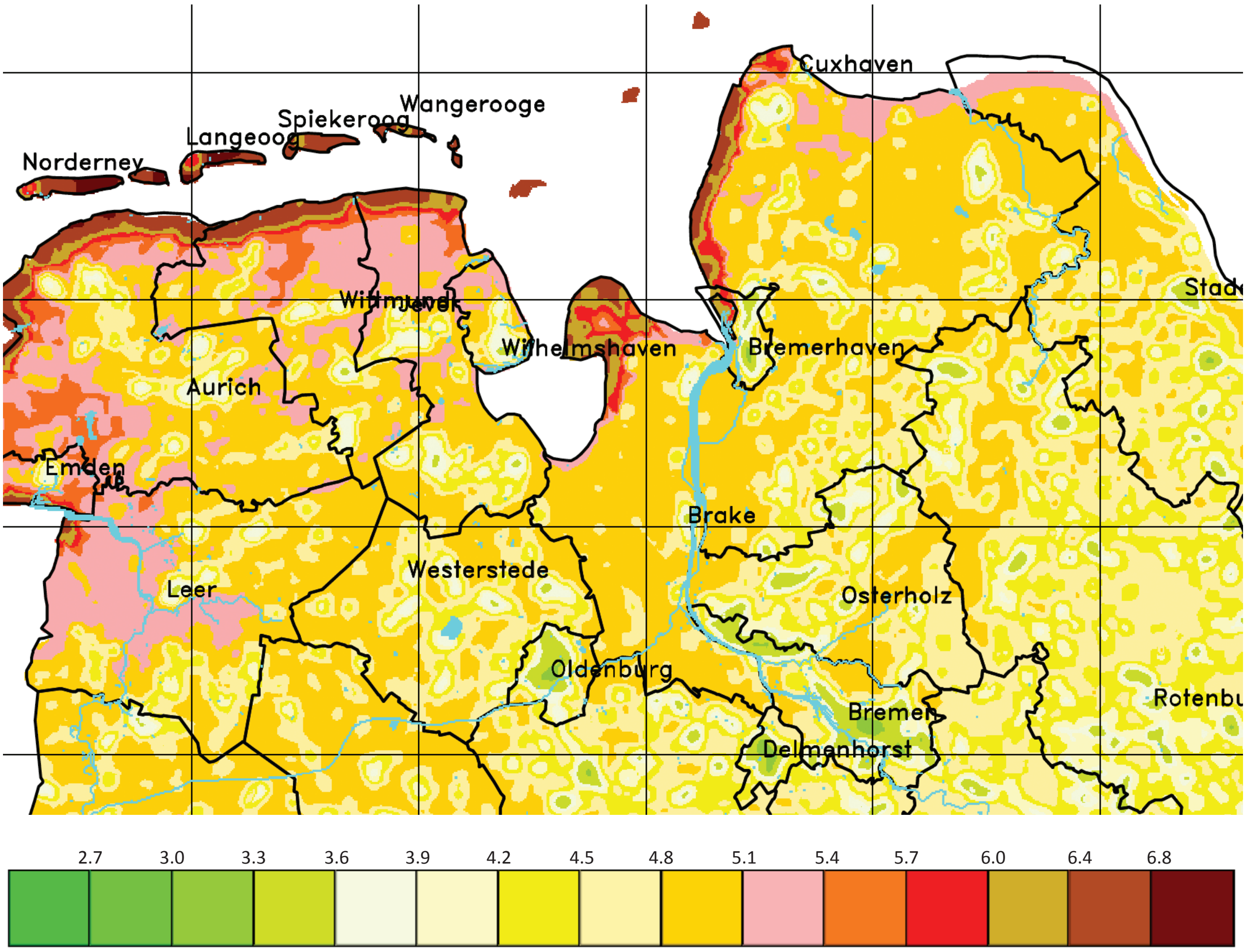


FIG. 39 Annual mean wind speed (m/s) at 10 m height above ground, Bremen and Bremerhaven, reference period 1981/2000

and Antarctica, as well as the thermal expansion of the oceans. Near the end of the 21st century and beyond, the rise in seas levels is likely to accelerate significantly. With a dramatic change in climate, it is assumed that sea levels will rise by about 30 cm to over 1 m by the end of the century.

High sea levels combined with storm events result in higher storm-surge levels. Based on the analyses of the North German Climate Office, which predict that sea levels in the German Bight will rise by approximately 80 cm by the end of the century, we can assume that an altered wind climate will produce North Sea storm surges at a level of 30 to 110 cm higher than at present by the end of the century. In the medium term, current coastal protection (including measures that have already been planned) will remain effective. In the long term, it is expected that higher storm-surge levels will require further action to be taken.[17]

FIG. 40

FIG. 41

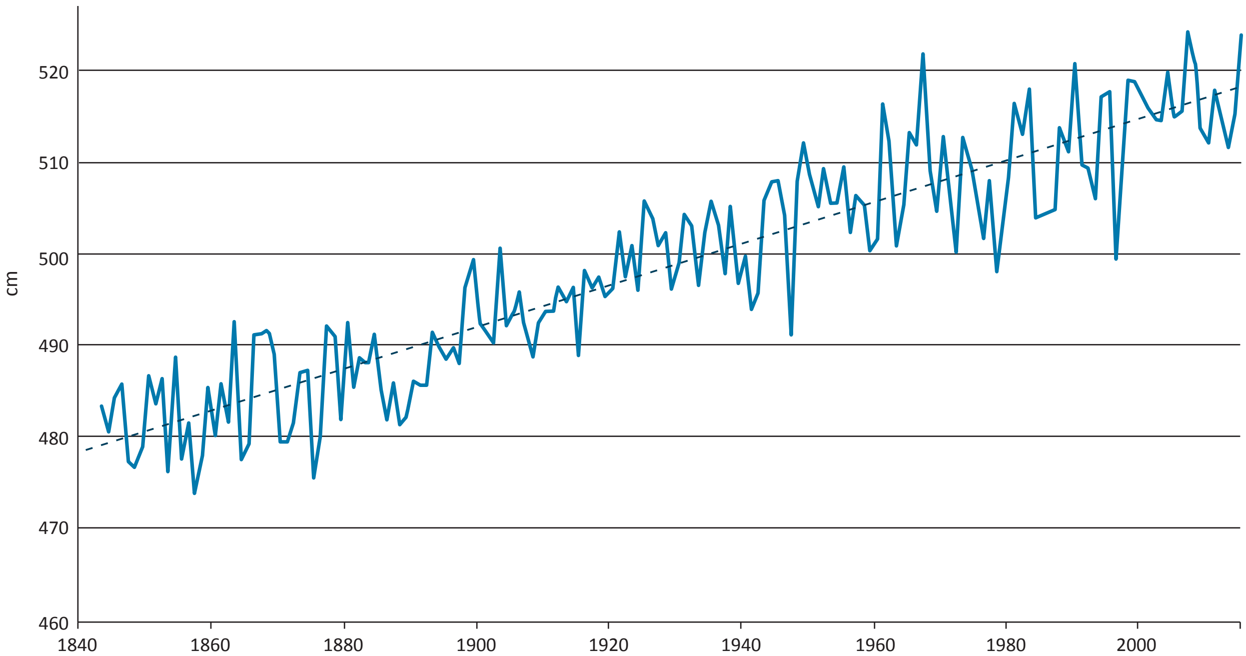


FIG. 42 Mean water level measured at the Cuxhaven tide gauge 1843-2015

Storms and storm surges

WHICH LOCATIONS WILL BE MOST IMPACTED BY THE CHANGES?

Maps plotting the areas at risk from storm surges reveal how both cities are exposed to potential flooding due to storm surges and/or river flooding (see Fig. 45). Around 86% of the State of Bremen is at risk of potential flooding. A population of approximately 515,000 people live in this area. The existing publicly accessible flood hazard maps provide up-to-date and detailed cartographical instruments, which enable spatial planning analyses when they are overlaid with data relating to various topics.

In addition to being vulnerable to water-related damage during storms, large coastal cities like Bremen and Bremerhaven are also directly impacted by high wind speeds. When wind hits a city, the arrangement of the buildings may cause it to be channelled into certain parts of the city – a process which also accelerates wind speed. It is already possible to methodically analyse and predict the areas where the greatest impact will be felt. In the context of implementing the adaptation strategy, a detailed, model-based impact analysis can be used to indicate the areas at greatest risk from storm damage based on changes to the frequency, intensity and routes of cyclones and/or storm cells.

Fig. 43

Fig. 44

WHAT ARE THE POTENTIAL CONSEQUENCES OF THESE CLIMATE CHANGES?

In areas that are normally considered safe, high wind loads can pose a sudden high risk to people, transport arteries, supply systems and private and public property in particular. The impact of extreme storm events on a city's stock of trees is especially severe. In addition to damage to buildings and infrastructure, hazards due to falling trees count among the major consequences of extremely high wind speeds.

Assuming that the dykes are secure, the increasing frequency of storm water levels (in connection with the expected rise in sea levels) will, in future, continue to present a challenge for coastal protection and the ports, in particular in terms of ongoing adaptation to climate change. Bremerhaven is more directly exposed to storm surges than areas further inland. During storm surges, the North Sea poses a threat to Bremerhaven's urban centre, located directly on the coast. The severity of this threat is determined by the interplay of tides, water level in the Weser and the possible occurrence of heavy rain events. Embankments on and deepening of the Weser make it all the more likely that flood waves will accumulate. The Weser is tidal as far as Bremen. This means that, during a storm, flood waves could also reach the centre of Bremen.

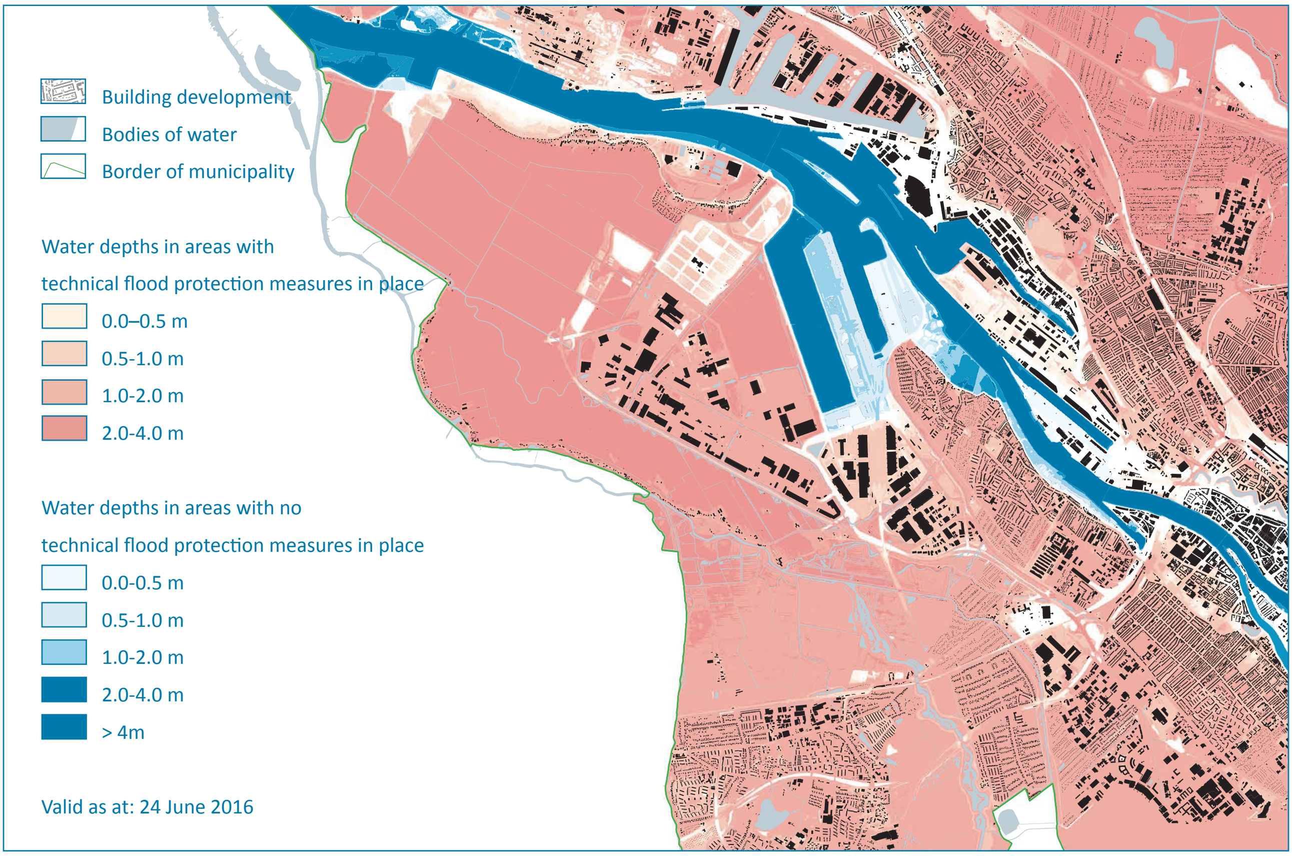


FIG. 45 Flood risk in the municipality of Bremen (map section)

POTENTIAL CONSEQUENCES OF STORMS AND STORM SURGES

- Increasing hazard potential due to a rise in storm-surge levels
- Long-term need to adapt coastal protection due to rising sea levels
- Increasing costs of inland drainage due to the rise in mean low-tide water levels
- Increasing costs of maintaining defensive structures, risk communication, alert services etc.
- Release and distribution of hazardous substances due to flooding and sediment displacement in front of the main dyke line
- Damage to land used for agriculture and forestry and to infrastructures caused by backflow at high tide
- Bottlenecks in port entry and transportation due to storm water levels at sea
- Changes to areas used for nature conservation, forestry and agriculture due to essential flood protection measures
- Damage to and loss of city trees and wooded areas due to wind load during storms
- Risk of accident and injury during storms, e.g. due to windfall
- Storm damage to transport routes and systems
- Obstruction and disruption of overland transport due to storms
- Storm damage to buildings, property (material assets) or to equipment and means of transport
- Storm-related damage and/or failure of supply facilities
- Negative impact on soils and bodies of water due to erosion or the entry of pollutants
- Increasing cost of maintaining and restoring the traffic safety of trees
- Economic (consequential) losses due to operational delays, outages and the destruction of business property
- Damage to/restrictions on the use of green areas and open spaces due to heavy winds during storms

Objectives and measures for adapting to the consequences of climate change

Fig. 46

CLIMATE CHANGE ADAPTATION OBJECTIVES

The climate change adaptation strategy aims to improve the resilience and climate tolerance of the State of Bremen and its two cities of Bremen and Bremerhaven in order to reduce their vulnerability to the consequences of the expected changes in climate.

This primary objective can be divided into a total of 19 sub-objectives for climate change adaptation. These have been compiled into a catalogue of objectives (see Tab. 02) and each assigned to one of the following spheres of activity: “People”, “Environment” and “Buildings and Infrastructure”. In addition to these, various “overarching objectives” have been formulated. These look beyond the level of individual spheres of activity and seek to create the overall framework necessary for successful implementation of climate change adaptation in Bremen and Bremerhaven.

MEASURES FOR ADAPTATION

A raft of conceivable measures for adapting to climate change were compiled as part of the strategy development process. The first question to be addressed when doing so was the issue of where further research on climate change or its consequences is still needed and where more awareness of climate change adaptation needs to be raised among stakeholders and institutions. It was also essential to determine which structural/spatial or ecological measures are productive in terms of climate change adaptation and which organisational or procedural changes are necessary within the administrations of both municipalities.

From the large number of potential measures compiled (see the attachment to the long version of the climate change adaptation strategy), a number of key measures were identified. These are regarded as being particularly likely to facilitate implementation of the climate change adaptation strategy and, for reasons of urgency or to enable a lighthouse effect, should be implemented as soon as possible. They also include measures that are already underway and are to be continued.

Taking account of regional-specific impacts and objectives, ten key measures in total were defined for the municipality of Bremen, nine for the municipality of Bremerhaven, and another nine key measures for the State of Bremen as a whole. These measures are briefly described on the following pages.

Fig. 47

Climate change adaptation strategy objectives for Bremen and Bremerhaven
CATALOGUE OF OBJECTIVES

OBJECTIVES FOR THE "POPULATION" SPHERE OF ACTIVITY

1. Support the population in dealing with human bioclimatic stress
2. Avoid personal injury during storm and heavy rain events

OBJECTIVES FOR THE "ENVIRONMENT" SPHERE OF ACTIVITY

1. Increase the resilience and protection of trees and other plants against heat, drought stress and storms
2. Halt the infiltration and dispersal of invasive thermophilic animal and plant species
3. Secure sufficient green spaces and corridors to enable natural adaptation to the spread of species
4. Protect water quality and water levels to avoid and compensate for ecological stress caused by drought and heat
5. Strengthen soil functions and biodiversity to cope with warming and fluctuating water content
6. Avoid the entry of pollutants into soil and water during heavy rainfall events
7. Protect the groundwater near the coast from salinisation *(Bremerhaven only)*

OBJECTIVES FOR THE "BUILDINGS AND INFRASTRUCTURE" SPHERE OF ACTIVITY

1. Preserve or improve cooling systems and climate comfort in buildings in an energy-efficient manner
2. Prevent or reduce the heating-up of exposed traffic areas and open spaces
3. Improve the protection of property to reduce damage to buildings, equipment and assets caused by extreme weather
4. Safeguard and reduce the pressure on drainage systems and protect bodies of water during unusually heavy rain
5. Guarantee the functional reliability of technical infrastructures (energy, water, telecommunications) during extreme weather events
6. Protect transport infrastructures against weather-related damage and safeguard the flow of both river and land traffic before and after extreme weather events
7. Guarantee long-term adaptation capacity in coastal protection (incl. inland drainage) against the backdrop of rising sea levels

OVERARCHING OBJECTIVES

1. Intensify interdepartmental cooperation and maintain the structures, processes and measures for climate change adaptation that have already been established
2. Spread information about and raise awareness of issues relating to climate change adaptation and the need for action among policymakers, administration and the general public
3. Expand national and international networking to facilitate the exchange of information among experts and mutual support in issues relating to climate change adaptation

TAB. 02 Catalogue of objectives

Key measures

ANALYTICAL MEASURES

Fig. 48

Evaluate potential flood zones across all urban areas **

A topographical flood analysis is to be conducted for Bremerhaven's municipal area. This will identify potential flood zones in the event of heavy rainfall and pinpoint where the greatest risks arise. These analyses will provide the groundwork for additional measures for risk management, water-sensitive urban development and the raising of public awareness.
In the medium- to long-term, the option of establishing an information system for Bremerhaven can be investigated.

Fig. 49

Evaluate the application of urban climate analysis in planning processes *

The city of Bremen already has an urban climate analysis and a climate change adaptation plan to accompany its land use plan. It is necessary to determine the extent to which this existing information is noted and taken into account as part of spatial and climate-relevant planning and approval processes. In addition, an evaluation will be made to determine whether these planning instruments are appropriate and which in-depth studies are required to ensure that adaptation-related concerns are taken into account in an effective manner as part of preliminary and finalised urban land use plans.

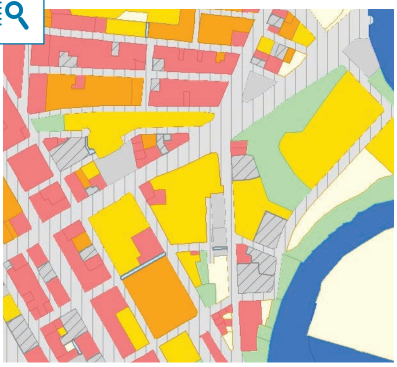


Fig. 50

Requirements planning for an urban climate analysis ***

In the context of setting up the Landscape Programme in Bremerhaven, an assessment will be carried out to determine the extent to which it is necessary to conduct an urban climate analysis for the municipality of Bremerhaven. The first step will be to evaluate the results of the temperature measurement runs conducted by the Deutscher Wetterdienst (DWD). Next, a decision will be taken as to whether more detailed modelling is required or whether a cartographic analysis and representation of urban climatopes/the degree of ground sealing in the municipality of Bremen is sufficient. (Note: At the time this strategy summary was created, an evaluation had already been completed. An urban climate analysis is currently at the planning stage.)

Fig. 51

Monitoring of groundwater ***

Based on research to date by the Geologischer Dienst für Bremen (GDfB), changes in groundwater caused by climate change will be further modelled and analysed as part of optimised monitoring. Furthermore, additional measuring points and shorter measuring cycles, as well as optimisation of short-term data availability across all areas, will enable the identification of areas at risk of subsidence or waterlogging. In Bremerhaven, monitoring will be intensified in relation to a potential increase in groundwater salinisation due to an accelerated rise in sea levels.

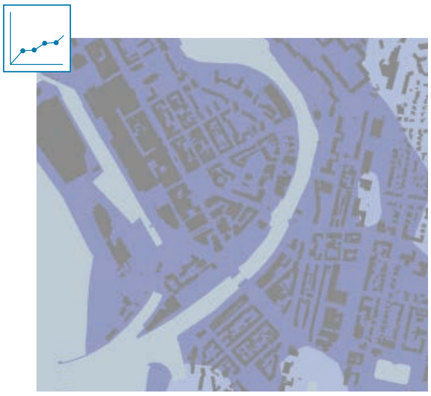


Fig. 52

Modelling of groundwater changes associated with climate change ***

Model calculations should be used to determine the potential changes in groundwater levels in the State of Bremen in the years ahead. While relevant maps are available for the current groundwater level, there is still a good deal of uncertainty in relation to future changes. Future development should be estimated as accurately as possible. The results of the model calculations will be made available to planning and engineering offices, companies and individuals by the Gewässerkundlicher Landesdienst (State Hydrological Service) of The Senator for Environment, Urban Development and Mobility.

CONCEPTUAL/PLANNING MEASURES

Fig. 53

Measures for flood protection during sewage system renewal projects *

In Bremen, any sewage system renewal measures that become necessary will be accompanied by simultaneous flood protection measures at surface level. Where there is a risk of flooding, the streets and open spaces will be designed to improve their protection against flooding, once the sewer renewal works have been completed. This cost-efficient strategy results in improved protection against heavy rainfall in areas where structural measures are already being undertaken.

Key measures

Fig. 54

Climate change-adapted design and maintenance of bodies of water */**

To minimise the negative consequences of climatic changes in air and water temperatures and rainfall distribution on bodies of water, both standing and moving water bodies will continue to be protected, and structurally affected water bodies in Bremen and Bremerhaven will continue to be developed as naturally as possible. Analyses will also be conducted to determine cost-effective yet environmentally sound methods for regular de-sludging of backed-up bodies of water and standing water bodies.

Fig. 55

Intensification of near-natural rainwater management *

The design of water-permeable surface and the conservation of rainwater will be intensified on public and private property in Bremen. In future, increased efforts are to be made to ensure that rainwater is not exclusively channelled into the sewage system and surface bodies of water and that a considerable portion is instead infiltrated into the soil or evaporated. Investigations will also be conducted into the potential benefits of the re-exposure of sealed surfaces, the use of rainwater infiltration systems and the design of water-permeable surface, as well as the possibilities offered by rainwater evaporation. In addition, the possibility of incorporating recommendations or requirements for near-natural rainwater management into urban land-use plans is to be investigated, and the existing provision of information and advice on near-natural rainwater management is to be stepped up.

Fig. 56

Concept for water-sensitive urban and open-space design **

Near-natural/ecological rainwater management is to be intensified in Bremen. For this purpose, an interdisciplinary working group with the name “wasser-sensible Stadtgestaltung” (Water-Sensitive Urban Development) will be established to develop a concept that aims to improve the way in which available capacities in the sewage system can be managed and exploited, and identifies solutions for near-natural river remodelling and for reviving the use of moats for water retention. In collaboration with the Municipal Drainage Works and Urban and Landscape Planning, the possibilities of using traffic areas and open spaces as temporary rainwater catchment areas will be investigated, as well as the possible incorporation of recommendations or requirements relating to near-natural rainwater management into urban land-use plans.

Fig. 57

Strategy for roof greening and open-space greening, in particular as part of inner development *

Focussing in particular on inner urban development, a greening strategy is to be developed for those areas of Bremen that are already densely populated, exposed to climatic stress and/or at risk of flooding, i.e. those areas indicated by green shading on the land use plan. This process will analyse the various instruments and approaches used to intensify roof greening in developed areas and bring them together in an overall strategy. As part of strategy development, the possibilities and limitations of recommendations or, where necessary, requirements in urban land-use plans and contractual agreements on the greening of roofs and open spaces will also be explored. The strategic approaches are to be implemented and evaluated through pilot projects (e.g. in the Bahnhofsvorstadt district). In addition, the existing provision of roof greening information and advice is to be continued in this context and, where necessary, modified or stepped up.

Fig. 58

Action plan for city trees */**

To increase shade, binding of CO_2 and evaporative cooling, interdepartmental concepts will be developed for both Bremen and Bremerhaven. Conflicts of interest often arise due to other street planning requirements, e.g. in relation to parking spaces, building stock, pipes and cabling or streetscape considerations. Against this backdrop, criteria and integrated solutions will be developed for the selection of effective new locations and for the optimisation of existing tree locations in the city. For the existing tree stock, critical locations and soil conditions in the rhizosphere are to be optimised. Climate-resistant shrub and tree species and varieties are to be selected for new planting. In addition to the specified measures, innovative strategies for aeration, manuring, soil improvement and watering are to be tested in a number of specific locations.

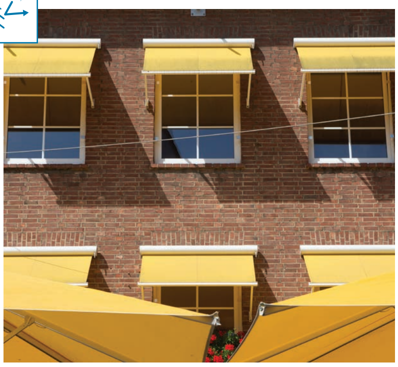


Fig. 59

Concept for the protection of public buildings **

To reduce cooling energy requirements and increase climate conditions in urban buildings in Bremerhaven, a concept is to be developed, detailing how measures can be implemented in buildings and in the adjoining public spaces to achieve cooling of the building interiors. The first step will be to analyse the relevant urban buildings (including their climatic environment) on hot days. The concept will include, in particular, measures for evaporative cooling, sunscreening and adaptation of reflection and thermal storage behaviour. In addition, strategies for incorporating heat protection in building structures and technology are to be formulated in this concept. Finally, but no less importantly, organisational and technical solutions are also to be developed to enable more effective use of night-time cooling during the warm summer months.

Key measures

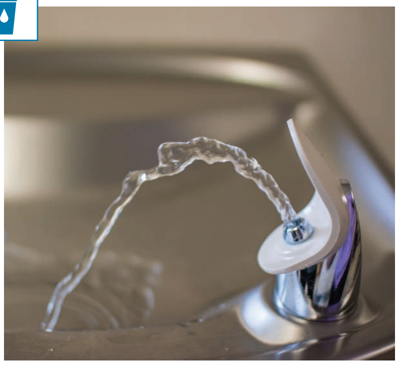


FIG. 60

Drinking water provision on hot days */**

To improve the way in which heatwaves are handled, the populations of Bremen and Bremerhaven will, in future, be provided with drinking water free of charge during such periods. The water will be made available in public areas, in particular in publicly accessible buildings and, where relevant, in outdoor public spaces. With this in mind, potential locations in each of the municipalities will be inspected to determine their suitability as locations for drinking water distribution. A concept will be developed, detailing the locations and quantities in which accessible drinking water dispensers can be put in place and how the costs of setup and subsequent costs can be funded, in particular through donations, patronage and/or sponsorship. In addition, approaches will be developed whereby older people who live alone and are in need of care can be reminded to drink enough water.

FIG. 61

Luneplate as an example of the development of industrial areas in preparation for climate change **

Based on the example of the development of a sustainable industrial park on the Luneplate nature reserve in Bremerhaven, measures will be identified and evaluated that will enable companies to contribute both to limiting the extent of future climate change and to reducing their susceptibility to damage due to the climate and weather effects that are by now inevitable. Furthermore, an appropriate set of framework conditions will be defined, which will need to be taken into account as of the development stage of industrial areas and are intended to help the companies located in the area to adapt to climate change. To ensure the transferability of results, a set of guidelines will be created, containing recommendations for action, e.g. for land drainage, surface sealing, roof greening, building orientation and tree planting in preparation for climate change.

FIG. 62

Special map for the protection and further development of climate-relevant green spaces and corridors in Bremerhaven ***

As part of the restructuring of the Landscape Programme for Bremerhaven, a map will be created to depict which green spaces and green corridors are relevant for the urban climate and to provide guidance for planning in terms of how the bioclimatic situation can be improved in densely populated areas that are at risk of thermal stress. The map will also indicate which parts of the city contain fresh-air corridors that can be reinforced by developing adjacent brownfield sites. A registry of brownfield sites in Bremerhaven will be compiled as an accompanying measure. Furthermore, steering groups will be established covering the areas of nature conservation and agriculture/nature conservation and industry, with the aim of resolving conflicts of interest in relation to land use (the District of Cuxhaven will also be involved in this measure).

FIG. 63

Adaptive and phenological management of protected areas ***

Adaptive management of protected areas is necessary, for example, in order to continue to fulfil legal obligations to guarantee the status quo and to achieve specific development targets (Natura 2000 – the European network of protected areas, obligations under conservation legislation), even in the face of changing climate conditions. Updating of the monitoring-based management plans and climate-adjusted area management (adaptive and phenological management of protected areas) will be continued and expanded in collaboration with agricultural enterprises in Bremen and Bremerhaven.

FIG. 64

Ensuring the long-term functionality of coastal systems in line with climate change ***

In view of the uncertainties associated with climate projections, the measures listed in the general plan for coastal protection will be reviewed and, if necessary, adjusted on an ongoing basis. This approach is intended to ensure that the protection mechanisms and emergency system remain fit for purpose. Steps are to be taken to guarantee inland drainage in the long term despite rising sea levels. For example, lesser bodies of water (moats) are to be re-evaluated, the dimensions of the pumping stations checked and the vulnerability of smaller river courses to extreme rainfall events with simultaneous storm surges investigated.

FIG. 65

Climate change adaptation concepts for port facilities ***

In consultation with the “Port-Klima” (“Port-Climate”) project being run by the Bremen University of Applied Sciences, region-specific, localised climate change adaptation concepts will be developed to guarantee that the port facilities in Bremen and Bremerhaven remain operational and fit for purpose in future. This will involve, on the one hand, compiling all of the most up-to-date knowledge regarding the changes expected to occur due to climate change and the potential consequences of these. On the other hand, this will also necessitate a sector-specific, location-specific assessment of the associated risks and opportunities. The next step will be to identify and prepare measures and projects to boost resilience to climate change (in particular in relation to port development and port construction and in connection with compensation measures) and to work towards the ultimate goal of robust transport chains.

Key measures

MEASURES RELATING TO ORGANISATION AND COMMUNICATION

FIG. 66

Informationssystem Starkregenvorsorge (Information system for protection against heavy rainfall, AIS) *

AIS, the GIS-based information system for protection against heavy rainfall that was developed for Bremen as part of the KLAS project (Climate Change Adaptation Strategy for Extreme Rainfall Events), will be activated for permanent operation. All key stakeholders in urban planning processes, in particular infrastructure providers, as well as those responsible for urban, street and free-space planning, will be provided with the data they need in relation to flooding risks and potential adaptations, thereby supporting decision-making processes for risk management and water-sensitive urban development in both cities. In addition, the system will serve as a basis for informing property owners in Bremen about potential risks of flooding, thus reinforcing personal protection on private property by means of property protection measures.

FIG. 67

Procedural rules for incorporating climate change adaptation in formal and informal planning and decision-making processes *

The Senator for Environment, Urban Development and Mobility will develop internal procedural rules outlining how issues concerning climate change adaptation can be taken into account at an early stage and in an efficient manner in urban development plans and projects (in particular land use plans, development concepts and urban development competitions) in Bremen. Primary concerns relating to climate change adaptation, in particular protection against heat and heavy rainfall and flood protection measures, still need to be efficiently incorporated into planning and decision-making processes within the administrative organisation. This requires, on the one hand, identifying and permanently securing the official roles required to deal with the various concerns relating to climate change adaptation. On the other, it will also be necessary to prepare climate-relevant data as guidance for planning and make this available in a systematic way.

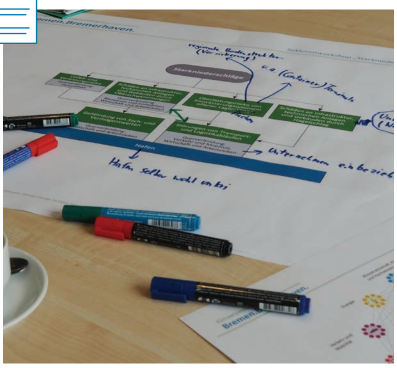


FIG. 68

Guidelines for incorporating climate change adaptation in formal and informal planning and decision-making processes **

Based on the legal obligations established by the Federal Building Code and the Bremen Climate Protection and Energy Act, guidelines are to be formulated for Bremerhaven, so that climate change adaptation can be integrated into spatial and urban climate-relevant planning and decision-making processes. In addition to the awareness-raising and informative effect of these guidelines, tangible and well-founded planning requirements will be defined and qualifying recommendations as to how concerns relating to climate change adaptation can be incorporated into planning procedures in a real way (practical assistance). Within the administrative organisation, those responsible for "taking care of" various issues relating to climate change will be nominated and climate-relevant data will prepared in the form of planning recommendations across departments.

FIG. 69

Implementation management for the climate change adaptation strategy */**

Implementation of the climate change adaptation strategy is dependent on efficient implementation structures and continuous monitoring. To this end, an implementation management team will be set up in both municipalities and at State level. In this context, an application for funding that will enable climate change adaptation management to accompany implementation of the strategy will be submitted to the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). Some measures can only be implemented at a considerable financial cost and/or with external expertise. If necessary, the relevant authorities will be supported in their acquisition of third-party funding in the area of climate change adaptation. In addition, activities, networks and measures that have been initiated will be integrated on a permanent basis and the exchange of knowledge and expertise within each administration and within intermunicipal networks will be expanded. The interdepartmental working group will continue to pursue its work.

FIG. 70

Climate change adaptation information campaign for policymakers, administration, industry and the general public ***

Communication and information are hugely important in creating public awareness of the risks and opportunities associated with climate change and in gathering knowledge of the consequences of climate change and how we can adapt to these. The State of Bremen and its two municipalities will develop, continue and intensify appropriate communication structures and instruments for this purpose. In particular, the significance of climate change adaptation for the quality of life in both urban communities must be emphasised and citizens and businesses motivated to protect themselves.

FIG. 71

Integrated concept for managing extreme weather events ***

To enable improved joint management of extreme weather events that occur in future in Bremen and Bremerhaven, the State of Bremen will – in addition to the emergency strategies that are already in place – collaborate with both municipalities to develop an integrated, cross-departmental concept. This will include, for example, an outline of how the provision of essential public services can be optimised and how intensified exchange between emergency services, authorities and volunteers can be supported. Based on crisis simulations for various event scenarios relating to climate change (power failures, flooding, long periods of drought, extreme heat, etc.), the procedures, processes and essential prerequisites are to be communicated to the relevant stakeholders for incident management, and are to be harmonised and compiled in a cross-departmental action plan.

Outlook

Fig. 72

WHAT HAS BEEN ACHIEVED THUS FAR?

With the climate change adaptation strategy for Bremen and Bremerhaven, the State and both municipalities have established a sustainable strategic framework for confronting both the gradual and the abrupt consequences of climate change. Permanent strengthening of our resilience in the face of climate change can be achieved, in particular, by integrating our knowledge about climate change into the relevant policy areas and planning decisions of the State and both municipalities.

The key measures defined in the strategy were formulated with the specific aim of enabling integration and connection and their long-term benefits. Some measures have already been set in motion. Others need to be defined in greater detail and will be implemented gradually over the coming years. The long-term, continuous institutionalisation of climate change adaptation management within both municipal administrations is a central prerequisite for the successful implementation of measures.

Furthermore, a successful implementation of the strategy also requires that the topic of climate change adaptation is taken into account, as a matter of course and as early as possible, in all future planning processes in both municipalities. For this to happen, those working in relevant departments must be made aware of the issues involved and as broad a consensus as possible must be reached. Involving the stakeholders in the development of the climate change adaptation strategy via the two interdepartmental project groups has established some of the essential groundwork in this regard. The dedicated cooperation of these groups has meant that some key points of the concept, in particular objectives and measures, were agreed between the various departments involved while the project was still ongoing.

The practical implementation of measures will also be simplified by virtue of the fact that the key measures have identified a manageable number of solutions for adaptation. With almost all of these key measures, activities that are already ongoing can be built upon, so that fewer initial hurdles are to be expected during the implementation phase. Furthermore, the task of implementing the key measures is shared among a large number of departments within both municipalities and at State level. This division of responsibilities will facilitate implementation and will also promote acceptance of the topic of climate change adaptation throughout the entire municipal administration.

FUNDING FOR IMPLEMENTATION

Climate change adaptation is an ongoing task that will necessitate the use of State and municipal finances and staff resources, in line with the relevant departmental budgets. The implementation of cost-effective measures must be ensured in each case in line with these budgets, and the precise form these measures take must be continually reviewed in terms of efficiency and efficacy.

The climate change adaptation strategy should also serve as a basis for the State and municipalities in terms of acquiring additional funding and initiating pilot projects. Funding is available at a national and EU level to support climate change adaptation projects. Externally-funded projects can be used, for example, to help initiate key measures, establish further technical groundwork or implement pilot measures.

WHERE DO WE GO FROM HERE?

Climate change adaptation is a long-term undertaking. The climate change adaptation strategy for Bremen and Bremerhaven defines key measures that will begin to be implemented by the relevant authorities in the coming years. Within the context of monitoring, their implementation will be supported by the interdepartmental working groups that have already been established. Progress reports will be published at intervals of five years. The State of Bremen is home to a wide range of climate-related research institutes, and efforts will be made to ensure that the expertise that resides in these continues to be actively involved even after the climate change adaptation strategy has been adopted. Efforts to facilitate an exchange of expertise at a regional level and, where necessary, harmonisation and coordination of a joint approach between adjacent municipalities are also being pursued.

A communications strategy (see the extended version of the climate change adaptation strategy) will help define in greater detail both the measures presented here and further projects). In line with this, differentiated communication with citizens will also aim to enable their participation.

Resolution

A resolution on this climate change adaptation strategy was passed on 18 January 2018 by the Deputation for Environment, Mobility, Urban Development, Energy and Agriculture, on 7 February 2018 by the Municipal Authority ("Magistrate") of Bremerhaven, on 3 April 2018 by the Senate of the Free Hanseatic City of Bremen and on 12 April 2018 by the City Council Assembly of Bremerhaven. A resolution was passed by the Bremische Bürgerschaft on 29-31 May 2018.

More information

You can view and download additional information, including the extended version of the strategy and the accompanying study by the Deutscher Wetterdienst at: *www.bauumwelt.bremen.de/info/klimaanpassungsstrategie*

You will also find more information on the subject of climate change and climate change adaptation in the State of Bremen on the following web pages:

- *www.bauumwelt.bremen.de/info/klimaanpassung*
- *www.klimastadt-bremerhaven.de*
- Aqua Add: *www.aqua-add.eu*
- Climate-resilient city of the future: *www.bresilient.de*
- Heavy rain protection: *www.klas-bremen.de*
- Landscape programme: *www.lapro-bremen.de*
- Land use plan *www.fnp-bremen.de*

Contact:

Use the contact address below if additional information is required: *klimaanpassung@umwelt.bremen.de*

Fig. 73

Image sources

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