PART III: MODULES

Check Vulnerability

The FUTURE CITIES vulnerability check starts by determining the current vulnerability: The development of a city is subject to many uncertainties, e.g. changes in the demographic situation. The climate projections add more uncertainties. They are considered in a separate step.

The local physical features and socioeconomic conditions – called receptors – are the starting point for the check of current vulnerability towards weather events. The list of receptors (see below) is based on the experiences of the FUTURE CITIES organisations and provides a comprehensive checklist for the urban environment. For customized use,

- You can select the receptors of individual interest and describe the spatial relevance of the receptors for the area in question. For this, practical indicators are proposed.
- You can submit individual information regarding former events, e.g. heavy precipitation or heat waves, what impacts they imposed on the different receptors and which actions were taken, e.g. in the infrastructure system or in organisational procedures.

For each receptor, the current vulnerability is summarised in basic categories: low, medium, high.

List of receptors

- Population: public health and vulnerable groups
- Infrastructure: transport, electricity and heating services, water supply and sanitation services, social infrastructure
- Built environment: building stock and materials
- Economy: tourism, industry, retail
- Natural resources: green spaces, water resources and quality, air quality, agriculture, forestry, biodiversity / ecosystems

Key terms

Vulnerability

The degree to which a system is susceptible to and unable to cope with, adverse climate or weather induced impacts. Vulnerability is a function of sensitivity (assessed in “Select Receptors” and “Former Events”) and exposure (assessed in part “Spatial Relevance”) of a receptor to the weather impacts and the capacity to adapt towards those conditions (assessed in “Vulnerability Check”) (based on Smit & Wandel, 2006).

Demographic change

The term describes changes in the population. In general it is a change in the structure of the population. One main consequence of declining birth rate and increased life expectancy in most European countries, such as Germany, is an aging population.

Beside these facts, there are also other demographic developments, such as altered migration patterns (today most countries of Europe have a positive net migration balance) or other social tendencies of development, concerning the demographic situation of the society.

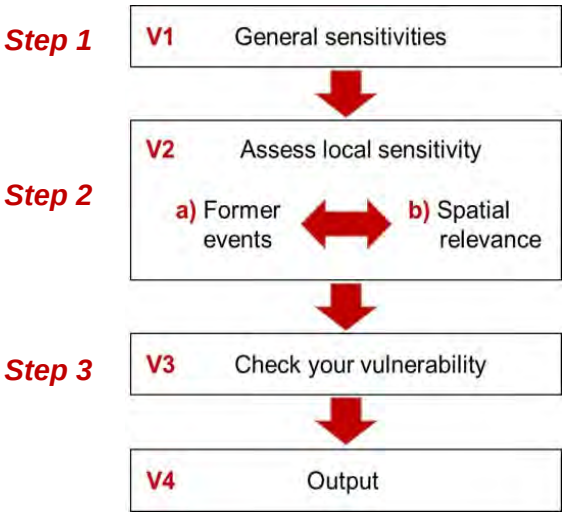
1.1 Purpose of the module and proceeding

By checking your current vulnerability you will understand how weather extremes affect the different sectors and features of your city. This makes it easier to assess the impacts climate change might have and could reveal measures for adaptation that you already realised, e.g. establish an emergency warning system. To know your current situation in detail is especially helpful when trying to convince the public, your colleagues or superiors to implement your proposed adaptation measures. To assess the current vulnerability of receptors the Adaptation Compass provides three steps:

Step 1: Get to know the receptors and sensitivities: An introduction to the used receptors and their sensitivities towards climate extremes is given.

Step 2: Assess your local sensitivities: Two tables are provided that help you assessing your own city's sensitive receptors and areas. Nevertheless, you are not forced to fill in local information to carry on working through the Compass. You can leave the tables blank and still might be able to identify a suitable general adaptation strategy for your city. But you should be aware that the more intense you work with the Compass, the better your result will be.

Step 3: Check your vulnerability: Prefilled categories of vulnerability and capacity to adapt can be changed to represent your specific situation.



Step 1: Get to know the receptors and sensitivities

First you should take a close look at the receptors and their sensitivities in the Compass.

The receptors and their sensitivities are generally described. Not all details may be correct for your local situation. Nevertheless, read through the table carefully to get an overview on how broad the interactions between a city's features and weather extremes are.

Key terms

Vulnerable Group

Used in the Adaptation Compass, the term refers to population groups or parts of society, which are easily susceptible to or have difficulties to cope with climate or weather impacts. These are mainly groups with limited mobility, e.g. elderly, disabled or children and people with chronic illnesses.

Receptor

In the Adaptation Compass receptors describe local physical features and socio-economic conditions of cities and regions that are affected by weather impacts. They include the major functions and features of a city like population, infrastructure, built environment, economy and natural resources.

More information…

…on the general sensitivities of receptors towards weather events is also given in chapter 1.2 "Impacts of weather extremes on cities".

We have concentrated on the weather events heat, drought, extreme cold, heavy precipitation/flood and storm. Sea level rise is not further considered although it is a major problem for North-West Europe. It is not a weather extreme but a long-term impact. If required, it can be added to the receptors by the user.

You have the possibility to add new receptors and also new sensitivities or weather events, if you feel that the receptors don't cover all physical and socio-economic features of your city or all weather problems.

V1 - General sensitivities

Here you get an overview on the sensitivity of different receptors to weather events. Go through all receptors listed to get an insight in the potential sensitivities. In the heading of the table you can find definitions and explanations of the terms used.

If you are only interested in working with your own receptors, you can add more receptors (will be added at the bottom of the table) or even more weather parameter to the given receptors.

	Receptors	General weather sensitivity of receptor: Extreme weather event	Potential effects	Who / What is affected
pulation	Public health / vulnerable groups	Heat wave	-Deaths, mainly due to cardiovascular diseases -Spread of vector-born and infectious diseases -Altered allergic pattern -Heat stress	Elderly people, babies, children, sensitive people; sportsmen
		Extreme cold	-Injured and deaths -Spread of respiratory and infectous diseases	Sensitive people, babies, elderly and imn people, homeless

In the next step (step 2) you have the possibility to describe the local specialities of your city.

Step 2: Assess your local sensitivities

This step structures the information required to understand the sensitivities of your city. You do not need to fill this table to complete the Compass. Though, it helps you in the evaluation of vulnerability in Step 3.

To assess your local sensitivity fill in information about your city:

a) **Collect information on former weather events** that had an influence on the different features.
You can go back in time as far as you deem necessary. A good way to collect the information is to consult local newspapers, ask your colleagues or question the city services (police, fire departments etc.) and administration.

b) **Assess the spatial relevance of the receptors regarding the weather events**: The sensitivities of the receptors are influenced by the exposure of a receptor towards a weather phenomenon. To assess the spatial relevance of the receptors, possible indicators are given. Use the prefilled or add your own ones and describe the local relevance of the receptors and their sensitivities.
E.g. if all your hospitals are located on relatively high altitudes compared to the river or coast in your city, they are less prone to flooding than buildings situated next to a river or the coastline.

Key terms

Sensitivity

The degree to which a system is affected by climate or weather stimuli. The impacts may be direct or indirect and can be beneficial or adverse (IPCC, 2001; Ribeiro et al. 2007).

Why fill in local information?

The process of collecting the information will help you to understand the interaction and links between the functions of your city/region and weather events. Often we have pictures in mind that simplify the situation regarding own experiences. But it is important to broaden your view, in order to make good selections (see step 3) for

a) Receptors
b) Capacity to adapt
c) Vulnerability classes.

Functions within the tool will make you aware of the collected data, when necessary: In module "Determine need for action and select measures" the tool offers advice on how to locate the adaptation measures found suitable for your situation. Here the filled data of the "Former events" table and the "Spatial relevance" table reappear.

V2 a) Assess your local sensitivity - Former events

Here you can fill the experiences of your city regarding past weather events.
Specific event: Add name and/or year of event (e.g. extreme summer 2003)

Weather extreme: Describe the direct impacts of the event (e.g. temperatures up to 35 degrees for more than 5 days).

Consequences: Describe indirect impacts (e.g. heat stress, mortality rate increased).

Responses taken: If applicable, describe responses taken after the event and the outcome of the measures. Were they successful?

Receptors affected: Double click on the empty cell in the table and choose the receptors which were affected by the described event.

Location: Add the names of the city quarters, regions, streets etc. affected by the specific event.

Specific event	Weather extreme	Consequences (indirect impacts of events)	Responses taken	Receptors affected <double click to select>	Location
at wave					
ought					
avy precipitation / Floods					

V2 b) Assess your local sensitivity - Spatial relevance

Fill the table for the indicators which seem relevant for your specific situation or add your own indicators. Not all rows need to be filled. The accuracy and scale you assess and fill in is up to you.

Indicators: Please use one or more indicators to describe the major core areas of the respective receptor in your city.

Where are the sensitive receptors located in my city: Describe qualitatively the locations or amount per indicator, e.g. population density: highest in quarter xy.

Future changes: Are the described locations subject to changes (e.g. new planning in your region / city)?

Internal reference: Here you can add information on relevant maps, pictures, studies, references or contact persons of your organisation [insert text].

Receptors	Indicators *Use one or more indicators per receptor to describe the core areas*	Where are the sensitive receptors located in my city?	Future changes: *Are the described locations subject to changes?*	Internal reference
Public health / vulnerable groups	Spatial distribution of vulnerable groups			
	Age structure of different groups in the city			
	Population density			
	Capacity of medical system			
	Capacity of emergency system			
	Amount of green spaces			
	Distribution of air corridors			
	Degree of air quality			
	Allocation of traffic			
	Major roads & railways			

To fill the tables might take some time and it might require an intensive cooperation with different departments of your organisation. Please take your time! The more comprehensive your collection of former events and spatial relevance is, the better your choice of adaptation measures can get.

Key terms

Indicator

Indicators are sizes to monitor and classify the environment - in our case the receptors of a city. The indicators help to make definite statements and to systemise observations and information. To describe the spatial abundance (spatial relevance) of the receptors, practical indicators are used in the Adaptation Compass.

Uncertainty

An uncertainty is the degree to which a variable (e.g. the climate condition) is unknown. Uncertainties can result from lack of information or from disagreement about what is known or even knowable. Uncertainty can therefore be represented by quantitative measures, e.g. by modelling and taking assumptions or by a qualitative statement, e.g. reflecting the judgment of a team of experts.

Spatial relevance

The term spatial relevance is used in the Adaptation Compass, to describe the local abundance of the previously identified sensitivities with the help of indicators. In this step you determine, if the general sensitivities towards weather events listed in step 1 of the module are relevant (do they exist in my city?) and where they are relevant.

As mentioned before, the tables do not have to be filled. You could also assess the spatial relevance and the former events occurrences in media (e.g. with maps) that are available in your city. It is nevertheless crucial that you look beyond your own department or area of expertise.

Step 3: Check your vulnerability

In a third step, you can finish your vulnerability check by reviewing the capacity to adapt and the vulnerability classes given in the table "Check your vulnerability". Furthermore, single receptors can be deselected, if they don't apply to your local situation. Keep in mind the local information you have just collected.

To assess your specific **capacity to adapt** you should pose the following question for each receptor:

- *Is the receptor able (financially, technologically, socially), willing and ready to cope with weather extremes?*

For the non-human receptors, e.g. buildings, you can pose the question to the responsible persons dealing with the impacts of weather extremes.

Keeping in mind the table of former events, you should be able to choose a category:

- **High**: Yes, the receptor is highly able, willing and ready to cope with such events
- **Medium**: The receptor has only little ability, willingness and/or is partly ready to cope with such events.
- **Low**: The receptor alone is not able, willing and/or ready to cope with such events. Any change or adaptation to a change will be connected with lots of effort.

To choose the suitable **class of vulnerability** take into account the information that was collected in step 1 and 2: Vulnerability is a function of sensitivity (check table "General sensitivities" in step 1) and exposure of a receptor to the weather impacts (check the table "Former Events" and "Spatial relevance" in step 2) as well as the capacity to adapt (categories assessed in step 3) towards those conditions.

You can choose the categories as follows:

- **High**: The receptor is highly sensitive and highly exposed to the respective weather extreme. The capacity to adapt is medium or low.
- **Medium**: The receptor is partly / mildly sensitive and exposed to the respective weather extreme. The capacity to adapt is medium or high.
- **Low**: The receptor is only very little or not sensitive at all to the respective weather extreme. Also the exposure is little. The capacity to adapt is medium or high.

Collect local information

You don't need to fill in endless tables; mapping is also a good instrument to assess your local sensitivities.
The strategy for your assessment should be:
- look beyond your own department / area of expertise
- cooperate
- look at all receptors
- share your insights

Key terms

Capacity to adapt

Ability to adjust to changes, to take advantage of the opportunities or moderate potential harm (IPCC, 2007; Ribeiro et al. 2009). In the Adaptation Compass, the capacity to adapt is used in relation to the receptors.

How to select your receptors

All receptors are affected by weather extremes. This means you should consult experts from different departments and sectors in order to assess your cities' vulnerability. The deselection of receptors can generally not be recommended – with one exception: If one receptor is not represented in your city, e.g. there is no tourism in your city and touristic development is unlikely in future.

You need to be aware that the selection of the capacity to adapt and the vulnerability is a qualitative and subjective choice. It might be a good idea to discuss your selection in a team.

V3 - Check your vulnerability

Having filled the tables on former events and spatial relevance, you should be able to check the current vulnerability in your city. First, select your receptors. The capacity to adapt and the vulnerability are pre-filled for each receptor; if the pre-set adaptive capacities and vulnerability classes don't apply in your city you should change them to another category (just click on them).

If you are not sure about the categories, please review your collected local sensitivity assessment and talk to specialists in your city.

			General weather sensitivity of receptor			
ılect		Receptors	Weather event	Potential effects	Capacity to adapt	Class of vulnerabil
☑	Population	Public health / vulnerable groups	Heat wave	-Deaths, mainly due to cardiovascular diseases -Spread of vector-born and infectious diseases -Altered allergic pattern -Heat stress	*high*	**medium**
			Extreme cold	-Injured and deaths -Spread of respiratory and infectous diseases	*high*	**medium**
			Drought	-Effects on the air-hygienic situation -Leads to an accumulation of trace elements	*high*	**medium**
			Heavy precipitation / Floods	-Injured and deaths -Spread of diseases due to contaminated water, mainly infections	*high*	**medium**
			Storm	-Casualties and deaths	*high*	**medium**
☑		Transport	Heat wave	-Damages -Changes in behaviour pattern / demand -Air quality problems -Higher maintenance costs	*medium*	**medium**
			Extreme cold	-Damages -Changes in behaviour pattern / demand -Higher maintenance costs	*medium*	**medium**
			Drought	-Difficult transport of bulk material	*medium*	low

Output

Finally, before going on to one of the other modules, you can get an overview of the vulnerabilities assessed for your area in the output sheet. There are text boxes where comments about your work can be included. You can forward the results of the vulnerability check to colleagues, external experts and your superiors.

Example for capacity to adapt and vulnerability

Receptor "Industry"

In an exemplary city, the industry sector is highly sensitive to heat and drought as well as mildly sensitive to further extreme events as e.g. storm; (see chapter 1.2.4, page 23).

The industry sector is highly able, (mostly) willing and ready to adapt to heat and drought: Knowledge and availability of alternative cooling systems is apparent. Though, application in case of droughts is limited. Whereas adaptation to storm is not as easily possible: the knowledge and capacity would be there, but the willingness to reduce the impacts of storms is little, as the extreme events only appear very infrequently and the course of the event is hard to predict.

Therefore, the capacity to adapt for industry is

- **High** for heat waves and
- **Medium** for drought
- **Medium** for storm.

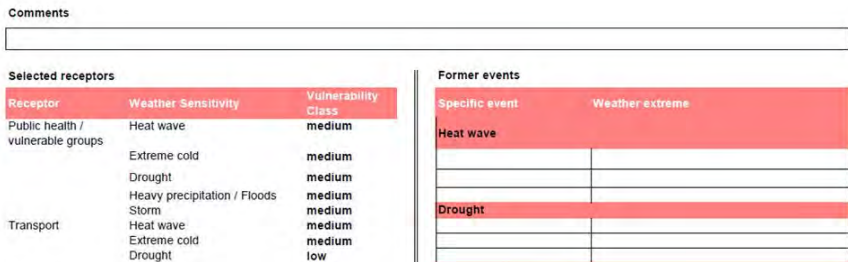
In the exemplary city there are vast industrial areas, so you should take a closer look. Therefore the vulnerability classes for industry are assessed as **medium** for heat waves and droughts as well as for storms.

V4 - Output / Summary

Comments: Please add comments / problems etc. This might help others to understand the results of your vulnerability check.

Selected Receptors: summarises the selection of sheet V3; to see more receptors go back to **V3** and select more.

Number of Former events: You can see the number of former events you have identified for each climate parameter. To add more go back to the former events table.



Comments

Selected receptors

Receptor	Weather Sensitivity	Vulnerability Class
Public health / vulnerable groups	Heat wave	medium
	Extreme cold	medium
	Drought	medium
	Heavy precipitation / Floods	medium
	Storm	medium
Transport	Heat wave	medium
	Extreme cold	medium
	Drought	low

Former events

Specific event	Weather extreme
Heat wave	
Drought	

1.2 Impacts of weather extremes on cities

Weather extremes have always affected humans and their settlements. It is no new phenomenon that we prepare ourselves for extreme events and deal with the consequences. Changing weather conditions cause not only short-term damages but also affect the interaction between the different sectors of human society and natural resources. All physical features and socioeconomic conditions – called receptors – of a city are, in different ways, sensitive to extreme weather events. European cities look back on a long history of extreme events and can learn from the ways they were coped with. This knowledge should be used for sustainable adaptation to climate change.

Climate scientists project an increasing number of weather extremes. This trend can already be observed for e.g. heat waves (BBSR 2009; IPCC, 2007). Over the last 25 years, high temperatures in Europe have surpassed all records and heat waves have caused considerable casualties. The most extreme example is the heat wave during the summer 2003, which resulted in a large number of social, economic and environmental consequences (National Climate Commission Belgium 2010). Many scientists say that 2003 is very likely to have been the hottest summer on record.

It is crucial to understand the impacts and consequences of the past weather extremes in order to adapt to the changes that future climate change has in store for us. Thus, in the following chapters, potential impacts of weather extremes on the receptors are described. The impacts described are not meant to be a comprehensive collection but a gathering of most apparent and widely common impacts in North-West Europe. For other parts of Europe (e.g. the Mediterranean or the Alpine region) the collection may not be fully applicable.

Key terms

Weather extremes / extreme weather events

An event connected with extreme weather conditions like heat, storm or heavy precipitation that occurs rarely at a certain place and time.

Climate change impact

Impacts or consequences of climate change on natural or human systems (IPCC, 2007). In the Adaptation Compass theses consequences are assessed for each receptor individually.

IPCC = Intergovernmental Panel on Climate Change

Public health

Public health refers to all organized measures (whether public or private) to prevent disease, promote health, and prolong life among the population as a whole. Its activities aim to provide conditions in which people can be healthy and focus on entire populations, not on individual patients or diseases. Thus, public health is concerned with the total system and not only the eradication of a particular disease.

1.2.1 Population

Weather extremes lead to manifold health problems, especially for people who need assistance, who are less mobile and are already sensitive to environmental changes: the very young, elderly, disabled or chronically ill.

Public Health / Vulnerable Groups

Heat

In Europe, extreme temperatures occur either during heat waves in summer or as cold spells in winter months. With regard to the latest trends in climate, the impacts of heat waves on human health are especially noteworthy: Direct impacts of extreme high temperatures are immediate consequences from thermal extremes on the human organism: among others, the requirements for the cardiovascular and respiration system rise with increasing heat.

Indirect impacts are increases in the infection potential of pathogens (vectors), e.g. by a raised number of mosquitos as well as in the behaviour or society, e.g. an increasing crime rate. Additionally, an important aspect about high temperatures and public health is the durability and safety of food. The most common infectious diseases are infections by salmonellae, campylobacter and other pathogens from contaminated food. Scientists have shown that there is a significant rise in mortality during days with intense or extreme heat stress. In urban areas, especially in high density areas, the “urban heat island effect” results in even higher temperatures and additional health risks.

Droughts

Droughts have a major effect on the air-hygienic situation. Precipitation binds parts of the trace elements in the atmosphere; everyone knows the clean air after summer rain. Thus droughts, which usually happen in combination with non-windy atmospheric conditions, lead to an accumulation of trace elements, e.g. respirable dust in the urban atmosphere.

Further extreme weather events

Floods, storms and their impacts, e.g. landslides, have in North-West Europe usually less direct impact on human health, although there are stress implications. Nevertheless, major consequences for human health arise from damage to buildings, infrastructure, power supply or health care. Depending on the extent of the extreme event, often a large number of injuries can be assessed.

1.2.2 Infrastructure

Infrastructure is the basis for physical and organisational structures in a city. A functioning infrastructure is the most important feature of a city and its society. All “hard” infrastructure, like transport facilities, water, sanitation and energy plants, is especially prone to damage caused by extreme weather events. This damage can be directly caused by storm and flooding but also by extreme cold,

Examples:

Public health / vulnerable groups

Heat wave in England, 2005

During a heat wave in 2005 South East England reported that paramedics across the county received around 60 % more callouts per day than normal as temperatures reached 28°C.

Storm in England, 2008

During a storm in 2008, pupils at Torfield School in Hastings were evacuated after winds blew off the roof.

Heat wave in Germany, 2003

During the summer heat wave of 2003, 7,000 people died from cardiac infarction, cardiovascular disease and renal failure plus problems with respiratory systems and dysfunctions of the metabolism. Besides the direct health impact of the heat wave in 2003, a regional shortness of potable water led to further health problems.

heat and drought. Indirect impacts are functionality loss, changes in the demand pattern or higher maintenance costs.

Transport

Storm and flooding

Storms and flooding can lead to damages on transport routes. Due to damage to streets, railways, airports etc., people have problems getting to their daily destinations, especially commuters are affected.

Heat, extreme cold

Urban areas are particularly vulnerable to heat; the “heat island effect” causes the temperatures to rise much higher than in the surroundings. Densely build areas with little shading and ventilation are especially vulnerable. Extreme heat can damage transport infrastructure. For example rail tracks buckle and road surfaces can melt, as was reported during the heat wave 2003.

Extreme cold spells can cause road damage, which is costly to repair. Public services need to spend lots of time, effort and money ensuring ice/snow-free roads. Also public transport, especially railways is affected: extreme cold can freeze overhead contacts, switches and the rail tracks itself. This can lead to major delays or failure, while at the same time more people tend to use public transport during extreme weather conditions.

Electricity and heat service

Storm and flooding

Storms and flooding can also lead to damaged electricity lines or power plants. This can result in power cuts or failure and high costs for repairing the infrastructure. For example a common problem is that trees falling on electricity lines cause blackouts.

Heat, drought and extreme cold

Conventional power plants may have problems with water cooling and due to high temperatures the efficiency is reduced. At the same time more energy for e.g. air-conditioning is demanded, so that during long-lasting heat waves in combination with droughts electricity supply may be limited.

Extreme cold can cause increasing costs for heating of buildings. During special conditions, ice cover can even twist electricity lines.

Water supply and sanitation services

Storm and flooding

Besides the damages on the technical infrastructure, water supply and sanitation services have to deal also with potential contaminations by e.g. industry plants. Water quality may be affected and impacts on natural resources and public health have to be avoided.

Examples:

Transport

Storm in Europe, 2007

A severe storm that struck Europe was Kyrill in 2007. It showed the damage potential of such storms for the traffic infrastructure: Traffic was paralysed over most of Europe.

Heat wave in Europe, 2003

In South-East England damages on streets and rail roads were caused by the heat. The County Council afterwards received £4.6 million to help repair roads damaged during the Heat wave.

Extreme cold in Germany, 2009/10

During the winter 2009/10 the long lasting icy weather caused shortages in road salt and prices exploded due to the high demand.

Electricity and heat service

Extreme icy conditions in Germany, 2005

In the Eifel region in 2005 special weather conditions caused the accumulation of ice on electricity lines. The electricity poles broke down under the weight and the region was without electricity for days.

Heat, drought and extreme cold

Main impacts on infrastructure result from the combination of heat waves and droughts. During droughts water resources can be squeezed, especially as people tend to use more water when it is hot and dry: they shower and wash their clothes more often, the gardens are watered etc. Algae and bacteria spread in the surface water bodies at high temperatures and water services have to use more chemicals to treat drinking water.

Extreme cold can also cause damage to water and sanitation infrastructure. An example is the fact that regularly during cold winters, water pipes burst.

Social infrastructure

Storm and flooding

Storms and flooding can lead to damage to all social facilities. Challenges arise from the secondary impacts of the extreme events: hospitals may be overcrowded and a sound emergency management is needed.

Heat, drought and extreme cold

The social infrastructure is also experiencing more demand, as hospitals are more crowded and people use outdoor leisure facilities a lot, like swimming pools, beaches, barbecues in the local park. Therefore, additional costs for maintenance arise for the public budget. Furthermore, statistics say that during hot weather, the crime rate rises significantly.

The impacts of extreme cold are well known: more heating is needed which increases the maintenance costs for public buildings. Accidents occur more often and hospitals may be crowded.

1.2.3 Built environment

Extreme events affect not only the people and functions of buildings but also the buildings, represented by the receptor building stock and the materials.

Building stock and materials

Storm and flooding

Storm and floods cause damage not only on infrastructure (see receptors on infrastructure) but also on buildings in the affected areas. The damages vary from strength and kind of event. One example is that strong storms often dislodge tiles from roofs. Floods cause water penetration in houses which can cause long-term damp in the walls.

The damages are intensified by sealing surfaces, such as tar etc. Water therefore has to runoff on the surface and is accumulated at deeper reaches as in garages, cellars.

Heat, extreme cold

Heat can produce damage to buildings, especially in densely built up areas. E.g. plastic parts of roofs, windows etc. can be deformed. Urban areas are particularly vulnerable to heat; the “urban heat island effect” describes the

Key terms

Social infrastructure

The receptor social infrastructure includes all public service facilities, like community and recreational facilities (e.g. schools, libraries, public sports grounds, swimming pools), hospitals as well as volunteer networks and community based agencies.

temperatures difference between the warmer cities and the cooler surroundings. Densely build areas with little shading or ventilation are especially vulnerable. Buildings are often equiped with air-conditioning which increases electricity use and costs. Heat also leads to damages on many surfaces, like asphalt, tar, rail tracks or plastics. Dark surfaces in densely build areas with little shading and no ventilation are especially vulnerable (heat island effect). Damage caused by extreme cold are mostly connected to water freezing, i.e. pipes burst or moisture in the walls causing cracks.

1.2.4 Local economy

All economic sectors are exposed to impacts related to extreme weather events; the impacts can destroy the local economic activity of a city for a certain time.

Tourism

Storm and flooding

Storm and flooding can affect the tourism sector with damages on tourist monuments, accommodation etc. This damage to, e.g. historical or cultural buildings, are very costly for public budget.

Heat and droughts

Local tourism in North-West Europe usually profits from high temperatures and droughts: Day trippers and weekend visitors arrive in great numbers especially to the coast. Hence, for public administration some challenges arise: More visitors leave more waste and need more parking, more accidents are likely to happen and nightly disturbances increase.

Industry

Storm and flooding

Storm and flooding can affect the local economy with damage to all kinds of infrastructure, also on industry plants. Damages at industrial sites, e.g. caused by flooding, can additionally result in immense environmental problems.

Heat and droughts

For the industry high temperatures cause an increasing need for cooling the production process and the factories or power plants itself. During droughts rivers often suffer from low water. Therefore, the water resources for cooling may be limited at the same time as more cooling is needed. Furthermore, industry plants that are not situated at the coast may have problems to be delivered with bulk commodities, which are transported mainly via inland navigation. During extreme weather conditions prices for commodities and electricity rise fast. The demand for seasonal products is highly depending on weather conditions. Thus industries can profit or experience losses, depending on their orientation.

Examples:

Industry

Heat wave in Europe, 2003

As experienced in 2003 all over Europe, a large-scale heat wave together with a drought led to highly rising prices at the stock exchanges:

* for electricity due to limited production

* for raw materials due to difficult transport conditions and

* for oil due to higher demand.

Retail

Storm and flooding

Storm and flooding can affect the local economy with damage to all kinds of infrastructure, also on shops etc.

Heat and droughts

The demand for seasonal products is highly dependent on weather conditions. Local retail or services can profit or experience losses, depending on their orientation.

1.2.5 Natural resources

Even relatively small changes in climate have always affected the natural environment. Adaptation to changing environmental conditions is a basic feature of flora and fauna, but climate change as well as the special conditions in urban areas limits the possibilities for natural resources to adapt. In cities natural resources are not only natural water resources and surrounding air but also green spaces which are mainly found in form of parks and some urban gardens. These receptors are major influencing factors for the quality of life in cities and determine human well-being. The receptors Agriculture and Forestry have no very central role in urban regions. They are nevertheless included in the Adaptation Compass as there is e.g. an increasing trend for urban gardening in some metropolitan regions and city forests are an important recreational space on the outskirts.

Green spaces

Flooding and storm

Events, such as storms or floods lead to damages to the infrastructure and vegetation. This can devastate open green spaces that are important for urban regions. As a consequence of flooding, pollutants or salt water may be enriched in water bodies and soil which again can lead to damage to flora and fauna. That will also be noticed in open green spaces of cities.

Heat, droughts and extreme cold

During heat waves and droughts water availability is limited: This is caused firstly by a high evaporation and high uptake by the flora. Secondly, the surface and ground water resources shrink. This causes heat and drought stress for plants and animals and leads indirectly to higher maintenance cost (e.g. for irrigation, watering). At long-lasting droughts, sensitive plants are dying and the risk of fire is increasing.

During extreme cold events, depending on the region and kind of vegetation, plants are damaged or die. For example the palm trees along the south coast of England do not tolerate long and extreme cold.

Key terms

Natural resources

Natural resources are assets occurring in nature that are used, consumed or exploited by human activities.

Biodiversity / ecosystems

The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.

Water resources and quality

Flooding and storm

As a consequence of flooding pollutants or salt water may be enriched in water bodies and soil which can lead to water quality problems.

Heat and droughts

A main problem is that the surface and ground water resources shrink. This leads indirectly to higher maintenance cost (e.g. for water conditioning). Furthermore, in the water bodies itself algae and bacteria spread and, depending on the local situation, salinization of the water bodies may become an urgent problem. Usually, during heat waves water demand and consumption rises significantly, which aggravates the water quality problems.

Air quality

Heat and droughts

Smog and high concentration of air pollutants and allergens are further consequences of long-lasting heat waves and droughts. Especially in urban regions air quality is decreasing enormously during such events. The changing air quality has also impacts on other receptors of a city.

Agriculture

Flooding and storm

Events, such as storms or floods lead to damages at the crops. Furthermore pollutants or salt water may be enriched in water bodies and soil which again can lead to damages for flora and fauna. The top soil layer is quickly eroded during flooding and storm.

Heat, droughts and extreme cold

Already today, the agriculture sector is as well positively as negatively affected by short term extreme events and the changing climate conditions. As long as the precipitation pattern has not changed significantly, warmer periods are rather positive for agriculture in North-West-Europe, e.g. for certain crops such as wheat. Coupled with the elevation of CO_2 concentration, plant growth is expected to be increasing. Nevertheless, extreme weather events such as heavy rains or droughts combined with pollution problems have always been negative for the harvest.

The shrinkage of surface and ground water resources causes heat and drought stress for plants and animals and leads indirectly to higher demand for watering. At long-lasting droughts, sensitive plants are dying and the risk of fire is increasing.

Extreme cold weather causes damages for many crops and orchards, when it is occurring in the vegetation period. Especially in the early spring month, very hard frosts cause freezing of young plants or the fruit tree bloom.

Examples:

Extremes go hard on European agriculture

In the past decade, agriculture in some regions in North-West Europe (e.g. Western Germany) has suffered from cold and extreme frosts in the spring months, especially in 2004, 2006, 2001 and 2012. This has damaged the crops and orchards in the important early vegetation phase. Often this was followed by extremely dry spring and early summer month:

Most extremely in 2003, but also in 2006, 2007, 2008, 2011 and 2012.

Not all crops are suffering from the descending conditions, e.g. for sugar-beet root, or potato the dry spring and warm autumns of the past years have caused bountiful harvests.

Forestry

Flooding and storm

Storms and floods lead to damage to vegetation and forest infrastructure. Especially the tree population is vulnerable to storms. Furthermore, pollutants or salt water may be enriched in water bodies and soil which again can lead to damages for flora and fauna.

Heat and droughts

The shrinkage of surface and ground water resources causes heat and drought stress also for trees and animals in the forest and therefore influences the health and growth of trees. At long-lasting droughts, sensitive plants are dying and the risk of forest fires is increasing.

Biodiversity / ecosystems

Flooding and storm

The impacts of climate change can already be observed in ecosystems: biodiversity losses have been recorded due to air, water and soil pollution, fragmentation and destruction of habitats, intensive agricultural and forestry practices or exotic invasive species.

Heat and droughts

The limitation of water during heat waves and droughts has also consequences for the biodiversity. But the new situation opens up new living conditions for flora, fauna and all kinds of species. Furthermore, in the water bodies itself algae and bacteria spread and, depending on the local situation, salinization of the water bodies may become an urgent problem. Both aspects lead to a reduction of aquatic biodiversity.

1.3 Experiences from FUTURE CITIES

Regional Vulnerability Assessment in South East England (UK)

In the South East of England, the Partnership Board, a partnership between the South East's local authorities and the regional economic development agency, undertook a regional vulnerability assessment. Due to changes in administrative structures in 2010 the Board is not existent anymore.

Different sectors were explored, e.g. population and health, water resources and the economic development. The Board decided to first look at the current vulnerability: What consequences are currently experienced as a result of flooding and erosion? The regional vulnerability assessment has focused on identifying areas at greatest risk or "vulnerability hot spots". These were identified by overlaying maps with the geographical information available at the regional planning association. Starting from the current vulnerability, the experiences made with the receptors were integrated into the FUTURE CITIES Adaptation Compass.

Examples:

Invasive species cause problems all over Europe

Well known examples are the plant ambrosia or the grey squirrel, which is native in Northern America. Also the harlequin ladybird, native to Asia has gained lots of attention, as it suppresses the native European ladybird species.

An inventory in the UK showed a decline of 20% of the native species due to environmental changes and competition from invasive species.

Read more:

Regional Vulnerability Assessment, South East England

www.climatesoutheast.org.uk

Hastings Local Vulnerability Check

www.hastings.gov.uk

The Local Vulnerability Check in Hastings (UK)

The FUTURE CITIES partner, Hastings Borough Council, explored its local vulnerability by conducting a Local Climate Impacts Profile. This is a procedure introduced in the UK by the UK Climate Impacts Programme to explore the consequences of extreme weather events. In Hastings, a town on the South East England coast, weather events reported in the news during the past 10 years were connected to the impacts they caused on the municipal services and communities. For the past 10 years, 20 events of flooding, 14 events of drought and each 7 events of heat waves and high winds were noted. Heat waves had positive and negative consequences. More tourists came to visit Hastings because the sea and wind lowers the temperatures. Negative was the increase of complaints due to more noise in the streets during warmer nights. The process also raised awareness among the various departments of the administration as they were requested to gather the necessary information.

Following the vulnerability check Hastings Borough Council developed a town-wide climate change adaptation 'plus' plan, drawing on regional and local climate impacts data of the UK Climate Projections 2009 with actions shared across a range of local partners. Before filling the table "Former Events" in the Adaptation Compass you can take a look on the reported former events that were collected by Hastings Borough Council.

Assessing the urban climate of the city of Arnhem (NL)

The Dutch city of Arnhem focuses on the urban vulnerability due to heat and the urban heat island effect: The average temperature in a city is higher than in the surrounding area. Different types of instruments are used. The Urban Climate Analysis Map shows areas at most risk for heat storage and possibilities to ventilate and cool the city based on five factors: topography, land use, urban morphology, material use and colour, and wind paths. Additionally, in August 2009 after a series of hot days the temperature on the ground was measured with special bicycles. Late in the evening a maximum temperature difference of 7 °C was measured between stony and green areas in the city. These results validate the theoretical results of the Heat Map. In the same period, an aeroplane at 4000 m altitude took pictures with a heat sensitive camera for a so-called heat scan. Analysing the Heat Map and the heat scan leads to interesting conclusions: E.g. the heat scan shows that the football stadium "Gelredome", a stony area, radiates in the evening a lot of heat which was absorbed during the day. The Heat Map concludes that the open area around the stadium prevents the area as a whole from heating up because it is well ventilated.

To define the actions required, the Heat Map was translated into a "Heat Attention Map". This map distinguishes between four types of areas which require different measures. The Heat Map and the Heat Attention Map triggered city planners and project developers and made them aware of the possibilities to make their projects climate resilient and more attractive.

Extreme rainfall event in Dortmund, July 2008 (DE)

On July 26th 2008 in the city of Dortmund about 200 mm rain fell within three hours. This amount of precipitation is twice as high as the average monthly rainfall in July in this area. An area of 2.5 km² was affected, so it was an extreme local event. In three city quarters streets were completely flooded, and

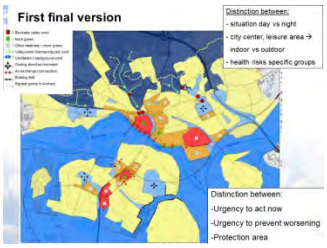
Key terms

Urban structure / Urban morphology / City structure

Urban structure is in the Adaptation Compass a category for adaptation measures addressing the whole city and its morphology, i.e. the city build-up as well as its elements and materials are regarded.

Examples:

Heat attention map of the City of Arnhem:



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Read more about the Experiences from FUTURE CITIES in the final report of the Partnership "The Future Cities Guide to liveable and climate-proof cities" The Report is available on www.future-cities.eu

partly the dikes of the Emscher and its tributaries were overflowing. A kindergarten was flooded and a shop for electronic devices was totally destroyed. The existing drainage had no chance to cope with the masses of water. The damage summed up to several millions of Euros.

Statistically only every 100 years such an extreme event happens. The existing rules for dimensions of drainage and flood prevention (e.g. in Germany) do not foresee the prevention of such an event. The upgrading of the water infrastructure to provide security against any future event of this dimension is economically not sensible. Therefore, different strategies are implemented: consequent monitoring and implementation of the existing flood risk management by all involved actors, a careful check of the water management situation of the urban area, and finally an agent for flood issues at the municipality who cares for these concerns and is contact person for citizens.

1.4 Get to know more

There are several tools and guidelines to help different target groups in assessing their vulnerabilities towards the changing climate. Mostly, the vulnerability assessment is included in a wider process of adaptation, as in the Adaptation Compass.

Tools and Guidelines that include a vulnerability assessment are for example:

- The **Adaptation Wizard** by the UK Climate Impacts Programme (UKCIP) and the webpages of the UKCIP

  www.ukcip.org.uk/wizard/

- **Klimalotse**: Leitfaden zur Anpassung an den Klimawandel
  by the Federal Environment Agency (Umweltbundesamt) Germany

  www.klimalotse.anpassung.net

- **KlimaateffectAtlas**: gives information on impacts in the regions of Netherland by the Royal Netherlands Meteorological Institute

  http://klimaateffectatlas.wur.nl/bin/cmsclient.html

More tools are being developed. It is worthwhile to check some of the links provided in the module “Understand Climate Change Impacts” for updated information.

If you want to get an overview on the potential vulnerabilities of your region, a good start is to take a look at the **Adaptation Strategies** of your country or region. In smaller countries the Adaptation Strategy covers the whole country, but in larger ones, there are often regional Adaptation Strategies. In Germany for example, the Federal States have their own adaptation strategy. In the UK several cities have already finished their **Local Climate Impacts Profile**, a very detailed assessment of vulnerabilities.

National and regional adaptation strategies

The following national or regional adaptation strategies are available on http://www.future-cities.eu/

Belgium

National Climate Commission (2010): “Belgian national climate change adaptation strategy”

France

La Documentation française, (2007): “Stratégie nationale d’adaptation au changement climatique”

North-Rhine Westphalia

Ministerium für Umwelt und Naturschutz, Landwirtschaft und Verbraucherschutz des Landes NRW (2009): “Anpassung an den Klimawandel
Eine Strategie für NRW“

The Netherlands

Ministry of Housing, Spatial Planning and the Environment et al. (2007): “National Programme for Spatial Adaptation to Climate Change“

United Kingdom

Department for Environment, Food and Rural Affairs (Defra) (2009): “Adapting to climate change UK Climate Projections”