ADAPTATION COMPASS

Future Cities

urban networks to face climate change

Guidance for developing climate-proof city regions

The FUTURE CITIES partners want to hand on their experiences gained, lessons-learned and problems encountered to other cities or regions in North-West Europe. During five years of intense cooperation, the partnership developed and implemented a variety of measures to make their cities and city regions fit to cope with climate change. In the FUTURE CITIES Adaptation Compass, these experiences are presented together with a structured and understandable approach which shall support cities to identify their own adaptation strategy.

This document is a guide to the process of adapting cities and complements the FUTURE CITIES Adaptation Compass tool: *It provides technical instructions on how to use the Compass and gives additional explanations and references.*

Aim: *The FUTURE CITIES Adaptation Compass aims to help planners, climate change policy officers, technical staff and experts at cities and water boards to structure their adaptation work. It gives examples for good-practice, presents the experiences of FUTURE CITIES partners and highlights possible obstacles.*

The focus is on "guiding through the process" based on a pre-structured assessment: Different modules guide you from assessing vulnerability to selecting options.

Handling of this document: *It might be beneficial to read through this Guidance document first and then start to take a look at the Compass tool. You could also start with the Compass tool and consult the Guidance where you need further explanations or want to dig deeper into the subject.*

The Guidance document is structured into four parts:

- Part I: Introduction

- Part II: How to use the Adaptation Compass

- Part III: Modules

- Part IV: Perspective

- Part V: Additional documents

On every page, there is a small column on the right providing explanatory notes, like key words, links and examples.

Contents

PART I: INTRODUCTION

1 The challenges of climate change for cities

Our climate is changing and adaptive action is required.

The heat island effect in summer or wetter winters with increased flood risk are phenomena which impact greatly on urban living conditions. This is where the impacts are felt and the adaptation measures have to be implemented “on the ground”. Rising temperatures and weather extremes like floods and storms can be detrimental for the quality of life in our towns and cities – challenges we have to face. Our urban city regions must be prepared to cope with the effects of climate change as city structures and the urban living environment are especially vulnerable.

At the same time well-functioning city regions are one of the most important pre-requisites for sustainable economic development. A mere reaction on the impacts of climate change will lead to increased costs for adaptive measures. Anticipatory strategies are needed for adapting the urban structures in a way that the impacts of a changing climate will not endanger the urban living environment.

The FUTURE CITIES partnership developed the Adaptation Compass to help the partner organisations and other similar organisations to find their way to cope with the impacts of climate change.

Key terms

Climate vs. weather

Climate is described by long-term statistic values, like means, variances, probabilities etc. of meteorological parameters (e.g. temperature). Long-term in the context of climate typically means a time span of at least 30 years.

Weather describes the day-to-day changes in atmospheric conditions in a specific place at a specific time.

Heat island effect

The Heat Island or Urban Heat Island (UHI) Effect describes the possible temperature difference between rural areas and build-up urban areas. The effect can be explained by the absorption of solar radiation by materials in cities (e.g. dark surfaces: tar etc.). Furthermore, in cities buildings block the air exchange with the outer and cooler surrounding of the city.

2 FUTURE CITIES - urban networks to face climate change

About the FUTURE CITIES-project

At European and national level, urban networks exist to promote strategies to mitigate greenhouse gas emission. Mitigation is important, but not sufficient. If mitigation and adaptation measures are linked at the local level, synergies can add value. It’s no longer possible to reduce the emissions quickly enough to avoid dangerous or negative impacts on people's life, economy and ecology. It is obvious that beside mitigation, adaptation is also necessary. As there are still practical obstacles to overcome, this calls for coordinated action and transnational cooperation. Acting locally is essential to directly face the challenges of extreme weather. But it is not enough because the impacts of climate change do not stop at national borders or city limits. Through international partnership, sectoral and individual know-how can be built upon and several actors can work together on local and regional improvements.

The German Lippeverband has collaborated with seven partners from five European countries on “FUTURE CITIES – urban networks to face climate change”. The project aims to make city regions in North-West Europe fit to cope with predicted climate change impacts.

Project partners

The FUTURE CITIES partnership includes water boards, urban administrations, planning companies and project developers in North-West Europe. The geographical scope of the partnership covers densely populated areas in river catchments or directly at the coast: Northern Ruhr area with the catchments of the rivers Lippe and Emscher as tributaries of the Rhine, the province of Gelderland in the catchment of the rivers Nederrijn and Waal, the region Haute-Normandy in the catchment of the River Seine, West Flanders with the river catchment of the Schelde and finally South-East England on the southern coastline of Great Britain.

Each partner of the FUTURE CITIES project has special expertise in a field of necessary action: E.g. the expertise of water boards about the urban water system is combined with the expertise of the municipalities with regard to the effects of green structures. The involvement of regional planning authorities secures the expertise in planning guidelines as well as development agencies provide for know-how in planning with investors.

Map of North West Europe showing the location of Future Cities Partner organisations

Key terms

Mitigation

Mitigation is used for actions which reduce the potential impacts of global warming (see climate change) by decreasing or avoiding greenhouse gas emissions.

Adaptation

Adjustment in natural or human systems in response to observed or expected climatic changes or their impacts. Adaptation moderates harm (risks) or exploits benefits (opportunities). Various types of adaptation can be distinguished, including anticipatory, autonomous and planned adaptation (IPCC, 2007; Ribeiro et al. 2009).
When using the term adaptation in the Adaptation Compass, planned adaptation – i.e. adaptation that is the result of a deliberate policy decision – is meant.

FUTURE CITIES Project Partners

(DE) Lippeverband

(NL) City of Arnhem

(DE) Emschergenossenschaft

(GB) Hastings Borough Council

(NL) City of Nijmegen

(FR) Rouen Seine Aménagement

(NL) City of Tiel

(BE) West Vlaamse Intercommunale

Project results

During five years of intense cooperation, the partnership developed and implemented a variety of measures to make their cities and city regions fit to cope with climate change.

You can find some examples here (for more information see links on the right):

<u>Exemplary measures - on town and city quarter level:</u>

The **Dutch city of Arnhem** focused on the urban vulnerability due to heat and the urban heat island effect. Based on the analysis of the urban climate a “Heat Attention Map” was developed to provide recommendations for urban planners and developers.

The **French city of Rouen** is developing the “quartier Luciline” on the banks of the river Seine into a sustainable business and housing site. The first measures to be taken concern the reconstruction of the water system in order to deal with weather extremes more efficiently. These include decentralised percolation, water retention, landscape-greening and the aeration of the currently completely sealed 12.000 square metre area.

The **West-Vlaamse Intercommunale (Belgium)** developed a sustainable new district, the city quarter “de Vloei” in the Belgian city of Ieper. In the FUTURE CITIES project, the focus lay on networks which combine the needs of water management and urban greening. Green-Blue corridors connect the district with an adjacent housing area and the main roads. Planners placed a particular emphasis on including decision-makers in their considerations: construction techniques leading to sustainable towns are often already known, but these have to be implemented by the right persons at the right time.

Emschergenossenschaft and the municipality of Bottrop cooperated to restructure an industrial park to become climate-proof. On the site, with mostly impermeable surfaces, like roofs and roads, flash floods after heavy rainfall often occurred. This situation is exacerbated by the impending climate change. Adaptive measures in the water system – like disconnecting the storm water discharge from the sewer system – reduce the potential sewer overflow in case of heavy rainfall.

The **German water board Lippeverband** created a green-blue corridor in the city of Kamen to improve the city microclimate. Additionally, in combination with the ecological enhancement of the stream "Heerener Mühlbach" storm water from private properties was disconnected from the sewer.

In the **Dutch city quarter of Tiel East** the overall aim was to develop sustainable, climate and waterproof building to deal with several water related problems. An integral scenario for water was developed with innovative design principles and technical measures combining water management, climate resilient building and renewable energy.

Read more on the FUTURE CITIES results

FUTURE CITIES Website:
all relevant information on the Project and its results

www.future-cities.eu

More information on the Rouen Luciline site can be found here:

www.rouen-seine.fr/luciline

Information on the sustainable new city quarter “**De Vloei”** in the Belgian city of Ieper:

www.devloei.be

The results and experiences made, while implementing local measures for adaptation and mitigation in the project FUTURE CITIES, are integrated in the Adaptation Compass.

To read more local examples, go to the fact sheets in the Compass or the separate Annex.

Exemplary measures - on building level:

A good example of a new climate-conscious construction is the Sussex Exchange building in the **region of Hastings / Bexhill** in the south of England. The right location, an architectural design which favours a healthy climate, with natural ventilation, the use of renewable energy, rainwater systems and roof greening make this an ideal example of how to construct new buildings to face the challenge of climate change. An exhibition of techniques and materials within the building gives visitors further insights in how to construct buildings to meet the challenge of climate change. The exchange building is simultaneously a conference centre offering optimal facilities for future events dealing with sustainability themes.

As part of a climate campaign, the **Dutch town of Nijmegen** installed green roofs and green facades on existing buildings. These help to cool the buildings, retain rainwater and reduce energy needs. Furthermore Nijmegen changed a parking lot in the city centre into a green-blue public courtyard to help cool the area. Monitoring studies investigate what positive impacts on the urban climate are achieved in reality.

The FUTURE CITIES partners want to hand on their experiences gained, lessons-learned and problems encountered to other cities or regions in North-West Europe. In the FUTURE CITIES Adaptation Compass, these experiences are presented together with a structured and understandable approach which shall support cities to identify their own adaptation strategy.

Key terms

Lessons-learned

The experiences made by the FUTURE CITIES partners while implementing adaptation measures are collected and assessed during the project. Finally, they are integrated in the Adaptation Compass to pass the experiences to further users.

3 Aim and general structure of the Adaptation Compass

Aim

In a city, almost all departments face the impacts of climate change. They have to adapt their policies and practice. Measures taken by one department might also meet the adaptation needs of another. Moreover, adaptation activities of one department may also conflict with the adaptation aim of another urban structure; e.g. planting more vegetation like trees to keep public spaces cool will mean more falling leaves into the discharge system to be cleaned up and might increase the possibility of blocked gullies and storm water flooding. Using green structures and the water system for cooling the city instead of energy-consuming air-conditioning supports also mitigation aims: reducing or omitting greenhouse gas emissions.

This is where the Adaptation Compass starts from: It is a guide to interlink different interests and stakeholders and to check the vulnerability and adaptation options across the sectors. Often the effectiveness and efficiency of an adaptation measure is increased when combining different options. Also, on local level adaptation and mitigation can easily be interlinked. The FUTURE CITIES Adaptation Compass is meant to help planners and experts at cities and water boards structure the working steps, give examples for good-practice and experiences of FUTURE CITIES partners and highlight possible barriers.

The focus is on “guiding through the process”. Based on a pre-structured assessment and documentation layout, this Compass shall facilitate a well-structured and substantiated preparation of the stages to create climate proof cities.

The Adaptation Compass was developed for the application on cities or city quarters. It can however also be applied for other scales, like city regions or rural areas, because the Compass gives the opportunities to change all pre-settings, to add new receptors, new sensitivities and new measures. The main intention of this approach is to interlink the different stakeholders and departments in the regarded area.

General structure

The FUTURE CITIES Adaptation Compass is a computer-aided guide built up of five modules to be used as a whole or part. The procedure as a whole is based on the risk management approach. The tool provides general information and automated answers. It also gives you the opportunity to submit local information. The guidance explains why automated answers are given and how they can be altered to adapt the Compass to the individual needs. Each table can be printed and the results of the Vulnerability Check and the Selection of suitable adaptation options are documented in an output sheet which can be stored and printed for further use.

A list of adaptation measure is provided which address the problems identified with the different modules of the Compass. Furthermore, Guidance is given on how to proceed further regarding the decision for implementation and the location for the measure.

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).

Adaptation measure

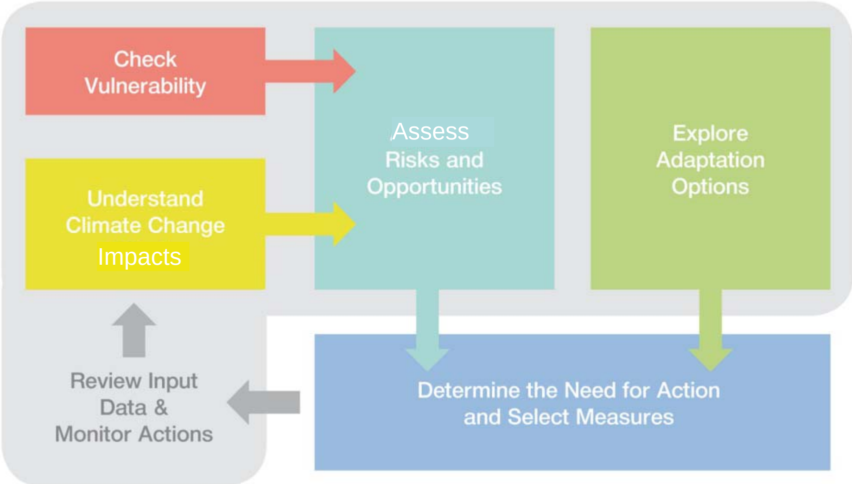
Measure to adapt to climate change impacts can be technical, participatory, communicative, planning, etc.

The goal of implementing an adaptation measure is

- to reduce the vulnerability of a receptor,
- to enforce the capacity to adapt and / or
- to strengthen the positive impacts (opportunities) of climate change.

For the FUTURE CITIES adaptation compass the measures are categorised according to their function: green structures, water system, energy efficiency and mitigation measures, city structures, awareness measure and others.

The FUTURE CITIES Adaptation Compass is structured in five modules:



- CHECK VULNERABILITY – this module provides the basis to determine the current vulnerability for a city region or parts of a city.
- UNDERSTAND CLIMATE CHANGE IMPACTS – here the Compass informs how to get the necessary information. Advice is given on how to cope with the uncertainties involved in climate projections and related impacts.
- For the ASSESSMENT OF RISKS AND OPPORTUNITIES a method is proposed which uses the results from the vulnerability check and the projected climate change trends.
- The module EXPLORE ADAPTATION OPTIONS facilitates exploring the various adaptation options: especially the combination of different measures for improved efficiency and effectiveness. Possible links to mitigation measures are given.
- With the module NEED FOR ACTION the core problems and problem areas can be identified and suitable adaptation options can be found. The user receives a list with suitable adaptation measures addressing the vulnerabilities and risks identified for their city.

You can save the results and can REVIEW later whether parameters and collected information are still correct. Additionally, examples for MONITORING the results of measures are provided.

Check Vulnerability" and "Explore Adaptation Options" are the main focus based on the practical experiences and evaluation of measures from the FUTURE CITIES partnership. For the other modules, instructions for action and background information are provided.

Some instructions and information may seem trivial to you. This is not a scientific compilation, but is written for the practical usage by planners, technical staff and experts of different professions. The benefit of the Compass is the collection of information from different sectors, expertise and professions.

Key terms

Risk

In the FUTURE CITIES Adaptation Compass risk is composed of the current vulnerability (high, medium, low) and the climate change impact (balancing, indifferent, reinforcing) and is categorised in the classes very high, high, medium, low.

Opportunities

In combination with climate change the term opportunities is used to describe the positive aspects of climatic changes for certain regions, e.g. hotter summer can influence the tourism sector positively.

Please note:

Although the FUTURE CITIES project has gathered lots of background information, the Adaptation Compass does not attempt to be comprehensive. There are many more facts, options and possibilities for the different sectors and geographical regions. The information described in the modules are the good-practice from FUTURE CITIES.

Also, the state of the art is changing fast: Adaptation strategies and processes are continuously developed further and new ideas are implemented.

So, keep an open mind towards innovative ideas for adapting to climate change!

PART II: HOW TO USE THE ADAPTATION COMPASS

1 Technical issues

Before you are getting started with the Adaptation Compass, please read through the following technical requirements and instructions carefully.

You have probably received the Adaptation Compass on a CD; the instructions given here are tackling your situation. There is also a .zip-file available for download on the FUTURE CITIES' Website with the same folders, files and requirements as described here:

Software used

The Adaptation Compass was developed in Microsoft Excel 2010 under a Windows 7 operating system. It was subsequently made serviceable to Microsoft Excel 2003. Furthermore several files in pdf (Portable Document Format) are interlinked with the Adaptation Compass. The Tool works with VBA Codes (Visual Basic Application), i.e. the Macro function of your Excel installation is required.

Software requirements

- 25 MB space on hard drive
- Microsoft Excel 2003 or Excel 2010 with activated Macro function
- Adobe Acrobat Reader or similar for opening pdf files

File concept

You received a CD containing a folder "FUTURE-CITIES_Adaptation-Compass" containing the following structure:

- Text file with instructions and copyright/liability notes: **Adaptation-Compass_READ-ME.txt**
- Excel file with the Adaptation Compass for use in Excel 2003 and 2010: **FUTURE-CITIES_Adaptation-Compass.xls**
- Guidance document as .pdf **FUTURE-CITIES_Adaptation-Compass_Guidance.pdf**
- Folders with background information in .pdf (open via hyperlinks from the Adaptation Compass):
  - Types of measures
  - FS_Structural
  - FS_Awareness
  - Examples_filled-tables
  - Guidance_chapters

Screen settings

The Adaptation Compass is optimised for a screen size of 19 inch. If your screen is smaller, you will need to scroll also left and right.

Several links to pdf - files are provided, especially in module "Explore Adaptation Options". Please set your pdf-Reader to a zoom level of 75 % or 100 % to ensure best readability.

Do's

- Save the whole folder "FUTURE-CITIES_Adaptation-Compass" at your hard disk or server.
- Enable Macros in Excel before starting the Adaptation Compass!
- Be patient. Depending on your hardware, the Compass might be slow when opening for the first time.
- After you started working with the Compass, save it under a new name (e.g. add your name at the end of the file name) in the same folder.
- Use the Save / Save as… function of your Excel whenever you changed anything in the Compass.
- When changing the pre-settings, you should write down what your reasons are, so that your colleagues or you comprehend your thoughts at later use.
- Sometimes the hyperlinks don't work at the first click; click on any other cell on the sheet and then try again.
- Print via the print function of Excel; this allows you also to change the defined print pre-settings.
- Feel free to include all relevant local information: several possibilities to add your data are given in the Compass.

Don'ts

- Do not save only parts of the CD; the whole folder "FUTURE-CITIES_Adaptation-Compass" needs to be saved locally. Otherwise the hyperlinks to the .pdfs don't work.
- Do not overwrite the Original – you might need it later.
- Do not save the Adaptation Compass at another location than the folder "FUTURE-CITIES_Adaptation-Compass".
- Don't forget to save the Compass in regular intervals.
- Don't select more than one sheet at a time – this will disturb the VBA code and may lead to the breakdown of the file.
- Don't jump quickly between the different sheet, we advise to use the given navigation path (arrows, see following page).

Having understood the technical requirements and subsequently starting to work with the Compass, you also need to be aware of:

- It might take some time to gather all information, especially in the Module "Check Vulnerability".
- It might be beneficial to involve your colleagues and possibly also other stakeholders.
- It is not necessary for the outcome of the Compass to fill in every table. But you should be conscious of the information requested.
  Keep the filled-in local information and data updated (See also chapter 3 on reviewing your input data).

What could go wrong?

Any functions don't work:
Most probably the reason is that the Macro-functions from Excel are not activated. You can change it withing the programme via the security rules.

Hyperlinks are not working:
There can be two reasons for that:
- Either no cell on the respective sheet is activated → just click somewhere on the sheet and try the link again;
- Or, if an external link is concerned, you might have changed the file structure. Please make sure that the folders under ***FUTURE-CITIES_Adaptation-Compass*** are not separated.

2 Navigation

For the navigation within the Adaptation Compass and to the respective Guidance chapters the following main functions can be used:

Guide: This button will lead you to the respective chapter of the Guidance document (.pdf document opens), where you can find instructions, definitions and literature references.

Go back to the module's overview page: This button will navigate you to the overview of each module; From there you can navigate to all sheets of the module or click through the module step by step.

Go on: This button will navigate you to the next sheet situated after the one you are in; If you want to use the Compass step-by-step, use this buttons.

Add Comments: This button will navigate you to the "Comments" sheet. Here you can enter comments for colleagues or yourself for later use.

Two more symbols appear in the Guidance as well as the Compass:

The pen shows you where you can

- write into the tables and
- influence the results for your assessment.

The light bulb indicates the tables that provide information or sum up the results of previous steps.

The adding of receptors or adaptation measures in the Compass can be done additionally in several steps, as indicated on the respective sheet.

FAQ

How much time do I need for the Adaptation Compass?

For going through the Adaptation Compass once you will need anything from a few hours (for a rough scan with a rough result) and a few months (for a thorough assessment with a more precise result).
Be aware that the Adaptation Compass should guide you through the process of adaptation to climate change. And adaptation always is a long-term process.

Do I need to fill every table?

In the module "Check Vulnerability", two tables are provided that help you assessing your own cities' 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.

PART III: MODULES

1 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.

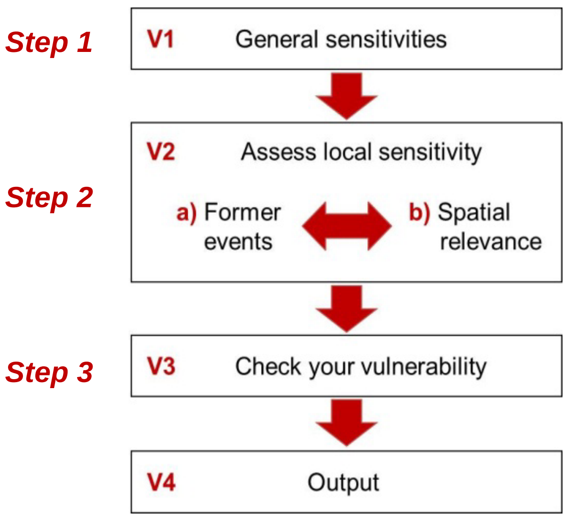
1.1 Purpose of the module and proceeding

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		Who / What is affected
		Extreme weather event	Potential effects	
pulation		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
	Public health / vulnerable groups	Extreme cold	-Injured and deaths -Spread of respiratory and infectous diseases	Sensitive people, babies, elderly and imm 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.

elect		Receptors	General weather sensitivity of receptor		Capacity to adapt	Class of vulnerabil
			Weather event	Potential effects		
☑	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

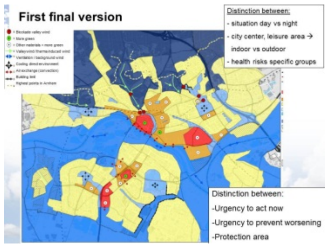
Key terms

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:



© City of Arnhem

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”

2 Understand Climate Change Impacts

Detailed research is being undertaken to determine the impacts of climate change. Nevertheless, climate models involve many assumptions about how the parameters will develop and interact. Almost every country is working on its own regional climate projection model derived from different global climate models. For some regions, various regional climate models are being used providing varying results. For a planner in the city the Adaptation Compass supplies practical information to guide you through questions such as:

- What do I need to know? What kind of information do I need?
- How can I handle uncertainties?
- Where can I get information?

2.1 Purpose of the module and proceeding

The module “Understand climate change impacts” consists of three sheets providing information:

Step 1 — **C1** - Learn about regional trends

↓

Step 2 — **C2** - Impacts of climate change

↓

Step 3 — **C3** - Further information: Link lists

Step 1: Learn about regional trends

For the regions of the FUTURE CITIES partners, trends for climate variables are provided, e.g. increase of temperature during summer. The trends are displayed with directions, not absolute values. A distinction between trends for summer and winter is necessary as some trends are directing in opposite ways.

The used parameters are **Air temperatures, Precipitation, Heavy precipitation, Storm** and **Sea level change.**

Key terms

Climate change

Any change in climate over time, whether induced by natural variability or as result of human activity (IPCC, 2007).

Climate model

A quantitative (mostly dynamic) model, which tries to simulate the global climate and related processes on earth.

Climate change impact

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

If you have more detailed information regarding your city and region, you can

- Alter the trend given, if this is incorrect for your situation: The altered trends will change the further results (see module “Assess Risks and Opportunities”) or
- Add a new parameter to the list and select the trend suitable: The added parameters cannot be included in the appraisal of risks or the choice of adaptation measures, due to technical reasons.

C1 – Learn about regional trends

Country: Germany **Region:** North-Rhine Westphalia

Key parameters	Climate change trend		Consequences for weather events - Summer	Consequences for weather events - Winter
	Summer	Winter		
Air temperatures	increasing ↗	increasing ↗	**Heat waves - reinforcing in summer:** The average air temperatures in summer are increasing. Additionally, heat waves are expected to happen more often and last longer in future.	**Extreme cold - balancing in winter:** The average air temperatures in winter are increasing. Extreme cold are therefore expected to happen less frequently.
Precipitation	decreasing ↘	increasing ↗	**Drought - reinforcing in summer:** In summer not only less precipitation but also higher air temperatures and therefore higher evaporation rates will cause longer and more frequent droughts.	**Drought - balancing in winter:** Due to the increase in average rainfall in winter, the rising temperatures and therefore less buffering through snow, droughts are expected to happen less often in winter.

This sheet gives you information on the expected climate change trends for some key climate parameters. The trends are based on climate projections until 2050. The consequences for weather events explain the link between the climate change trends and the weather sensitivities identified in the module Check Vulnerability.

→ To **change the country and region**, click on the name and select other countries from the list. You can even change it to “Your country” – but then all parameters have to be filled by yourself.

→ You can **add more parameters** and **change the given trends** to adapt it to your local situation. But be aware, that the added parameters cannot be included in the following assessment steps.

Step 2: Impacts of climate change

Here you can see the impacts of the trend directions on the previously selected receptors (see module “Check vulnerability”). The impacts are the following:

- **Reinforcing**: The trends are intensifying the respective situation (e.g. it gets hotter in summer) and therefore the vulnerabilities identified in module “Check vulnerability” will increase in future.
- **Indifferent**: No changes in the trends are expected; therefore the vulnerabilities identified in module “Check vulnerability” will not increase in future.
- **Balancing**: The trends are balancing the respective situation (e.g. it gets warmer in winter) and therefore the vulnerabilities identified in module “Check vulnerability” will decrease in future.

Key terms

Climate change trends

A trend is defined as the direction of change of a variable for a specific time span. In the Adaptation Compass the term climate change trend refers to the direction of changes which are projected by regional climate models (see climate model) for the indicated time span. The trend gives no information about the amount and probability of change.

Climate parameter

Climate parameters are all parameters, which are essential to the climate system (e.g. humidity, temperature, radiation). In the Adaptation compass only a selection of climate parameters are used.

C2 – Impacts of climate change

Here you can see the impacts of the trend directions on your selected receptors and weather sensitivities (see module "Check Vulnerability"). The impacts are categorised as **Reinforcing** - **Indifferent** – **Balancing**
To change the selected country and region, you need to go back to C1- Learn about regional trends.

Country:	Germany	Region:	North-Rhine Westphalia

	Receptors	Weather sensitivity	Climate change impact - Summer	Climate change impact - Winter
Population	Public health / vulnerable groups	Heat wave	reinforcing	n/a
		Extreme cold	n/a	balancing
		Drought	reinforcing	balancing
		Heavy precipitation / Floods	reinforcing	indifferent
		Storm	balancing	reinforcing

For the extreme weather events used in the module "Check Vulnerability" the following situation is apparent in North-West Europe:

	Climate change impact	
Extreme weather event	**Summer**	**Winter**
Heat wave	**Reinforcing**: The average air temperatures in summer are increasing. Additionally, heat waves are expected to happen more often and last longer in future.	n/a
Drought	**Reinforcing**: In summer not only less precipitation but also higher air temperatures and therefore higher evaporation rates will cause longer and more frequent droughts.	**Balancing**: Due to the increase in average rainfall in winter, the rising temperatures and therefore less buffering through snow, droughts are expected to happen less often in winter.
Extreme cold	n/a	**Balancing**: The average air temperatures in winter are increasing. Extreme cold are therefore expected to happen less frequently.
Heavy precipitation / Floods	**Reinforcing**: The average rainfall is expected to decrease in summer and increase in winter. As the climate in North-West Europe gets more extreme, also extreme and heavy precipitation events are expected to increase, especially in summer. This may lead to more flooding.	**Indifferent**: no changes expected

Key terms

Reinforcing effect

Climate change impacts the parameters in an intensifying way: extremes are amplified and therefore, identified problems will increase.

Balancing effect

Climate change impacts the parameters in a balancing way: extremes are moderated and therefore, identified problems will ease.

Indifferent effect

The trends are not significantly changing the current situation; therefore, identified problems stay the same.

	Climate change impact	
Extreme weather event	**Summer**	**Winter**
Storm	**Balancing**: To model the possible development of wind and storm for the future is very difficult and therefore uncertainties are high. Nevertheless, different models expect the average winds to decrease in summer and increase in winter. Future amount of storm days and intensities follow the same pattern.	**Reinforcing**: To model the possible development of wind and storm for the future is very difficult and therefore uncertainties are high. Nevertheless, different models expect the average winds. Future amount of storm days and intensities follow the same pattern.

Step 3: Further information: Link lists

For further information on climate projections and the important institutions on a national and regional basis, link lists are provided for all FUTURE CITIES regions.

The regions can be selected by clicking on the country field in Sheet C1.

C3 – Further information: Link lists

Here you can find links to important institutions that provide information on climate change in general, climate projections and climate impacts for the Future Cities countries and regions.

If you choose Your Region, feel free to add your own links. To change the selected country / region, go back to C1- Learn about regional trends.

Several institutions focus on the transfer of knowledge regarding climate change and adaptation; some major institutions are named here:

- KomPass - Kompetenzzentrum Klimafolgen und Anpassung in Umweltbundesamt
  http://www.anpassung.net/
- Regional climate information offices of the Helmholtz Gemeinschaft
  http://www.klimabuero.de/
  Süddeutsches Klimabüro: http://www.sueddeutsches-klimabuero.de/
  Mitteldeutsches Klimabüro: http://www.ufz.de/index.php?de=17016
  Norddeutsches Klimabüro: http://www.norddeutsches-klimabuero.de/
  and their key product "Regionaler Klimaatlas": http://www.regionaler-klimaatlas.de/
- Climate Service Center:
  http://www.gkss.de/science_and_industrie/klimaberatung/csc/index.html.de
- Websites of the Deutscher Wetterdienst (Germany's National Meteorological Service)

Countries and regions provided:

Climate trends and links are provided for the Countries and regions that participated in the project FUTURE CITIES:

→ Germany, North-Rhine Westphalia

→ Netherlands, Gelderland

→ United Kingdom, South East England

→ France, Haute-Normandie

→ Belgium, West - Flanders

If your city lies within the named regions, you can use the given information and eventually change it to your specific situation (climate change trends in C1).

If your city doesn't lie within the named regions, you can use "Your country / Your region" and fill the information yourself.

2.2 Climate change – practical information

The intention with the following sections is to give you a practical insight into the complexity of the data and figures on climate change to enable you to judge for your city:

- If you want to learn more about the regional and local climate changes to be expected or
- If – given the effort and uncertainties related with climate change data – the information provided here is enough.

The chapter is not meant to give you an overall explanation on what climate change is about.

2.2.1 Climate versus weather

The terms climate and weather describe two very separate circumstances. **Climate** is the **average** state of the atmosphere and the underlying land or water, whereas **weather** describes the **day-to-day changes** in atmospheric conditions.

Due to the chaotic nature of our earth's climate system**, weather** can only be predicted for a short time period. Little differences in the starting conditions of meteorological parameters, e.g. the humidity level, can lead to very large differences in the results, even over a short period of time.

Climate on the contrary is described by long-term statistic values, like means, variances, probabilities etc. of meteorological parameters. Long-term in the context of climate change typically means a time span of at least 30 years. The predictability of climate is further complicated by what is known as "climate change" and the unknown development of global greenhouse gas emissions in the next decades. Further internal influencing factors to global and regional climate are land use patterns, population, hydrological, glacial and geological activities – all of these are hard to predict for longer time ranges. And, what makes it even more complicated, these variables are interacting with our climate: They are influenced by changing climate conditions and their change, in turn, influences the climate changes. The information available on future climate is therefore no forecast but a pick from the various projections of a future climate situation.

No weather-like forecast of future climate for one specific year or month or day is thus possible, only ranges and changes of mean values can be provided.

2.2.2 Climate projections

Changes in mean values are valuable information if you know how to read it. Climate models calculate these mean values in order to deduce important trends in global climate:

Climate models that simulate the whole climate on earth are called **global climate models**. They can deliver data on a horizontal resolution of about 200 x 200 km. Since for many analyses this resolution is not detailed enough, **regional climate models** have been developed. These regional models use a

Key terms

Global Climate Model

A General Circulation Model (GCM), more commonly called a global climate model, is a mathematical model of the general circulation of the planet's atmosphere or oceans. GCMs are widely applied for weather forecasting, understanding the climate, and projecting climate change.

Regional Climate Model

A Regional Climate Model is a mathematical model of the general circulation of the atmosphere or oceans on a regional scale. These regional models use a statistical or dynamic downscaling of the global model data and reach horizontal resolutions of 10 x 10 km.

statistical or dynamic downscaling of the global climate model data and reach horizontal resolutions of 10 x10 km.

When considering a city with small scale features and lots of influencing factors to the micro-climate, even regional climate models are not detailed enough. But as uncertainties increase with time and resolution, a further downscaling makes little sense (see chapter “How to handle uncertainties”).

The bases for all climate models are assumptions on future development of emissions, demography, society, techniques, economy and ecology. These assumptions are described in scenarios. Most climate models use the SRES- (Special Report on Emission scenarios) **emission scenarios** defined by the Intergovernmental Panel on Climate Change (IPCC): The major four scenarios are describing the future worlds as follows (Nakicenovic et al., 2000):

- **Scenarios A1**: very rapid economic growth; rising global population until mid-century and thereafter declining; rapid introduction of new and more efficient technologies.
- **Scenarios A2**: a very heterogeneous world; increasing global population; regionally oriented economic growth that is more fragmented and slower than in other scenarios.
- **Scenarios B1**: same global population as in the A1 but with rapid changes in economic structures towards a service and information economy; reductions in material intensity; introduction of clean and resource-efficient technologies.
- **Scenarios B2**: emphasis on local solutions to economic, social, and environmental sustainability, continuously increasing population (lower than A2) and intermediate economic development.

The scenarios have “families” that involve further assumptions on future development, e.g. the commonly used scenario A1B, set together from A1 and B adding more environmental aspects (see side column).

2.2.3 How to handle uncertainties

Uncertainties in climate projections are manifold. They can be classified into four categories according to their origin:

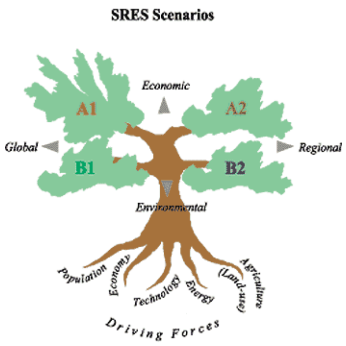
- Uncertainties from scenarios: Future emissions, land use and many other influencing factors on climate are projected under assumptions.
- Uncertainties from inaccuracies in global climate models are passed to regional climate models.
- Uncertainties from inaccuracies in regional climate models.
- The so called sampling uncertainties: The modelled climate always has to be estimated from a limited number of years. Statistically speaking it corresponds to the problem of population and random sample.

Moreover, there is the general problem, that climate is a chaotic system which cannot be forecasted (see chapter “Climate versus weather”). The amount or value of uncertainty is not sizable in general as it depends on the model input data, time frame, resolution and output parameters.

Key terms

Emission scenario

Assumptions on future development of emissions are the bases for all climate models. These assumptions are described in scenarios. The major scenarios A1, A2, B1, B2, A1B were defined by the IPCC Special Report on Emission Scenarios and are the so called SRES scenarios.



© Nakicenovic, N. et al (2000).

Uncertainty should not be used as an excuse for not taking appropriate action. Lots of decisions, in various fields like economy, politics, planning and water management, are taken in the face of uncertainty, e.g. most investment decisions. Decisions on adaptation should be approached similarly.

Therefore, the results of climate projections can be a valuable background information for regional and local adaptation decisions. The decisions though should always be taken on the basis of a variety of information, like vulnerability assessments or general spatial planning needs, development plans etc.

Most adaptation options are not only beneficial for climate change adaptation but also for other sectors, e.g. economic growth. Even if climate change impacts do not occur as expected the measures are though beneficial and cost-effective.

In the FUTURE CITIES Adaptation Compass several good-practice adaptation options are included and described. To explore them check the module “Explore Adaptation Options”.

2.3 Summary of projections for Regions of FUTURE CITIES

You can find a great number of very well designed online tools and information platforms to find out more about climate change. In the following chapters the climate change projections for the FUTURE CITIES regions are displayed in short. As the scientific basis, the models, emission scenarios and time scales used are different in the countries, the climate change projections cannot be compared without digging deep into the methodology. For the Adaptation Compass and the trends used in this module, it is sufficient to mention the most important regional climate models on national level, their time scales and scenarios used as well as the existing online tools or platforms to learn more.

2.3.1 Belgium, West-Flanders

In Belgium several studies have been conducted regarding climate change impact from the scientific point of view. The Belgian Federal Science Policy Office supports climate change research in Belgium through the “Science for a Sustainable Development” programme. A Climate Centre was created by the Belgian Federal Science Policy Office with the goal of interlinking climate research and services across the federal and private research institutes (Belgian national climate change adaptation strategy, 2010).

In Flanders, the climate projections are based on a number of foreign models. In general, the following scenarios are used:

- The wet climate scenario (a ‘high’ scenario)
- The dry climate scenario (a ‘low’ scenario)
- The moderate climate scenario (a ‘middle’ scenario).

The regional climate projections for Belgium are mostly modelled for the period 2071-2100 and compared to 1961-1990 like in Germany, France and the United Kingdom.

Key terms

No-regret measure

No-regret measures are measures that are not only beneficial for climate change adaptation but also for other sectors, e.g. economic growth. If the actual reason for implementing the measure - an expected climate change impact - doesn’t occur as expected, the measure is though beneficial.

FUTURE CITIES Partners & Regions

Lippeverband
→ Germany, North-Rhine Westphalia

City of Arnhem
→ Netherlands, Gelderland

Emschergenossenschaft
→ Germany, North-Rhine Westphalia

Hastings Borough Council
→ United Kingdom, South East England

City of Nijmegen
→ Netherlands, Gelderland

Rouen Seine Aménagement
→ France, Haute-Normandie

City of Tiel
→ Netherlands, Gelderland

West Vlaamse Intercommunale
→ Belgium, West - Flanders

Until now, no online tool or platform exists that provides easy accessible climate change information for the Belgian regions. The national climate change adaption strategy though gives a good overview on the expected changes and the impacts:

http://www.lne.be/themas/klimaatverandering/adaptatie/bestandenmap/nationale-adaptatiestrategie

2.3.2 France, Haute-Normandie

The national weather service *Météo France* provides information about the climate projections in France. There you can find an online tool, the *"simulateur climatique",* which informs about the climate simulations between 2050 and 2100:

http://climat.meteofrance.com/jsp/site/Portal.jsp?&page_id=13609

The simulation refers to the regional climate model "*ARPEGE-Climat*", developed by the *Centre de recherches de Météo-France*.

The projections are based upon two different future scenarios representing a rapid and less rapid increase of greenhouse gas emissions:

- A moderate scenario (B2 from IPCC): A less rapid increase of greenhouse gas emissions.
- An intensive scenario (A2 from IPCC): An increase of the greenhouse gas emission with today's rate.

The simulation includes five parameters: maximum temperature, minimum temperature, precipitation, hours of sunshine and soil moisture. As in Germany and the United Kingdom the results of the projection are compared with the reference values of the 30-year period between 1960 and 1990.

On the web-platform you can find further information on climate change as well.

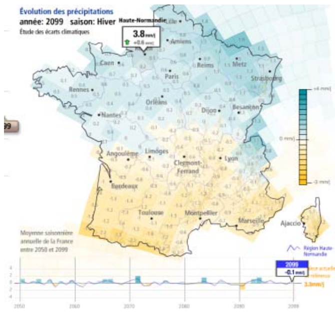
2.3.3 Germany, North-Rhine Westphalia

In Germany several regional climate models exist, which are developed and run by different scientific institutions. The four major models are (Walkenhorst & Stock 2009):

- The "Regional Model" REMO, a dynamic model, run by the Max-Planck-Institute for Meteorology: It calculates with the emission scenarios A1B, A2, B1.
- COSMO-CLM (CCLM), also a dynamic regional model developed by a community of around 25 institutions: The model is based on the emission scenarios A1B and B1.
- WETTREG, a statistical regional model dispersed by the company Climate & Environment Consulting Potsdam (CEC): Analogue to the model REMO it is based on the A1B, A2 and B1 emission scenarios.
- STAR, another statistical model, developed by the Potsdam Institute for Climate Impacts Research (PIK): The projections are based on the future scenario A1B.

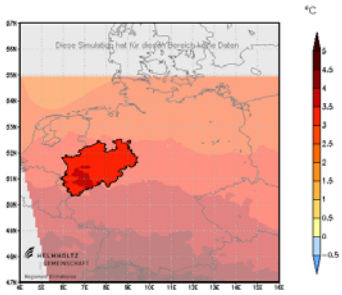
Examples of climate projection maps

Future precipitation in France/Rouen in winter 2099



© Météo-France, simulateur climatique

Future mean temperature in Germany/NRW in summer



© Regionaler Klimaatlas: model used: A1B REMO, time period: until 2100

The web-platform “Regionaler Klimaatlas” provides information about the climate projections of the regional climate models. The “Helmholtz-Gemeinschaft” with its regional climate offices operates the platform.

http://www.regionaler-klimaatlas.de/

The platform provides information on parameters such as maximum temperature, minimum temperature, precipitation, hours of sunshine and many more. The results can be compared with the reference values of the 30-year period between 1960 and 1990.

A further comprehensive climate atlas is provided and hosted by the German National Meteorological Service DWD. Several maps are available for download which compare today’s climate observations with the projections of the future.

http://www.dwd.de/

2.3.4 The Netherlands

In the Netherlands the Royal Netherlands Meteorological Institute (KNMI) developed and runs the Regional Climate Model RACMO which stands for Regional Atmospheric Climate MOdel. It played a crucial role in the formulation of the emission scenarios for the Netherlands, which are different to the emission scenarios used in France, Germany and the United Kingdom. Also, the reference period regarded is different than in the other FUTURE CITIES partner states: 1975 – 2005.

The four scenarios for 2050 are: W and W+ for “warm” as well as G and G+ for “moderate”.

The warm scenarios W/W+ are characterised by higher global mean temperatures compared to the moderate G/G+ scenarios. The scenarios with plus G+/W+ assume a change in the atmospheric circulation above the Atlantic Ocean and Western Europe which results in warm and wet winters, whereas the summers are extra hot and dry. In the G/W scenarios the air circulation pattern remains unchanged.

Further information on the climate model and the scenarios can be found here:

http://www.knmi.nl/research/regional_climate/models/index.html

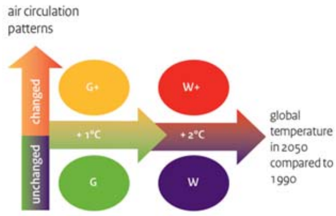
A practical tool that gives information on climate change projections and impacts in the regions of Netherlands is the *klimaateffect Atlas,* a geoportal that is supported by the *Royal Netherlands Meterological Institute, Alterra and DHV*.

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

This platform shows you simulations of climate scenarios for a chosen province in the Netherlands. On the one hand you get information about temperature and precipitation; on the other hand maps on flooding, water surplus and water shortage and further detailed information are given.

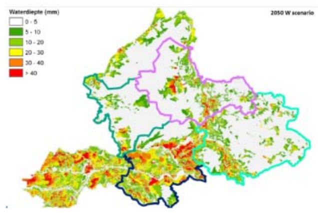
Examples of climate projection maps

The four scenarios for the Netherlands



© Climate change in the Netherlands; Supplements to the KNMI’06 scenarios, KNMI, De Bilt, The Netherlands.

Future water depth in the Netherlands/ Gelderland



© Klimaatatelier Gelderland 2010, model used: 2050 W

2.3.5 Great Britain, South-East England

In Great Britain climate projections are presented on the public information platform UK Climate Projections 2009 (UKCP09). The platform delivers detailed information about all results of the UK dynamic regional climate model HadRM3 up to the year 2100 including a user-interface for individualised maps. The results can be localised to the different regions in the UK.

The full set of results and prepared maps and graphs with key findings are available here:

http://ukclimateprojections.defra.gov.uk/

The Climate Projection Website gives you detailed information on the expected future climate conditions, similar as in the German *Regionaler Klimaatlas* or the French *Simulateur climatique*. The modelled scenarios are compared to the reference 30-year period 1961-1990.

The projections are based upon three different future scenarios representing High, Medium and Low greenhouse gas emission (corresponds to A2, A1B and B2 from the IPCC SRES). The data and science behind the projections are delivered by the Met Office Hadley Centre, which develops and runs both the Global Climate Model HadCM3 and the Regional Climate Model HadRM3.

2.4 Experiences from FUTURE CITIES

Experiences of the water boards Emschergenossenschaft and Lippeverband (DE)

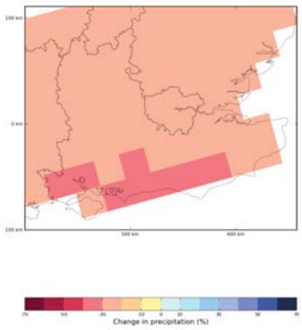
Which climate projections do we use?

To get an idea about possible impacts of changing climate conditions in the catchments of Emscher and Lippe, the water boards Emschergenossenschaft and Lippeverband use a broad pool of own water management data. These data are supplemented by data of the German Weather Service (DWD) as well as from the Federal state’s government North Rhine-Westphalia (NRW).

- For the observation of precipitation, Emschergenossenschaft and Lippeverband run 75 stations for terrestrial rainfall measurements, 16 of these stations since over 70 years.
- In addition, information from the radar measurements of the German Weather Service (DWD), climate data of the government NRW, the German Weather Service and the Ruhr-University Bochum is available regarding air temperature, relative air humidity, evaporation, wind speed and duration of sunshine.
- Further networks of the water boards, municipalities, industry, the state’s government and the mining industry provide more data for observing flood discharge and ground water levels – partly there is data available since the 1950’s.

Examples of climate projection maps

Future precipitation in South East England in summer



©UKCP09, used emission scenario: Medium, percentiles: 0.50, time period: 2070-2099

More examples from FUTURE CITIES:

Hastings, UK

When planning adaptation and assess risks, the UKCP09 key findings are regarded and used, but uncertainties are explained. It is still useful for the 'shock' factor to see how much hotter it could become, under three separate scenarios: low emissions, medium emissions and high emissions and the varying probabilities.

All these information give quite a good base for discussing possible impacts of climate change on the water cycle. But – concrete trends for the future climate development cannot be given, as no statistically relevant trend can be identified. Therefore, Emschergenossenschaft and Lippeverband work also with the SRES-scenarios of the IPCC. To break down these global scenarios to a regional relevance, existing regional climate models are used.

How to handle uncertainties?

Although these climate projections provide statements with a certain probability for large-scale trends, no secured conclusion can be made yet. It is not for sure how exactly the climate will change in the Emscher and Lippe catchments. We do not know how much rain exactly will fall in future.

Following the existing uncertainties, flexible strategies are needed with the possibility to adjust if necessary. Therefore, the water boards Emschergenossenschaft and Lippeverband follow a strategy based on no-regret measures, which is also supported by the German National Adaptation Strategy (DAS).

Within this strategy the water boards implement already today measures that will have a positive impact on a sustainable water management, independent from the dimension of climate change. These no-regret-measures serve also other objectives in the sense of sustainable development. They must be long-term effective, functional and reversible at reasonable costs if adaptation is needed. They shall create a robust and flexible system that serves multiple aims:

- strengthening the natural water cycle,
- increase the adaptive capacity of the water management,
- give time for more and better research,
- combine with attractive design of open space.

Combined with mitigation measures to reduce GHG, intense research work, close cooperation in projects such as FUTURE CITIES and active information and communication with stakeholders and citizens, the water boards Emschergenossenschaft and Lippeverband face the impacts of climate change despite existing uncertainties.

2.5 Get to know more

It is easy to get lost when searching for information about climate change on the internet. Searching for relevant information is very time consuming.

The Adaptation Compass gives you the basic links to start with. Mostly the links lead you to state institutions which provide good and easy to understand information. Often online maps are made available that show climate projections in a very clear way.

The link lists for the countries and regions of the FUTURE CITIES partners – Belgium, West- Flanders; France, Haute-Normandie; Germany, North-Rhine Westphalia; Netherlands; United Kingdom, South-East England - can be found in the Adaptation Compass.

More examples from FUTURE CITIES:

Ieper, BE

In the planning phase of the new sustainable city quarter “De Vloei” a water study was elaborated with the aim to have an integral vision on water within the quarter and in relation to the surrounding neighbourhoods. Climate change was an important element in the calculations (changed patterns and amounts in precipitation).

3 Assess Risks and Opportunities

The changing climate conditions lead to an increasing number of risks but also offer opportunities. Their assessment is based on the results of the vulnerability check (Module “Check Vulnerability”) and the projected climate change trends, which were described in module “Understand climate change impacts”.

The current vulnerabilities in your city are combined with the future climate change trends projected: By means of an evaluation matrix you can classify future risks for your city (see below).

The following questions will be answered in the module:

- What types of future risks and opportunities exist?
- Which receptors of the city are the most affected in future?

3.1 Purpose of the module and proceeding

The principal objective of adaptation is to moderate the impacts of climate change in cities and take advantage of opportunities that may arise. The identification of the risks and opportunities within this module helps you to get there.

The future problems identified (i.e. risks) will be the basis for the selection of types of adaptation measures in the module “Determine the Need for Action and Select Measures”.

For the assessment of future risks and opportunities regarding your identified receptors the Adaptation Compass provides two steps:

Key terms

Risk

In the FUTURE CITIES Adaptation Compass risk is the combination of the current vulnerability (high, medium, low) and the climate change impact (balancing, indifferent, reinforcing) and is categorised in the classes very high, high, medium, low.

Opportunities

In combination with climate change the term opportunities is used to describe the positive aspects of climatic changes for certain regions (see climate change impacts), e.g. hotter summer can influence the tourism sector positively.

Step 1: Assess the future risks and opportunities

This step is the automatic summary of the results from the previous modules. You should start by checking these results:
Remember the receptors, their sensitivities and vulnerabilities of your city. If you want

- to add new receptors or sensitivities because you feel that the receptors do not cover all physical and socio-economic features of your city or
- to change the vulnerability class of certain receptors

you should go back to Module "Check Vulnerability". There you can reconsider, add or edit your choices. Also, you might want to read again through the climate change information you received in Module "Understand Climate Change Impacts". Go back to the module and go through the pages once again or use the link lists to learn more.

Now, being sure all collected results are correct, you can read through the given future risks and future opportunities that are collected in the table.

Furthermore, the risks are evaluated for each receptor and the corresponding weather sensitivity. Categories are given regarding winter and summer:

very high – high – medium – low

The categories of risks are assessed with the evaluation matrix, which brings together the results of the Vulnerability Check (Vulnerability classes high, medium, low) and the module "Understand Climate Change Impacts" with the climate change impact (balancing, indifferent, reinforcing).

The classes are determined with the following **evaluation matrix**:

	Climate change impact		
Current vulnerability	balancing	indifferent	reinforcing
High	**medium**	**high**	**very high**
Medium	**low**	**medium**	**high**
Low	**low**	**low**	**medium**

A classical risk approach?

In classical risk approaches the term risk is defined as the combination of the probability of occurrence and the magnitude of the consequence or hazard (Metcalf et al. 2009).

For the Adaptation Compass the FUTURE CITIES partnership decided not to evaluate the probability of occurrence – in this case of a climate change impact – for the following reasons:

→No climate change data is used, only tendencies and qualitative descriptions are given. Therefore, it is hardly possible for a user to determine a probability of occurrence without having quantitative data at hand.

→The uncertainties of climate change projections are, at least for some parameters very high. A reasonable rating of probabilities seems therefore impossible.

R1 – Assess the future risks and opportunities

In this module the future risk for the selected receptors regarding their weather sensitivity is determined.

To achieve this, the results of your vulnerability check and the climate change trends are put together automatically in the evaluation matrix, from which the future risk can be followed. Furthermore, opportunities are named, as far as they are apparent.

Receptors	Weather sensitivity	Future risk (not comprehensive)	Future risk Summer	Future risk Winter	Future opportunity (not comprehensive)
	Heat wave	- Increasing number of deaths - Reinforcement of heat stress - Increasing spread of new vector-born and infectious diseases - Altered allergic patterns	high	n/a	
	Extreme cold	n/a	n/a	low	- Decrease of typical winter illness because of the warmer temperatu - Less spread of respiratory and infectious diseases
Public health / vulnerable groups	Drought	- Increased allergic reactions through pollen flight and others	high	low	

Be aware that the collected risks and opportunities are not comprehensive; they may not be suitable for every location and must not definitely occur as described! It might also be possible that for your situation further risks and other opportunities arise. That is why it is important to read through the information given carefully. Changes can be made in the previous modules, as described in the side column. In this table there is no possibility to change the risk categories as they are composed by the previous results (see chapter "Evaluating risks and opportunities").

Step 2: Rank the risk categories

The selected receptors and weather extremes (standing for the problems identified) are sorted according to their risk category (very high-high-medium-low). You can rank the problems either for summer or winter depending on your priorities for adaptation.

The described opportunities are not included in the categorisation. Keep them nevertheless in mind, especially for the selection of an adaptation measure.

R2 – Rank the risk categories

Here, the risk categories defined in the first step are sorted according to their priority for action. Measures should be prioritised in fields with extreme risk and high risk. For sensitivities with medium or low risk, action could also be taken, but the urgency is little.

Ranking according to risk category | Rank Summer | Rank Winter

Receptors - Weather sensitivity	Risk category summer	Risk category winter
Biodiversity / ecosystems - Heavy precipitation / Floods	very high	high
Green spaces - Heavy precipitation / Floods	very high	high
Water resources and qualitity - Heavy precipitation / Floods	very high	high
Transport - Heavy precipitation / Floods	very high	high

How to add new receptors:

You need to go back to module "Check Vulnerability", table "General sensitivities". There a button can be found adding a new line with your new receptor. Then go on in the module to fill the additional information (necessary: weather sensitivity, vulnerability class).The new line you added here will appear in the other modules as well.

How to revise the vulnerability class:

You need to go back to the module "Check Vulnerability", table "Vulnerability Check" and change the class by clicking on it. Or change the "Climate change trend" in module "Understand climate change impacts" by clicking on them.

If you want to revise the ranking order go back to the previous modules to alter the receptors, vulnerability class or climate change variables.

3.2 Opportunities of climate change for cities

Climate change offers many opportunities as well. Adaptation aims at both: reducing your risks and take advantage of the opportunities that arise.

In North-West Europe the opportunities are manifold: they result from

a) less cold spells in the winters or warmer temperatures throughout the year respectively as well as

b) new market possibilities from a warmer and drier climate and from the need for adaptation and mitigation in general.

Some important examples are given below. More opportunities are collected in table R1 in the Adaptation Compass.

a) Warmer temperatures throughout the year

Human comfort is expected to increase in average, except during heat waves. The public space, like green spaces, beaches etc. will probably be used more intensively. Moreover, extreme cold spells are decreasing in the medium- and long-term future. This implies that the sensitivities of the receptors against extreme cold are reduced. For example, less damages and limitations arise in all sectors of transport, as dangerous icy conditions probably occur less often. These conditions decrease also the amount of typical winter health problems and people in hospitals.

b) New market possibilities

Several receptors in a city can be counted as “winners” of climate change, this is mainly due to the fact, that with little effort of adaptation new possibilities arise: e.g. for agriculture and forestry. The warmer climate with a longer growth seasons creates better growth conditions and more harvest. More efficient plantations and new products can be established. Furthermore, for the whole economy the opportunities can be great, depending on the economic structure of the city. For tourism, the chances are obvious: more people are willing to spend their summer holidays and leisure time in North-West Europe when the likelihood for warm and dry weather is higher. But also for industry positive effects of climate change can be named: new products and innovations are required for a changing environment, including all technologies for renewable electricity production and mitigation. A specific example is the increasing potential for solar panels due to less cloud cover in the warm season. Furthermore, the building and renovation need in cities is high – local economy can strongly profit from this, if the know-how is available.

Key terms

Mitigation

Mitigation is used for actions which reduce the potential impacts of global warming by decreasing or avoiding greenhouse gas emissions.

3.3 Experiences from FUTURE CITIES

Risks and opportunities in Tiel East

An example for the assessment of risks and opportunities is given by the Dutch city of Tiel. The City has local groundwater problems. These local groundwater problems also create opportunities: By positioning sources and sinks for cold and heat storage in a smart way, local groundwater levels can be lowered in specific problem areas. This mechanism can also be used to tackle groundwater pollution. A business plan will give more insight into the cost efficiency of this combination of water and energy aspects. If possible, the system will be combined with residual heat from nearby factories. That way, climate adaptation will also serve economic and social purposes.

Risks and opportunities in Nijmegen

The city of Nijmegen investigated to which courtyards rainwater in the city centre flows. These courtyards have the potential risk of being flooded in case of storm and severe rainfall. The city plans to reduce the risk through adaptation while at the same time exploiting the opportunities: In the same study it was identified which of these courtyards have enough space to add green space in order to increase the potential of water infiltration. In 2012, one of these courtyards was turned from a public parking lot into a green-blue space after a redesign process with involvement of the inhabitants.

Key terms

Uncertainties

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 judgement of a team of experts.

4 Explore Adaptation Options

In this module the FUTURE CITIES Adaptation Compass provides an overview of possible options to adapt. The module “Explore Adaptation Options” consists of a catalogue of measures based on the FUTURE CITIES Projects experiences. The catalogue highlights not only the benefits and combination options of the measures but also gives an insight on possible obstacles.

The goal of this module is to broaden the mind of potential users regarding the questions:

- What types of adaptation measures exist?
- How do they work and what do I need to know in advance?
- Which combinations with other measures are possible and efficient?
- How can adaptation and mitigation be linked?

4.1 Purpose of the module and proceeding

The module guides you through the collected information on the adaptation options which are the focus of the FUTURE CITIES partnership. In the first place it is important to get an insight in the variety and amount of options possible.

Adaptation options are cross-sectoral, they are implemented at different spatial and time scales and they include different approaches: from building or reconstructing (e.g. infrastructure) to soft measures that aim at raising awareness for risks or adaptation and want to change behaviour.

Furthermore, you will soon realise that there is not one benefit to one option but an interaction of many. So, building green roofs helps you to cool down the building and it also retains precipitation and therefore attenuates local flooding. Moreover, by building more than one green roof in a street / quarter, the area can be upgraded and for the owners a green roof means a longer lifetime of the roof.

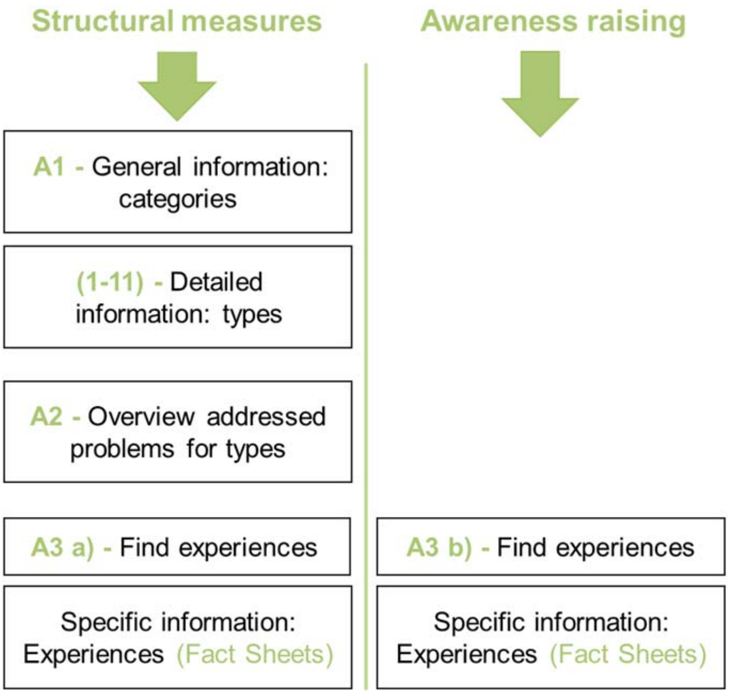
To nevertheless organise these different aspects, the following structure was developed: In the catalogue of adaptation options it is distinguished between structural measures and raising awareness measures.

Please note

Although the FUTURE CITIES project has gathered lots of background information on Adaptation Options, it is not complete. There are many more options for each sector, for urban and rural areas, for geographical regions, like e.g. the Alpine Space. The options described in the module are the good-practice measures from FUTURE CITIES, not a comprehensive catalogue.

Also, the state of the art is changing fast: Adaptation measures are continuously developed further and new ideas are implemented.

So, keep an open mind towards innovative ideas for adapting to climate change!



Structural adaptation options are those options that require building, reconstruction or modification of infrastructure, quarters, houses, industrial sites and more.

Information is provided on three levels:

- General information for each **category of measures** is provided.
- Detailed background information on each **type of measure** is given.
- Specific **examples of implementation** within the FUTURE CITIES partnership show good-practice experience and possible obstacles.

Raising awareness measures are options that inform about the risks and adaptation, that communicate with people and let them participate in any process. They aim at raising awareness for risks, raising acceptance and fostering adaptation options as well as changing behaviour.

Raising awareness measures have to correspond to the specific situation, thus generalised information is less useful. Specific **examples of implementation** within the FUTURE CITIES partnership describe activities in detail and show experiences and obstacles during implementation.

The tables provided in the module and information given are described in the chapters 4.2 and 4.3. There is no specific and recommended way through the module, you are welcome to EXPLORE.

Key terms

Category of measure/ Type of measure

Structural adaptation measures in the FUTURE CITIES Adaptation Compass are organised in categories and types: categories are green structures, water systems, energy efficiency and mitigation and urban structure. Types are described with more detail. In the Compass there are 2-4 types per category. The categories and types are listed in chapter "Categories and types of measures".

Synergy

In the Adaptation Compass the term is used with regard to the adaptation measures. The combination of several measures may produce a better result than implementing only one single measure. This context is called synergy.

4.2 Structural adaptation measures

In the following, the organisational structure and the tables providing information on the structural adaptation options are described. The contents can be found in the Adaptation Compass.

4.2.1 Categories and types of measures

The **categories** comprise the structural measures **green structures, water systems, energy efficiency and mitigation** and **urban structure.**

All categories and types of measures are displayed in an overview table with the major information like problems addressed, characteristic, scale of measure and synergies.

A1 – General information: Categories

The available adaptation options are shortly characterised in an overview table. Further information is given on the scale of measure, synergies and the problems addressed.

If more detailed information on a type of measure is needed, just click on "read more". You can also add more measures, if needed.

	Type of adaptation measure	Addressed problem	Short characteristic	Scale of measure	Synergies with other measures	
en structures	Green roofs	Heat wave; Extreme cold; Heavy precipitation / Floods; Drought	Roofs covered with soil and plants. Systems range from extensive green roofs (intended to be self-sustaining, minimise maintenance) to intensive green roofs (with higher soil layer for including shrubs, trees, more maintenance, more additional weight, less slope possible).	building; city quarter	water retention; increase energy efficiency; urban texture	read mc
	Green walls	Heat wave; Extreme cold; Heavy precipitation / Floods; Drought	Vertical parts of the urban environment, e.g. facades of buildings, covered with vegetation. Mostly, the green walls are whole facades or parts of the facade that are greened with mostly not deciduous plants. The plants can be rooted in the ground or be planted in boxes on	building; city quarter	urban texture; water retention; increase energy efficiency; green roofs	read mc

By clicking on ***read more*** you are directed to the selected type of measure.

On each **type** of measure general information is provided, e.g. within the category **green structures** the types **green roofs, green walls** and **green open spaces** (e.g. courtyards, alongside water bodies) are used. The presentation of the types of adaptation measures focuses on their synergies related to climate protection and impacts related to other aims which are on the agenda of cities, like coping with demographic change or regenerating industrial areas. These additional aspects of an adaptation measure facilitate actual implementation.

Key terms

Spatial scale of measure

The spatial scale of an adaptation measure describes where (area size) the measure is showing its impacts.

Addressed problems

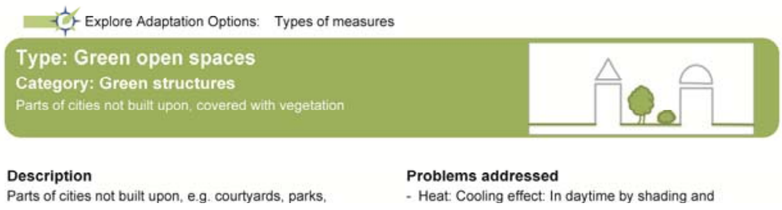
Addressed problem relates to the climate change impact and the hence arising risks, which are addressed and reduced by the selected adaptation measure.

Energy efficiency

Energy efficiency describes the capacity of a machine, method or approach to transform energy from an energy carrier. Often also efforts to power-saving (e.g. energy-saving lamps, insulation of buildings) are included under the term energy efficiency. The increase of energy efficiency is a claim in order to reduce energy consumption and eliminate energy wastage. The aim behind this strategy is to mitigate greenhouse gas emissions.

Detailed information: Types

For every type of measure a single page containing detailed information, like e.g. technical data, is given. Altogether, there are 11 tables for the types of measures.


Explore Adaptation Options: Types of measures

Type: Green open spaces
Category: Green structures
Parts of cities not built upon, covered with vegetation

Description
Parts of cities not built upon, e.g. courtyards, parks,

Problems addressed
- Heat: Cooling effect: In daytime by shading and

Table: Overview on categories and types of measures as well as descriptions used in the Adaptation Compass

Category of structural measure	Type of measure	Description as used in the FUTURE CITIES Adaptation Compass
Green structure	Green roofs	Roofs of buildings covered with vegetation
	Green walls	Walls covered with vegetation
	Green open spaces	Parts of cities not built upon, covered with vegetation
Water system	Water retention	Elements of the urban water system meant to delay the discharge of rainwater
	Water drainage	Elements of the urban water system that function for draining rainwater
	Urban water spaces-flowing	Open water elements in the urban environment with flowing water, e.g. rivers, streams
	Urban water spaces-standing	Open water elements in the urban environment with standing water
Energy efficiency and mitigation	Increase energy efficiency	Less energy need for the same results in the urban structure, water and green structures
	Renewable energy	Measures for using renewable energy sources, in the urban environment
Urban structure	Urban setting	Measures addressing the elements of the urban environment in their configuration
	Urban texture	Measures addressing the urban surfaces related to their material

Key terms

Urban or 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 (volume, density of buildings related to open spaces).

Lessons-learned

The experiences made by the FUTURE CITIES partners while implementing adaptation measures were collected and assessed. Finally, they were integrated in the Adaptation Compass to pass the experiences to further users.

Green structure

Green structure in the Adaptation Compass is a category for adaptation measures dealing with the installation of green features (flora) in the city, e.g. building green roofs, redesigning park areas.

Water system

Water system in the Adaptation Compass is a category for adaptation measures dealing with water in the city, e.g. the integration of water bodies in cities or the improvement of water management.

4.2.2 Experiences from FUTURE CITIES

Fact sheets inform about the **implemented measures** in FUTURE CITIES. They document the technical description and practical experience of FUTURE CITIES pilot projects and lessons learned: e.g. spatial characteristics of the measure – such as scale (region, town, quarter etc.) and use (city centre, business, residential), the adaptation problems which can be addressed with the measure and the synergies and conflicts encountered with other adaptation and mitigation measures or other sustainability aims.

The implemented adaptation measures cannot be connected with only one category of measure but is connected to more categories. In theory, the types of measures described have a very clear focus but all measures affect their surroundings in a variety of ways. For the implemented measures in FUTURE CITIES one major category was determined by its pattern and one or two further categories are additionally given remarking the further positive impacts of the options. For example a measure "Building green roofs" is mostly a green structure as vegetation is planted but water systems and energy efficiency are also involved as the measure is connected with ideas to improve rain water management and building insulation.

A3 a) - Find experiences

There are different ways to find the implemented examples you are interested in:

- the types of adaptation measures and their combinations
- the country and region (location) where the measures were implemented.

To learn more about the implemented measures, click on the respective names or on read more.

	Name/Location	Green roofs	Green walls	Green open spaces	Water drainage	Water retention	Urban water spaces - flowing	Urban water spaces - flowing	Increase energy efficiency	Renewable energy	Urban setting	Urban texture	
		Types of measures											
	Green roof De Tweeling Nijmegen, NL	●			●	●			●			●	Read more
	Green and brown roofs Hastings, UK			●	●				●			●	Read more

The Fact Sheets can be opened from the Adaptation Compass and are also available as a separate publication.

Key terms

Awareness raising measure

An awareness measure in the Adaptation Compass is a category for adaptation measures aiming to raise awareness and integrate the public or other target groups in the adaptation process.

Fact sheet

A fact sheet is a presentation of information in a format which clarifies the key points. The layout is simple and mostly standardised.
In the Adaptation Compass the Fact Sheets are standardised sheets, which contain information on the good-practice adaptation measures implemented in the FUTURE CITIES project.

Sustainability

Sustainability is a development that meets the needs of the present without comprising the ability of future generations to meet their own (UN, 1992).

4.3 Raising awareness measures – Experiences from FUTURE CITIES

The FUTURE CITIES Partnership has implemented many measures to raise awareness for the topic of adaptation in general, to support the implementation of structural adaptation measures and to change the behaviour of the citizens.

These actions are described in the **Raising awareness fact sheets** in the Compass. They comprise a description of the measures implemented, their location, aim of the measure and the target groups approached. Furthermore, details are given on the instruments used and the experiences made. For each measure contact data of the responsible organisation is given. Feel free to contact them for further insights.

The examples are structured into the types of target group integration:

- **Inform**: the role of the target groups is observer / listener.
- **Consult**: the target group advices or consults in the measure.
- **Co-produce**: the target group functions as co-partner in implementing the measure.

Similar to the structural fact sheets (see chapter 4.2) there are different ways to find the implemented examples you are interested in: you can search for

- the **type** of the measure (e.g. Inform or Consult)
- the **target groups** approached (e.g. professionals) or
- the **country and region** in which the measures were implemented.

A3 b) - Find experiences

There are different ways to find the implemented examples you are interested in: You can search for **type of measure - target group - location**. To learn more about the implemented measures, click on the respective names.

	Name/Location	Inform Role of target group: Observer/listener	Consult Role of target group: Consultant/advisor	Co-produce Role of target group: Co-partner	Target Group	
	Energise Hastings Hastings, UK	●	●	●	Population, Professionals	Re mo
	Sustainable stormwater management Essen, DE	●	●	●	Professionals, population, specific sectors	Re mo

Key terms

Target group

Each message that is disseminated should be fitted to a group of people to reach the optimum impact. This group of people is called target group. Messages specified for a target group are more likely to be understood and implemented.

4.4 Addressed problems

The types of adaptation measures (only structural measures) presented need to be assessed regarding the identified vulnerabilities and risks. Only after that the suitable types of adaptation measures for your local situation can be selected in the final module.

Therefore, an overview on the positive and negative impacts of all types of structural adaptation measures is included in the Adaptation Compass. This table lists all types of adaptation measures included in the Adaptation Compass and their addressed problems, i.e. the effect on the identified risks.

The criteria for evaluation are the following:

- Significant reduction of risks: **++**
- Reduction of risks: **+**
- If there is no impact to be expected: **o**
- Increases risks or has a negative impact: **–**
- No connection between the measure types and the problem: **n/a**

With this system you can, on the one hand, find all measures that address your specific problem. On the other hand, conflicts can be identified: E.g. you want to improve the city ventilation to address the increasing problems arising from heat in your city. The table shows you though that for extreme cold spells this measure has some negative impacts, as wind channels decrease the comfort and increase e.g. the risk for black ice.

A2 - Overview addressed problems for structural types

Get an overview on the types of adaptation measures and their addressed problems. You can come from the adaptation measure side: check all problems addressed; or from the problem's side: what measures address my problems?

- As standard the table shows only the receptors you selected in Sheet V3; you can switch the appearance of the table between all receptors and only the selected by using the buttons on the left;
- Additionally, a possibility to change the criteria given is provided – just click on the cells you want to change.

Adaptation measure / Addressed problems	Green structures			Water systems				Energy efficiency and mitigation		Urban structur	
	Green roofs	Green wall	Green open spaces	Water retention	Water drainage	Urban water spaces - flowing	Urban water spaces - standing	Increase energy efficiency	Renewable energy	Urban setting	Urb text
blic health - Heat wave	++	++	++	o	o	++	+	n/a	n/a	++	++
blic health - Extreme cold	+	+	o	o	o	-	o	n/a	n/a	-	o
blic health - Drought	-	-	-	o	o	o	o	n/a	n/a	o	o
blic health - Heavy precipitation / ›ods	++	+	++	++	++	+	o	n/a	n/a	o	+
blic health - Storm	o	o	-	o	o	o	o	n/a	n/a	-	o
ansport - Heat wave	n/a	n/a	+	o	o	+	n/a	n/a	n/a	+	++
ansport - Extreme cold	n/a	n/a	o	o	o	o	n/a	n/a	n/a	-	o
ansport - Drought	n/a	n/a	o	o	o	o	n/a	n/a	n/a	o	o

Please note:

The table A2 – Overview addressed problems for types is the basis for the sorting of adaptation measures according to the effect on the identified problems which is part of Module "Determine the need for action and select measures".

5 Determine the Need for Action and Select Measures

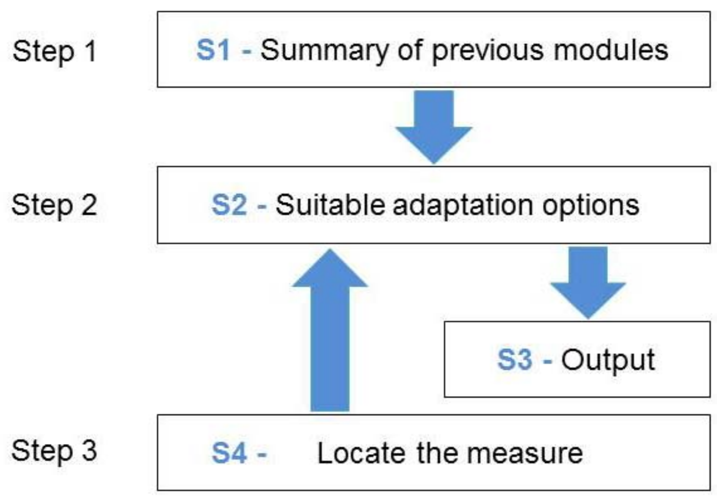
With this module the previously collected information and assessment steps are summarised and are matched with suitable types of adaptation measures. The result is a list of core problems which are to be addressed by measures, e.g. urban structures which are likely to heat up too much in an area where many older people live. In the list of adaptation measures, suitable actions and combinations of measures are given which will help mitigate the core problems. Additionally, guidance is provided on how locations for the implementation of the selected adaptation measures can be found.

5.1 Purpose of the module and proceeding

This module represents the conclusion from the previous modules and the previous work done. The purpose is to

- combine and consolidate work done in the previous modules
- select the types of adaptation measures suited best for the identified vulnerabilities and risks
- find the locations for implementing the selected adaptation options most effectively.

On the basis of these three goals three steps are provided:



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 condition.s

Reinforcing

Climate change impacts the parameters in an intensifying way: extremes are amplified and therefore, identified problems will increase.

Indifferent

The climate change trends are not significantly changing the current situation; therefore, identified problems stay the same.

Balancing

Climate change impacts the parameters in a balancing way: weather extremes are moderated and therefore, identified problems will ease.

Adaptation options

= adaptation measures

Step 1: Summary of previous modules

First, when entering the module, you will see the results of the three modules:

- **Check vulnerability**: the identified class of vulnerability is given for each selected receptor and weather sensitivities.

  High – medium – low

- **Understand climate change impacts:** the impacts of climate changes on the receptors are repeated.

  Reinforcing – indifferent – balancing

- **Assess Risks and Opportunities:** based on the results of the modules on vulnerabilities and climate changes, the future risks have been determined in the module “Assess Risks and Opportunities”. These are displayed again for each selected receptor and sensitivity.

  Very high – high – medium – low

If you realise that the outputs shown here are not correct for your situation or that important things are missing, please go back to the respective module to revise your input information.

S1 – Summary of previous modules

This table shows you the summarised results of your vulnerability check, the climate change trends and the concluded future risks.

Read through the results and check if the information is correct, according to your understanding of your city.

If yes, proceed to the next page. If not, please go back to the respective module and revised your input data.

Receptors and sensitivities	You have identified the following vulnerabilities:	Impact of climate changes regarding sensitivities:		Thereof arising risks identified:	
		Summer	Winter	Summer	Winter
ublic health / vulnerable groups - Heat wave	medium	reinforcing	n/a	**high**	**n/a**
ublic health / vulnerable groups - Extreme cold	medium	n/a	balancing	**n/a**	**low**
ublic health / vulnerable groups - Drought	medium	reinforcing	balancing	**high**	**low**
ublic health / vulnerable groups - Heavy precipitation / Floods	medium	reinforcing	indifferent	**high**	**medium**
ublic health / vulnerable groups - Storm	medium	balancing	reinforcing	**low**	**high**

After having read through the summarised results already collected in the previous modules and approving with them, the next page, S2, shows you a list of suitable adaptation options.

Step 2: Select suitable adaptation options

The suitable types of adaptation measures are already sorted according to your core problems determined in the previous modules. The list includes only structural measures, as raising awareness measures are tailored to a specific situation and are therefore not problem-specific.

The basis for the allocation of the adaptation options is the table of addressed problems, provided in the module “**Explore Adaptation Options**”, A2.

Key terms

Risks

In the FUTURE CITIES Adaptation Compass risk is the combination of the current vulnerability (high, medium, low) and the climate change impact (balancing, indifferent, reinforcing) and is categorised in the classes very high, high, medium, low.

Reminder on the revision of input:

If some of the receptors are not relevant for your situation, you can de-select them in the module **“Check vulnerability”** on the table V3.

There you can also change the class of vulnerability, which might for your city differ from the pre-set answers.

The climate change trends given in the module **“Understand Climate Change Impacts”** can also be changed if the direction is not correct in your region.

But please only change the given values **on the basis of facts**! Especially regarding the climate changes, people tend to “believe” or have doubts.

Furthermore, information on spatial scale and time frame for implementation is given in short keywords.

The table on addressed problems (A2) is the basis for the ranking of the types of adaptation measures. The method is based on the multi-criteria analysis approach: The risks identified (very high, high, medium, low) and the effects on the addressed problems (++, +, o, n/a and –) are weighed with numbers, as shown in the table below. The values for the risk categories and the effect on the problems are then multiplied. The adaptation measure with the highest number has the highest effect on the identified problems.

	Category / Criteria	Value
Risk category	Very high	10
	High	5
	Medium	2
	Low	1
Effect on problem	++	5
	+	2
	o	0
	n/a	0
	-	-1

Though, please keep the following issues in mind:

- Be aware that the number of types of adaptation measures integrated into the Adaptation Compass is limited. Therefore, the selection of suitable measures is **not comprehensive**; it can though provide a first overview on adaptation options, which should be developed further for your city or your situation.
- Moreover, this also means that the types of measures included in the Adaptation Compass are **not addressing all the problems you have potentially identified** in the previous steps. For some risks, the suitable types of adaptation measures are not represented in the Compass, e.g. for risks connected with agriculture or forestry. But you have the possibility to add more measures to the Compass in the module “Explore Adaptation Options”, if it is necessary for your specific situation. Collections of measures can be found e.g. on several national and international adaptation platforms (compare chapter 2.3 and 2.5).
- The types of adaptation measures included in the Compass were derived from the FUTURE CITIES’ experiences and lessons-learned. The types are hence **mainly focused on cities**. They are representing what can be done in the water system and regarding green structures. If you are applying the Adaptation Compass on a different scale than for a city, the measures might need to be altered and/or new measures have to be added.

Use maps to locate your measures

Mapping is the best instrument to find a good location for the implementation of your adaptation measures. The described steps can also be applied for mapping:

1) Map your problem areas and the distribution of your affected receptors.
2) Combine them.
3) Integrate further aspects like, e.g. existing projects in your city.

The order of appearance gives you a first impression on the possibilities you have and how these can be structured. To proceed in the selection of measures, you should gather more differentiated arguments concerning your specific situation.

S2 – Suitable adaptation options

The suitable adaptation options are sorted according to your core problems determined in the previous modules. The list includes only structural types of measures, as raising awareness measures are not problem-specific.

The basis for the allocation of the adaptation options is the table of addressed problems, provided in the module "Explore Adaptation Options", A2.

By clicking on the Rank buttons below, you can see the suitable adaption measures for summer or winter.

Suitable adaptation measures	Value	Scale of measure	Time frame for implementation	Internal Reference
highest effect on identified problems				
Summer				
Urban water spaces - flowing	377	city quarter; city; region	long-term	
Water drainage	365	building; city quarter; city	short-/ medium-term	
Water retention	305	building; city quarter; city	medium-term	
Green roofs	290	building; city quarter	short-term	
Green wall	245	building; city quarter	short-term	
Green open spaces	235	building; city quarter; city	long-term	

If you want to change some input to see how it affects the selection of types of adaptation measures, please click through the sheets C2, R1 and A2 once more to make sure that the change is correctly taken into account.

The choice which of these listed measure types is implemented is of course up to you. Lots of different criteria other than adaptation may have to be considered, e.g. political and economic strategies/aims, local social aspects or demographic change. Please read chapter "Further aspects for selecting measures" to get some ideas. If you already have a preference for implementation, go further to learn how you could locate the measure.

Output

The output sheet gives an overview of the suitable adaptation options assessed for your city. There are text boxes where you can add comments about your work. You might also want to forward the results to colleagues, external experts and your superiors.

Evaluating the effects of adaptation measures on the addressed problems:

The table A2 in the module "Explore Adaptation Options" lists all types of adaptation measures and their addressed problems. The criteria for their evaluation are:

"++" Significant reduction of risks

"+" Reduction of risks

"o" If there is no impact to be expected

"–" Increases risks or has a negative impact

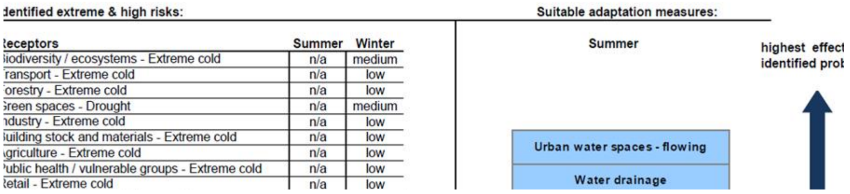
"n/a" No connection between the adaptation measure and the problem

S3 – Output / Summary

Comments: Please add comments. This might help others to understand the results of your selection.

Identified risks: The risks identified in module “Assess risks and opportunities” are listed here again, they are sorted according to the selection in S2 (summer or winter).

Suitable adaptation options: the types of measures are sorted according to your identified risks; Change the selection of summer or winter in S2.



dentified extreme & high risks:

eceptors	Summer	Winter
iodiversity / ecosystems - Extreme cold	n/a	medium
ransport - Extreme cold	n/a	low
orestry - Extreme cold	n/a	low
ireen spaces - Drought	n/a	medium
ndustry - Extreme cold	n/a	low
uilding stock and materials - Extreme cold	n/a	low
griculture - Extreme cold	n/a	low
ublic health / vulnerable groups - Extreme cold	n/a	low
etail - Extreme cold	n/a	low

Step 3: Locate the measures

In the Compass you get advice on how to find a location where you can implement the chosen adaptation measure in your city. The Compass doesn’t suggest one location where the measure should be implemented or build and no map tool is provided.

The searched location can be characterised as follows:

- **The potential for effective adaptation is high**,
  e.g. to set up a green space to create a climate oasis in the quarter is most effective if air exchange (wind channels) is guaranteed.
- **Further benefits are covered,**
  e.g. further urban development goals are reached.
- **A problem has already occurred there**,
  i.e. it is always easier to reach the people’s and politician’s acceptance if you solve an existing and possibly deteriorating problem.

To get a first idea about the location it is easiest to start with the question

(1) Where are my problems located?

In the Compass the addressed problems of your selected adaptation measure are displayed separately for the weather events and the receptors. Then, the locations are listed which were identified in the module “Check Vulnerability” in the descriptions of

- Former events for weather events and
- Spatial relevance for the selected receptors.

Probably, the same locations occur more than once on both sites. Therefore, as a second step, you need to

(2) Combine the information provided.

(3) Take into account further aspects

Use maps to locate your measures

Mapping is the best instrument to find a good location for the implementation of your adaptation measures. The described steps can also be applied for mapping:

1) Map your problem areas and the distribution of your affected receptors.
2) Combine them.
3) Integrate further aspects like, e.g. existing projects in your city.

Now, the impression you have about a potential location for implementing the adaptation measure is strongly dependant on the input information you filled in module “Check vulnerability”. Take into account further important aspects:

- **Always keep in mind the scale of the adaptation measure and your problem**, it is not the final solution to find one building where you could build a green façade, but your problem exists in the entire city quarter. Still, it could be the first step as part of a concept.
- **Climate change may also cause new problems in new locations** that are momentarily not known or expected.
- **Think cross-sectoral: Maybe other plans / projects or development goals can be combined with your measure**, e.g. the extension of a school building or the envisaged upgrade of a city quarter.
- **Use your existing resources:** Many cities have very good maps and geographical information systems. Maybe these could be developed further to facilitate future adaptation decisions? For an example on such a mapping project, see chapter 5.3.

S4 – Locate the measures

Here you get advice on how to find a location where it is suitable to implement the chosen adaptation measure in your city.

(1) Please choose the type of measure you want to locate from the drop-down list on top of the sheet.

(2) Previously collected data and information regarding the location of former extreme events and the spatial relevance should be checked again. You should go through the data and compare the locations given.

(3) Go through the further aspects that should be considered when searching for a good location to implement the adaptation options chosen.

(4) If you want to note your ideas for later use or colleagues, you can do so in the textbox given.

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).

Risk

In the FUTURE CITIES Adaptation Compass risk is the combination of the current vulnerability (high, medium, low) and the climate change impact (balancing, indifferent, reinforcing) and is categorised in the classes very high, high, medium, low.

5.2 Further aspects for selecting measures

For choosing the adaptation measures you start to implement in your city, several criteria should be kept in mind:

→ **Reduce your vulnerabilities and risks**

The problems and risks identified in the modules “Check vulnerability” and “Assess risks and opportunities” should be approached. Especially the already existing problems, that will in future deteriorate are good starting points for adaptation. Furthermore, these problems will likely find political support.

→ **Exploit opportunities**

Climate change offers also opportunities, which can be exploited along the way, e.g. by building new green and water structures in a quarter, vulnerabilities are reduced and the quarter is upgraded.

→ **Take into account regional and national legislation**

There are two aspects to be considered:

- National / regional restrictions and regulations: There are of course different regulations in every country, which need to be checked before selecting an adaptation measure. Sometimes, your choice for a measure might be put into question, if e.g. the use of rain water is regulated restrictively.
- Political will and funding possibilities: Implementation of an adaptation process is also a political decision. Therefore, it is best to take into account the political will and funding options at an early stage of planning adaptation.

5.3 Experiences from FUTURE CITIES

Developing Urban Climate Recommendations in Arnhem

Mapping the city climate of Arnhem related to overheating is one step, determining the consequences of this diagnosis, is the second step needed. For this the city of Arnhem looked into the characteristics or land use of each ‘heated up’ area to determine whether it may lead only to uncomfortable situations or to serious health risks for certain social groups. The aim was to determine the urgency to act. This leads to a series of actions, such as highlighting areas that should be adapted to prevent serious health risks for its users and inhabitants, or building restrictions in areas to prevent building schemes that block cooling winds. Further actions comprise adaptive measures to improve the human comfort situation.

Key terms

Opportunities

In combination with climate change the term opportunities is used to describe the positive aspects of climatic changes for certain regions (see climate change impacts), e.g. hotter summer can influence the tourism sector positively

PART IV: PERSPECTIVE

Adaptation is a process that demands monitoring and regular review. Only in this way you can assure that your city is well adapted in a permanently changing world.

It is important to stress the different approach of reviewing and monitoring adaptation:

Reviewing the adaptation process focuses on examining the background conditions, the initial reasons for starting adaptation. You should ask the following question:

- Have the input data, the arguments for adaptation changed in any way?
- Have new aspects or consequences for the goals set arisen?

Monitoring adaptation aims at checking the implemented measures for the goals predefined during the planning phase. You should regularly ask yourself:

- Are you reaching the goals concerning the moderation of unwanted climate change impacts or the exploitation of positive aspects of climate change?
- Is the implemented measure living up to your expectations, concerning functionality, acceptance, cost and time aspects?

1 Reviewing adaptation

The background conditions and the initial reasons for starting adaptation should be checked for actuality.

Step 1: Check the need to review

Climatic, scientific and technological advancements are very probable considering the lifetime of most adaptation measures. You should ask yourself if the input data or the arguments for adaptation changed in any way. E.g.:

- Has my city gained or lost resilience against climate change, so that the vulnerability classes would be different today than at initial assessment?
- Have any of the receptors changed in its character or spatial distribution?
- Climate change – have new scientific findings changed the tendencies which are the basis for the risk assessment?
- Have new findings or technical advancements for adaptation options changed the information given in the tool and used as a basis for your adaptation?

Key terms

Review

A review or reviewing process describes in the Adaptation Compass the check and examination of the background conditions, initial reasons for adaptation and input data to the Compass.

Monitor

Monitoring adaptation in the Adaptation Compass is described as checking the implemented adaptation measures for the goals predefined during the planning phase of the measure.

Climate change impact

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

Resilience

The ability of a system to recover from the effect of an extreme load that may have caused harm (UKCIP, 2003).

If you can answer one of these questions with "yes", you will need to go back to the planning phase of your adaptation measures, check the determination of your local vulnerabilities and risks, and assess the changes. What implications have these changes for my goals and evaluations?

Step 2: Revise your goals

After having checked if your goals are all fulfilled as planned or if not, to what extend the reality differs from your expectations, you should take a look at the goals themselves as well. The standards and demands can change as well as the input data to assess your need for adaptation.

But remember: if changes or additions at your goals are necessary, don't forget to adapt the monitoring process as well.

2 Monitoring adaptation

The purpose of monitoring the course of action is to understand whether the project or activity delivers the planned benefits. Furthermore, the findings from the monitoring process should be reflected in your adaption measures and future planning.

This chapter should give you practical advice to understand how to handle the questions highlighted above and how to organise the process of monitoring. In many sectors, e.g. environmental protection, monitoring programmes are well defined and established, like for water quality monitoring. If a monitoring programme in your city does already exist, the monitoring regarding adaptation should be integrated. Ask your colleagues and discuss possibilities to adapt existing monitoring programmes or establish new ones.

Step 1: Are the set objectives reached?

When having implemented an adaptation measure a wide range of objectives has been identified. These are specific for each situation, dependent not only on the local natural and technical background but also on the experts and decision makers in charge.

We structure the objectives in the following groups.

Greater goals for your city:

Is the measure contributing to the overall goals of adaptation for your city, like

- Are you reaching the goals concerning
    - the moderation of negative climate change impacts or/and
    - the exploitation of positive aspects of climate change?

Functionality goals for the adaptation measure:

Functionality aspects regard issues such as the amount of water storage, the quantity of green areas, green roofs etc.: Does everything **function** as expected?

Key terms

Receptors

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.

Target group

Each message that is disseminated should be fitted to a group of people to reach the optimum effect. This group of people is called target group. Messages specified for a target group are more likely to be understood and implemented.

Also the **success** of your measures should be assessed: concerning the reduction of climate change impacts and the exposure but also concerning the increase of resilience, the use of opportunities or further cross-cutting effects on other goals set, e.g. mitigation goals.

Practical questions can be used, e.g.:

- Has the urban heat or the consequences been reduced?
- Have the retention measures detained heavy rains in the planned area?

Economic goals for the adaptation measure:

Economic aspects concern the cost-benefit for the measures as predefined. Sometimes unexpectedly, new costs arise for building or maintenance of the measure that have initially not been thought of. Or a measure might cause higher maintenance costs in other infrastructure parts or with other stakeholders. On the other hand, costs might have been estimated too high in the beginning, to be on the safe side, but are less after implementation.

Acceptance / communication goals for the adaptation measure:

In your process of adaptation you have integrated several target groups and informed them about the necessity of adaptation in general and /or the adaptation measure itself.

- Have all defined target groups been reached?
- Do they understand and access the information?
- Did the participatory approach work as planned? Is continuous participation reached?
- Did the attitude of the targeted groups change?

Time aspects of the adaptation measure:

A further aspect is time. In the planning and implementation phase, time always plays a central role for decision-making. You should also integrate some thoughts in the monitoring:

- Was the time for decision making, for implementation as expected?
- Time frame of the measure's impacts (long-term, short-term): is it as planned?

Step 2: Set a time limit for monitoring your actions

In general, your adaptation actions have to be monitored **frequently** to assess the effectiveness of the adaptation measures.

Relevant adaptation literature mostly advises to monitor adaption strategies and measures annually or more often (UKCIP, 2010; Ecologic Institute 2009). But the decision is up to you.

Take care that the monitoring programme is described in detail and sufficiently structured to guide your colleagues through the process. This also ensures that the results are comparable from year to year.

Recommendation by Future Cities: "Total cost-benefit ownership"

Costs and benefits of an adaptation measure are often not in the hand of one person or organisation. Therefore, the approach of taking the investment costs and all long-term costs into account should be followed by all involved stakeholders. Here, collaboration is essential.

PART V: ADDITIONAL DOCUMENTS

1 Literature

Brown, A., Gawith, M., Lonsdale, K. & P. Pringel (2011): Managing adaption: linking theory and practice. UK Climate Impacts Programme. Oxford.

Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU) (2008): Deutsche Anpassungsstrategie an den Klimawandel. Berlin.

Bundesministerium für Umwelt und Naturschutz, Landwirtschaft und Verbraucherschutz des Landes Nordrhein-Westfalen (2010): Handbuch Stadtklima. Maßnahmen und Handlungskonzepte für Städte und Ballungsräume zur Anpassung an den Klimawandel. Düsseldorf.

Bundesministerium für Verkehr, Bau und Stadtentwicklung (2009): Klimawandelgerechte Stadtentwicklung. BBSR-Online-Publikation, Nr. 23. Bonn.

Center for Science in the Earth System (The Climate Impacts Group) (2007): Preparing for climate change. A Guidebook for Local, Regional and State Governments. Washington.

Ecologic Institute (2009): Final report. Design of guidelines for the elaboration of Regional Climate Change Adaptions Strategies. Berlin.

European Environment Agency (2009): Ensuring quality of life in Europe´s cities and towns. EEA Report No 5/2009. Available on: www.eea.europa.eu/

Gill, S. (2004): Literature Review: Impacts of Climate Change on urban environments. University of Manchester. Available on: www.sed.manchester.ac.uk/cure/downloads/asccue_litreview.pdf

Hunt, A. & P. Watkiss (2007): Literature review on climate change impacts on urban city centers: Initial findings. OECD. Available on: www.oecd.org/dataoecd/52/50/39760257.pdf

IPCC (2007): Climate Change 2007: Synthesis Report. Available on: http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf

Marbaix, P. & van Ypersele, J.-P. (2004): Impacts des changements climatiques en Belgique. Available on: www.climate.be/impacts

Metcalf et al. (2009): UK Climate Impacts Programm. A changing climate for business. Oxford.

Nakicenovic, N. et al. (2000). Special Report on Emissions Scenarios: A Special Report of Working Group III of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, U.K., 599 pp.

National Climate Commission Belgium (2010): Belgian National climate change adaption strategy. Available on: http://www.lne.be/themas/klimaatverandering/adaptatie/bestandenmap/nationale-adaptatiestrategie.

Nordic Centre for Spatial Development (2002): Climate Change Emergencies and European Municipalities. Guidelines for Adaption and Response. Stockholm.

OECD (2009): Competitives Cities and Climate Change.

Royal Netherlands Meteorological Institute (2010): KNMI publications. Available on: http://www.knmi.nl/knmi-library/climatereport.html

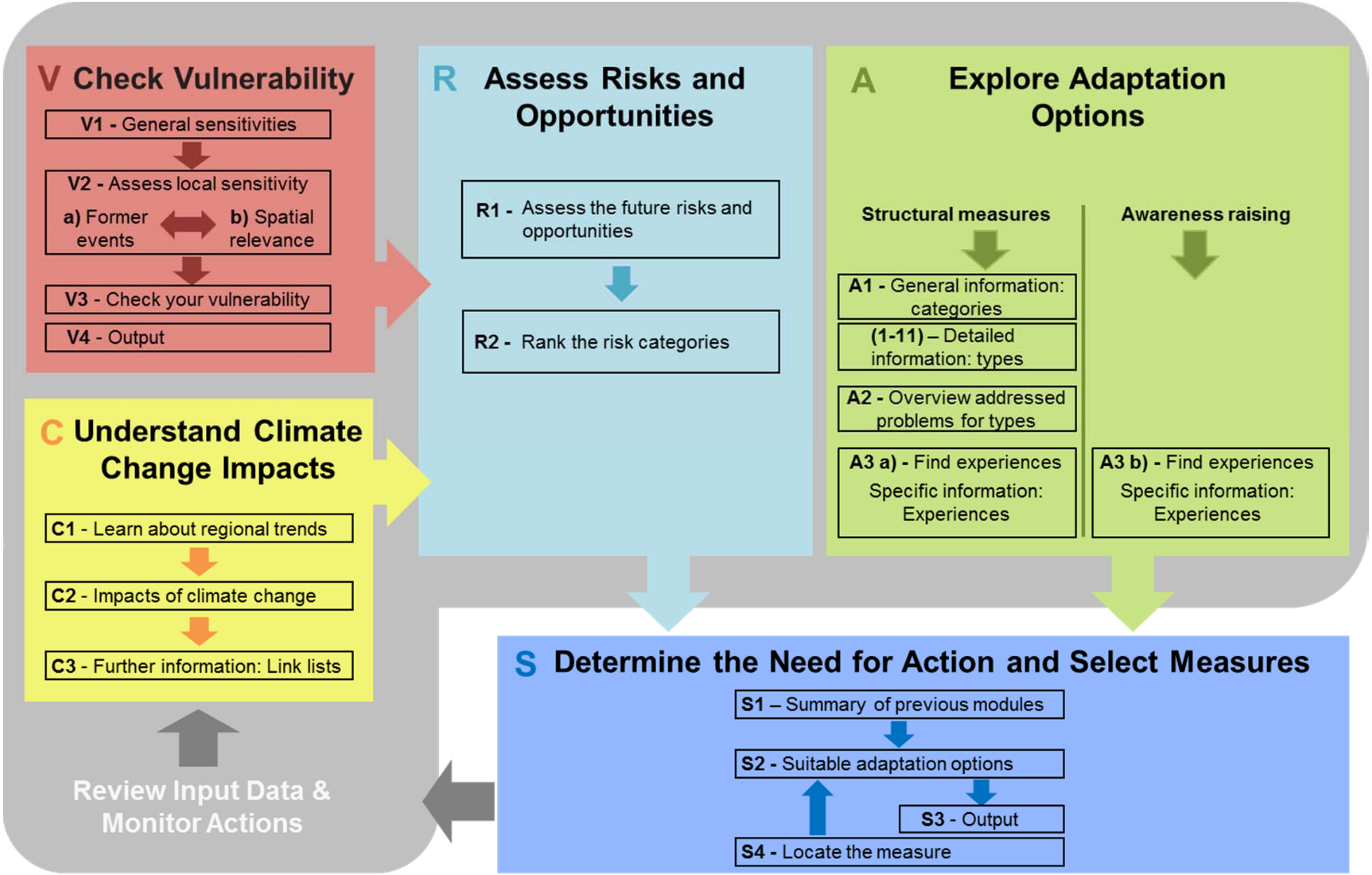
Smit, B. & J. Wandel (2006): Adaptation, adaptive capacity and vulnerability. In: Global Environmental Change. Nr. 16: 282-292.

UKCIP (2010): The UKCIP Adaption Wizard V 3.0. Oxford. Available on: www.ukcip.org.uk/wizard

University of Manchester (2010): GRaBS Adaptation Action Planning Toolkit. Available: www.ppgis.ac.uk

Walkenhorst,O. & M.Stock (2009): Regionale Klimaszenarien für Deutschland. Eine Anleitung. In: Akadamie für Raumforschung und Landesplanung. Nr. 6. Hannover.

Zebisch, M., Grothmann, T., Schröter, D., Haße, C.; Frisch, U. & W. Cramer (2005): Klimawandel in Deutschland. Vulnerabilität und Anpassungsstrategien klimasensitiver Systeme.


V Check Vulnerability
V1 - General sensitivities
V2 - Assess local sensitivity
a) Former events
b) Spatial relevance
V3 - Check your vulnerability
V4 - Output
R Assess Risks and Opportunities
R1 - Assess the future risks and opportunities
R2 - Rank the risk categories
A Explore Adaptation Options
Structural measures
Awareness raising
A1 - General information: categories
(1-11) – Detailed information: types
A2 - Overview addressed problems for types
A3 a) - Find experiences Specific information: Experiences
A3 b) - Find experiences Specific information: Experiences
C Understand Climate Change Impacts
C1 - Learn about regional trends
C2 - Impacts of climate change
C3 - Further information: Link lists
Review Input Data & Monitor Actions
S Determine the Need for Action and Select Measures
S1 – Summary of previous modules
S2 - Suitable adaptation options
S3 - Output
S4 - Locate the measure

3 Glossary of key terms

Aims for the Glossary
The Glossary implies the key terms that are relevant to understand and to work with the FUTURE CITIES Adaption Compass. The Glossary is not meant to be a general scientific glossary but a support to handle with the key terms in the context of the FUTURE CITIES Adaption Compass. *The main goal of the Glossary is:* • *To define terms as they are used in the Compass* • *To clarify terms, especially if used differently to (common) use, e.g. in certain sectors or in the scientific framework.* *Due to the interdisciplinary character of the project, the terms are sometimes differently used by the disciplines. The Glossary contributes to a better mutual understanding of the terms and the Adaption Compass itself.*

A

Adaptation

Adjustment in natural or human systems in response to observed or expected climatic changes or their impacts. Adaptation moderates harm (*risks*) or exploits benefits (*opportunities*). Various types of adaptation can be distinguished, including anticipatory, autonomous and planned adaptation (IPCC, 2007; Ribeiro et al. 2009).

When using the term adaptation in the Adaptation Compass, planned adaptation – i.e. adaptation that is the result of a deliberate policy decision – is meant.

Adaptation measure

Measure to adapt to *climate change and weather impacts* can be technical, participatory, communicative, planning, etc.

The goal of implementing an adaptation measure is

- to reduce the *vulnerability* of a *receptor*,
- to enforce the *capacity to adapt* and / or
- to strengthen the positive impacts (*opportunities*) of climate change.

For the FUTURE CITIES adaptation compass the measures are categorised according to their function: measures in *green structures*, measures in the *water system*, measures for *energy efficiency* and *mitigation*, measures regarding *city structures* and *awareness raising measures*.

Addressed problem

Addressed problem relates to the *climate change impact* and the hence arising *risks*, which are addressed and reduced by the selected *adaptation measure*.

Awareness raising measure

An awareness measure in the Adaptation Compass is a category for *adaptation measures* aiming to raise awareness and integrate the public or other target groups in the *adaptation* process.

B

Balancing effect

Climate change impacts the *parameters* in a balancing way: *weather extremes* are moderated and therefore, identified problems will ease.

In the Adaptation Compass this term is used to connect the projected *climate change impacts* with the impacts of weather extremes already identified in the module "Check Vulnerability".

Good-practice

Good-practice means methods, approaches and actions, which already proved successful and reliable for a certain situation / problem. In the Adaptation Compass the *adaptation measures* implemented in the FUTURE CITIES project, which have proven successful are presented separately in *fact sheets* as good-practice examples.

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.

C

Capacity to adapt

Ability to adjust to *climate change*, 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*, i.e. the following questions should be answered for all sectors individually (e.g. vulnerable groups, water and sanitary service, tourism, etc):

→ Is the receptor ***able*** (financially, technologically, socially), ***willing*** and ***ready*** to cope with the expected changes?

For non-human receptors, e.g. building environment or green spaces, the question has to be posed towards the respective decision makers (planning or administrative strength).

City structure

See *urban structure.*

Climate

Climate is described by long-term statistic values, like means, variances, probabilities etc. of meteorological parameters (e.g. temperature). Long-term in the context of climate typically means a time span of at least 30 years.

Climate change

Any change in *climate* over time, whether induced by natural variability or as result of human activity (IPCC, 2001).

Climate change impact

Impacts or consequences of *climate change* on natural or human systems (IPCC, 2007).

In the Adaptation Compass these consequences are assessed for each *receptor* individually.

Climate change trend	A trend is defined as the direction of change of a variable for a specific time span. In the Adaptation Compass the term *climate change* trend refers to the direction of changes which are projected by regional climate models (see *climate model*) for the indicated time span. The trend gives no information about the amount and probability of change.
Climate model	A quantitative (mostly dynamic) model, which tries to simulate the global *climate* and affecting, processes on earth.
Climate parameter	Climate parameters are all parameters, which are essential to the climate system (e.g. humidity, temperature, radiation). In the Adaptation compass only a selection of climate parameters are used.
Climate projection	A simulation of future *climate* with a *climate model* is called climate projection. All models have to make assumptions, which cause a range of uncertainties about the calculations. For climate projections the time frame is rather big (usually until 2050 or 2100) and therefore lots of assumptions are made and the level of uncertainty is relatively high. The models project different *climate parameters*, e.g. air temperature, rainfall.

D

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.
Decision support system	A decision support system (DSS) is a computer-based system that gathers relevant information, prepares and arranges it clearly in order to facilitate and guide the decision-making process to management, organizational or planning decisions.

E

Emission scenario	Assumptions on future development of emissions are the bases for all *climate models*. These assumptions are described in *scenarios*. The major scenarios A1, A2, B1, B2, A1B were defined by the IPCC Special Report on Emission Scenarios and are the so called SRES *scenarios*.

Energy efficiency	Energy efficiency describes the capacity of a machine, method or approach to transform energy from an energy carrier. Often also efforts to power-saving (e.g. energy-saving lamps, insulation of buildings) are included under the term energy efficiency. The increase of energy efficiency is a claim in order to reduce energy consumption and eliminate energy wastage. The aim behind this strategy is to *mitigate* greenhouse gas emissions.
Exposure	The nature and degree to which a system is exposed to significant climatic variations (IPCC 2001). In the Adaptation Compass the term is used in the context of the assessment of *vulnerability*, it comprises the local abundance of a *receptor* and its *sensitivity* against the respective *weather* phenomenon.
F	
Fact Sheet	A fact sheet is a presentation of information in a format which clarifies the key points. The layout is simple and mostly standardised. In the Adaptation Compass the Fact Sheets are standardised sheets, which contain information on the *good-practice* adaptation measures implemented in the FUTURE CITIES project and the experiences collected.
G	
Geographical information system	A geographical information system, short GIS, is a computer-based system to store, manage, analyse and present spatial data. The data can be linked in databases and displayed in maps.
Global Climate Model	A General Circulation Model (GCM), more commonly called a global climate model, is a mathematical model of the general circulation of the planet's atmosphere or oceans. GCMs are widely applied for *weather* forecasting, understanding the *climate*, and projecting climate change.
Green structure	Green structure in the Adaptation Compass is a category for *adaptation measures* dealing with the installation of green features (flora) in the city, e.g. building green roofs, redesigning park areas.
Guidance	The Adaptation Compass consists of two major parts: the Excel-based tool itself and a guidance document that leads the user through the process and gives additional background information and advice.
H	
Heat island effect	The Heat Island or Urban Heat Island (UHI) effect describes the possible temperature difference between rural and build-up urban areas. The effect can be explained by the absorption of solar radiation by materials in cities (e.g. dark surfaces: tar etc.). Furthermore, in cities buildings block the air exchange with the

	outer and cooler surroundings of the city.
Heat stress	Heat stress describes all strain for the human body/human health resulting from heat.
I	
Indicators	Indicators are parameters to monitor and classify the environment, - in our case the *receptors* of a city with regard to the impacts of climate or weather. The indicators help to make definite statements and to systemize observations and information. To describe the spatial appearance *(spatial relevance)* of the receptors, practical indicators are used in the Adaptation Compass.
Indifferent effect	The climate change trends are not significantly changing the current situation; therefore, identified problems stay the same. In the Adaptation Compass this term is used to connect the projected *climate change impacts* with the impacts of *weather extremes* already identified in the module “Check *Vulnerability*”.
Infrastructure	Infrastructure determines the physical and organisational structures in a city. It is differentiated between hard infrastructure, i.e. physical structures like transport facilities, water, sanitation, energy plants and soft infrastructure, i.e. organisational features, like institutions, community networks.
L	
Lessons-learned	The experiences made by the FUTURE CITIES partners while implementing *adaptation measures* are collected and assessed during the project. Finally, they are integrated in the Adaptation Compass to pass the experiences to further users.
M	
Mitigation	Mitigation is used for actions which reduce the potential impacts of global warming (see *climate change*) by decreasing or avoiding greenhouse gas emissions.
Monitor	Monitoring adaptation in the Adaptation Compass is described as checking the implemented *adaptation measures* for the goals predefined during the planning phase of the measure.
N	
Natural resources	Natural resources are assets occurring in nature that are used, consumed or exploited by human activities.

No-regret measures	The term no-regret measure is widely discussed and often substituted by low-regret measure. In the Adaptation Compass, "no-regret measure" is used in the following sense: No-regret measures are measures that are not only beneficial for *climate change adaptation* but also for other sectors, e.g. economic growth. If the actual reason for implementing the measure - an expected *climate change impact* - doesn't occur as expected, the *adaptation measure* is though beneficial. No-regret measures serve several objectives, especially in the framework of sustainable development. No-regret measures have a long-term impact, create a robust and flexible system and can be adjusted / rebuilt to future needs at reasonable costs.
O	
Opportunities	In combination with *climate change* the term opportunities is used to describe the positive aspects of climatic changes for certain regions (see *climate change impacts*), e.g. hotter summer can influence the tourism sector positively.
P	
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 (WHO 2011).
R	
Raising awareness measure	See *Awareness raising measure*
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.
Regional Climate Model	A Regional Climate Model is a mathematical model of the general circulation of the atmosphere on a regional scale. These regional models use a statistical or dynamic downscaling of the *global model data* and reach horizontal resolutions of 10 x 10 km.
Resilience	The ability of a system to recover from the effect of an extreme load that may have caused harm (UKCIP, 2003).
Review	A review or reviewing process describes in the Adaptation Compass the check and examination of the background conditions, initial reasons for adaptation and input data to the Compass.

Risk	In the FUTURE CITIES Adaptation Compass risk is the combination of the current *vulnerability* (high, medium, low) and the *climate change impact* (balancing, indifferent, reinforcing) and is categorised in the classes very high, high, medium, low. In classical risk approaches the term risk is defined as the combination of the probability of occurrence and the magnitude of the consequence or hazard (Metcalf et al. 2009). For the Adaptation Compass, the FUTURE CITIES partnership decided not to evaluate the probability of occurrence because no climate change data is used; only tendencies and qualitative descriptions are given. Additionally, the *uncertainties* of climate change projections are, at least for some *climate parameters* very high. A reasonable rating of probabilities seems therefore impossible.

S

Scale of measure	The scale or spatial scale of an *adaptation measure* describes where (area size) the measure is showing its impacts.
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. 2009).
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.
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 of the Adaption Compass 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. E.g. a large sealed surface area in your city can for example lead to an increasing risk for flooding. If you identify and localize the areas with high building densities you know where the potential danger zones are. The determination of the *spatial relevance* of the *receptors* helps you to avoid implementing an *adaptation measure* at a location where no vulnerability exists.
Structural adaptation measure	Structural *adaptation measures* change the structure of a house, street, quarter or whole city. Building, reconstruction or modification of the e.g. *infrastructure* is necessary.
Sustainability	Development that meets the needs of the present without comprising the ability of future generations to meet their own (UN 1992).

Synergy

In the Adaptation Compass the term is used with regard to the *adaptation measures*. The combination of several measures may produce a better result than implementing only one single measure. This context is called synergy.

T

Target group

Each message that is disseminated should be fitted to a group of people to reach the optimum effect. This group of people is called target group. Messages specified for a target group are more likely to be understood and implemented.

U

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 modeling and taking assumptions or by a qualitative statement, e.g. reflecting the judgment of a team of experts.

Urban morphology

See urban structure.

Urban 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 (volume, density of buildings related to open spaces).

V

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 climate / weather impacts and the *capacity to adapt* towards those conditions (assessed in “Vulnerability Check”) (Smit & Wandel, 2006).

This definition differs from the definition of the IPCC which refers to climate change impacts instead of integrating actual and observed climatic or weather related impacts (compare IPCC, 2007). The reason is that the FUTURE CITIES Partnership has found it more practicable to start with the already known vulnerabilities which give the user also better arguments for implementing *measures* to adapt to already existing problems.

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.

W

Weather	Describes the day-to-day changes in atmospheric conditions in a specific place at a specific time.
Weather extremes / extreme weather event	An event connected with extreme weather conditions like heat, storm or heavy precipitation that occurs rarely at a certain place and time (Birkmann et al. 2011).
Water system	Water system in the Adaptation Compass is a category for *adaptation measures* dealing with water in the city, e.g. the integration of water bodies in cities or the improvement of water management.
Weather sensitivity	*see sensitivity*
Win-win options	An arrangement in which all parties benefit. “Win-win-option” example could be the reduction of the greenhouse gas emissions while promoting, not limiting the economic growth at the same time. The term is often used in the context of *adaption measures* that could present an improvement or positive solution for several parties.

DISCLAIMER and COPYRIGHT NOTICE

The use of the Adaptation Compass is free of charge. The tool can be downloaded from the website www.future-cities.eu.

The Adaptation Compass provides background information on the process of adaptation and suggests adaptation options. The information, data and links were carefully put together and checked by the project partnership. Nevertheless, we cannot take any responsibility for neither the correctness of the contents, the completeness nor the decision-making that might be based on the information and data provided. Despite bestowing great care in checking also the external links, we assume no liability for the content or functionality of external pages.

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