RAMSES
Science for cities in transition

Transition Handbook

Training Package

www.ramses-cities.eu
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RAMSES is a European research project, which delivered much needed quantified evidence of the impacts of climate change and the costs and benefits of a wide range of adaptation measures, focusing on cities. RAMSES engaged with stakeholders to ensure its outcomes are policy relevant and ultimately enable the design and implementation of adaptation strategies in the EU and beyond.
Chapter 1

Introduction to the Transition Handbook and the Training Package

The RAMSES Project has produced an immense and highly valuable collection of reports and resources on climate change adaptation and resilience in cities. The Project has developed cutting-edge research on some of the most relevant topics for urban climate change adaptation. These include:

- Modeling climate projections and scenarios to understand future climate impacts and illustrate the effects of specific adaptation measures for cities;
- Understanding how to make architecture and infrastructure more resilient to climate change and how to assess the effects of improved architectural design on cities;
- Evaluating the costs of climate change and the benefits of different adaptation measures;
- Understanding the costs that climate change has on health and how different adaptation measures can reduce climate impacts on public health;
- Conducting high-level vulnerability assessments in order to understand which the climatic trends in European macro-regions are and consequently which are the main risks that cities in these regions are exposed to;
- Conducting detailed vulnerability analyses in the cities of London, Antwerp and Bilbao at a high spatial resolution to draw lessons from these cities’ experiences;
- Understanding existing political frameworks and decision-making tools that support adaptation, and drawing lessons from those.

All the knowledge generated by the project is available on the project’s website but in order to present this to cities in a synthesised and practical fashion that can be used to actually make concrete decisions on climate change adaptation, Tecnalia and ICLEI have developed the current Transition Handbook and Training Package.

The Transition Handbook embeds the key RAMSES findings in a process management cycle, using widely known methodologies such as the Urban Adaptation Support Tool (http://climate-adapt.eea.europa.eu/knowledge/tools/urban-ast), which is the official support tool of the Covenant of Mayors for Climate and Energy and synthesises the project results in a practical step-by-step fashion, presenting resources that cities can use to strengthen their knowledge of climate adaptation planning.

The Training Package complements the Transition Handbook by taking stock of existing toolkits to support adaptation management in cities and proposes worksheets and exercises that cities can use to progress on their adaptation endeavours. The worksheets are crossreferenced in the Transition Handbook so as to complement the information contained in it and to offer cities a clear path towards becoming more climate adaptive.

The Training Package is complemented by a slidedeck, available on the RAMSES website (www.ramses-cities.eu/results), which will summarise the most policy-relevant project findings to support cities in raising awareness on climate adaptation.

The Transition Handbook and Training Package do not intend to be stand-alone resources but instead aim to be used complementarily with other adaptation toolkits and with the http://climate-adapt.eea.europa.eu platform, which represents the major European information hub on climate adaptation.

Videos from the RAMSES audio-visual guidance tool (www.on-urban-resilience.eu), developed by Climate Media Factory are crossreferenced in the handbook and in the training package. They offer additional information on the different relevant sectors for adaptation planning by experts interviewed by the RAMSES Consortium in several occasions.
Chapter 2
Introduction to the Transition Handbook

This handbook is an educational tool, targeted to city stakeholders, to support cities in the definition of their transition towards successful adaptation. Therefore, the handbook provides guidelines and advice to local administrations in order to help their cities become more resilient and adapted to climate change.

The transition handbook is designed as a complementary guide to other step-format manuals and materials already developed by different entities, e.g. the Urban Adaptation Support Tool, developed by the European Environmental Agency in support of Mayors Adapt.

The transition handbook mainly encompasses the methods and tools applied in the context of the RAMSES project and its key outcomes, and therefore it is context-specific and refers to the European policy landscape and mainly to European cities. However, the suggested adaptive management cycle and supporting tools are also applicable to other urban realities.

Audience: Decision makers and technicians working in municipalities as well as practitioners and consultants supporting municipalities.

2.1. CONCEPTUAL FRAMEWORK

The conceptual framework used for the development of the transition handbook is aligned with two other approaches in particular:

1. The Integrated Management System* developed within the framework of the CHAMP project (2009-2011) and consisting of five major steps repeated in annual cycles.

2. The Urban Adaptation Support Tool**, linked to the Mayors Adapt initiative, which provides a step-by-step guidance through the adaptation planning and implementation cycles.

Table 1 compares the methodology followed by the above-mentioned approaches with the one followed in the RAMSES project. The Urban Adaptation Support Tool approach is designed as a practical guidance tool to assist signatories of Mayors Adapt and the Integrated Covenant of Mayors for Climate and Energy initiative. Therefore, the Handbook has been structured according to this approach and the RAMSES project results have been categorised according to the Urban Adaptation Support phases (Figure 1).

Table 1:
Adaptation cycle approach in different initiatives

<table>
<thead>
<tr>
<th>INTEGRATED MANAGEMENT SYSTEM</th>
<th>URBAN ADAPTATION SUPPORT TOOL</th>
<th>RAMSES APPROACH AND RELATED TOOLS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline review</td>
<td>Preparing the ground</td>
<td>Political framework (WP3, WP8), stakeholder engagement, impact chains definition</td>
</tr>
<tr>
<td>Target setting</td>
<td>Assessing risks and vulnerabilities</td>
<td>Hazard and exposure (WP1 coastal flood, WP3 pluvial flood, WP4 heat), vulnerability (WP3), risk (WP3)</td>
</tr>
<tr>
<td>Political commitment</td>
<td>Identifying adaptation options</td>
<td>Adaptation options, identify (WP2, WP3, WP4, WP5, WP6), assess (WP1, WP2, WP3, WP4, WP5, WP6) and prioritise (WP5, WP6)</td>
</tr>
<tr>
<td>Evaluation and reporting</td>
<td>Monitoring and evaluation</td>
<td>Monitoring (few things from WP3, WP4, WP7)</td>
</tr>
</tbody>
</table>

Figure 1:
RAMSES inputs on the Urban Adaptation Support tool
Other available manuals and guidelines for urban climate adaptation have been consulted for the development of the present Handbook:

- Adapting urban water systems to climate change: a handbook for decision makers at the local level (Loftus and International Council for Local Environmental Initiatives, 2011) in which a vulnerability analysis, and planning are the target issues.
- The Adaptation Support Tool (AST) is developed to support planning: identify adaptation options, assess the performance in order to prioritize (Van de Ven, F.H.M. et al., 2016).
- Spanish guideline to develop Local Adaptation Plan to climate change (Feliu, E. et al., 2015)
- The UNFCCC Information paper on experiences, good practices, lessons learned, gaps and needs in the process to formulate and implement national adaptation plans (UNFCCC, 2014).

As RAMSES does not provide sufficient input to cover all parts of an adaptation cycle, the Handbook will provide the main results and conclusions produced by RAMSES and will provide references to other sources where needed. In this way we are ensuring that existing work is not duplicated (e.g. the Urban Adaptation Support Tool, the EEA’s Urban Adaptation Report, the Mayors Adapt initiative materials etc.).

To USE THIS HANDBOOK

The handbook explains in an intuitive way how to approach the process of adaptation. The proposed methodological sequence suggested in this handbook is composed of six iterative (not necessarily linear) phases that can be adjusted according to the strategic objectives, needs and resources, which vary significantly from one case to another.

Each chapter of the handbook follows the structure below:

- **Phase description and key objectives:**
  - WHAT DO WE WANT TO ACHIEVE?
- **Steps to follow within each phase:**
  - WHAT TO DO TO ACHIEVE THIS OBJECTIVES?
- **Methods and tools applied in RAMSES:**
  - METHODS AND TOOLS APPLIED IN RAMSES PROJECT
- **Example boxes:**
  - EXAMPLES FROM RAMSES PROJECT EXPERIENCE
- **Worksheet developed in RAMSES:**
  - RAMSES TOOLS/Worksheet
- **Audio-visual material:**
  - “ON URBAN RESILIENCE”
  - AUDIO-VISUAL GUIDELINE

The handbook consists of a systemic step-by-step methodology based on the six phases of the Urban Adaptation Support Tool (Figure 2):

**Phase I** Preparing the ground

**Phase II** Assessing risks and vulnerabilities which feed into the definition of impact chains: analysis of the impacts, detection of the hotspots and identification of thresholds

**Phase III** Identifying adaptation options

**Phase IV** Assessing and selecting adaptation options: selection and evaluation (effectiveness and cost assessment), adaptation option prioritization

**Phase V** Planning and implementation pathway design

**Phase VI** Monitoring and evaluation

The Figure 2 shows the parallels between the Urban Adaptation Support Tool and the RAMSES methodology phases:
Phase I: Preparing the ground

Phase I of the RAMSES framework introduces the key elements needed to provide a basis for a successful adaptation process. These include the need to obtain and assure institutional support and stakeholder involvement, configuration of the work team, set up adequate coordination mechanisms, clarify roles and responsibilities, explore funding opportunities, identify already available information and increase awareness and understanding of climate change issues in urban areas.

Steps to follow

The main goal of this step is to define the objectives of the adaptation process and to configure the work team that will support the process.

The following activities will be needed:
- Institutional support of the organization and other institutions involved in the different stages of the adaptation process
- Involvement of all (private, public, associations, etc.) agents involved in the different stages of the adaptation process and empowerment of local communities
- Setting the internal team responsible for the adaptation process in all its phases

Funding and resources: to estimate the economic human resources needed for adaptation and seek funding for the implementation of adaptation at all stages
- Internal and external communication and citizen participation, provision and enabling of communication mechanisms and opportunities for citizen participation

Step II: Contextualization of the city in relation to climate change

The second step of this phase is focused on collecting information from the city in relation to climate change in order to generate a conceptual impact analysis that will help to understand city hazards and their potential impacts.

The following activities will be needed:
- Collection of information available on climate change, including historical events
- Collection of information on current climate threats and preliminary identification of potential local impacts of climate change
- Definition of a management plan uncertainty inherent in all phases of the process of adaptation and consideration of "maladaptation"
- Identification of significant potential impacts
- Analysis of existing local studies

Worksheet 1 of the RAMSES Training Package provides guidance on how to identify and engage relevant stakeholders for your adaptation process [follow this link to know more]

Methods and tools applied in RAMSES

IMPACT CHAINS: CONCEPTUAL IMPACT ANALYSIS

The key aim of this tool is detecting the climatic and non-climatic drivers that affect the system you are analyzing and define the impacts you are expecting. The purpose is to create a graphical diagram explaining the main drivers (climatic and non-climatic) which are affecting the main sectors, along with their impacts and consequences. They graphically represent the expected impacts on the city due to several drivers (climatic and non-climatic) in a easy way, which facilitates exchange with stakeholders. Therefore, it can be reviewed, modified or validated by other actors.

To do so, the researcher needs to detect the explanatory factors (drivers) of the detected problems that potentially increase or alleviate the impacts of climate change within any of the complex socio-environmental components that define complex urban systems (Cutter et al., 2010; Jacobs et al., 2012; Schauser et al., 2010). These explanatory factors are represented in a series of schematic figures summarizing the causal structure of vulnerability and risk within each impact chain.
Thermal risk is not necessarily proportional to outdoor environment temperatures, but other determined by several influences, some environmental and some individual. A conceptual model is presented in the figure, in which exposure to heat is determined by outdoor heat and indoor heat, the latter in turn determined by landscape and built environment factors that are heavily influenced by urban configurations. Outdoor heat is the exposure factor most directly affected by climate change. Conversely, sensitivity of the individual to heat is determined by his/her adaptive capacity, in turn determined by a multitude of factors, most of which are themselves risk factors for heat-related morbidity and mortality.

The high temperature in urban built environments is one of the most relevant climate hazard affecting the population. In order to mitigate this climate risk, a combination of climatic drivers, such as mean radiant temperature, relative humidity, wind speed etc. together with non-climatic drivers that influence outdoor heat which are for example urban density and morphology, geometric proportion of urban canyons, building orientation and exposure, and other socio-economic variables (i.e. age and habits of the population, health etc.) need to be taken into account. In the exposed population, the previous mentioned effects cause increases in thermal discomfort at pedestrian level, aggravation of pre-existing heat-sensitive conditions and reduce work productivity among others. Some adaptation options are to control the urban density, conversion of vehicular street in green pedestrian promenade and influencing urban planning regulations (i.e. orientation of the district, ration aspect H/W of urban canyon etc.) and urban decision makers (i.e. close some streets to vehicular traffic and create pedestrian promenades, change the finishing material of soil of the street etc.).
Example Box 3:
**Heat to work productivity impact chain**

**Drivers**
- High Temperatures (indoor and outdoor)
- Increase in heat-wave days
- Ageing Population
- Maladaptation to increased temperatures

**Urban Configuration**
- Increased Urbanization
- Increase of sealed surface
- Reduction in Green Spaces

**Use of solar Blinds**

**Building Design**

**INTERMEDIATE IMPACTS**
- Intense UHI effect
- Reduced indoor and outdoor comfort
- Decrease in wellbeing
- Decrease in cognitive performance
- Health effects

**MAIN IMPACTS**
- City production decreases
- i.e., production in each sector decreases and this is aggregated to form city GVA (Gross Value Added)

The main drivers for heat stress at the workplace are climatic drivers (e.g., high outdoor temperatures), drivers related to the workplace environment (urban configuration, building design) and socio-economic drivers (e.g., ageing population). In cities, the extensive use of concrete and asphalt, with a high percentage of replacement of natural surfaces with built surfaces, and lack of green spaces that provide shading, temperatures tend to be higher than in surrounding areas. In the future, these temperatures are likely to increase even more. High temperatures caused reduced indoor and outdoor comfort of workers, hindered their cognitive performance and ability to perform tasks. These decreases result in productivity losses. Productivity decreases are different for each sector of the economy, depending on the physical energy needed to perform each task and whether tasks are performed indoors or outdoors. Productivity decreases result in reduced production, in the form of a lower city GVA (Gross Value Added).

Example Box 4:
**Pluvial flood to traffic disruption impact chain**

**Drivers**
- Heavy Precipitation
- Sealed surfaces
- Surface Water Flooding
- Topography

**Intermediate Impacts**
- Traffic Volumes
- Rates of Permeability
- Building Design
- Drainage Systems (Antwerp only)
- Mode of Transport Chosen
- Planning Policies (e.g., locations of residential and employment areas)
- Green Roofs/TANKS/SUDS

**Main Impacts**
- The total time or monetary delay to commuters using the urban transport network.

Extreme rainfall events, caused by convective storms, are likely to become more frequent and intense as the climate warms. This will lead to greater disruption in the future. Cities are particularly vulnerable to these events due to the number of sealed surfaces in urban areas, and the concentration of people and assets. The vulnerability of the system is a function of the traffic volumes on the transport network, the mode of transport, and the location of residential and employment areas (e.g., the urban form). Adaptation options include improvements to drainage systems, protection of buildings and infrastructure, and green measures such as green roofs or SUDS. The combination of a flood hazard and vulnerability of the transport network can be used to assess disruption from surface water flooding due to delayed or interrupted journeys. The impact of this disruption can be measured in terms of total time delay for commuters across the transport system, or converted to monetary units to allow cost-benefit analysis of adaptation options which may reduce that delay.
3.2 PHASE II: ASSESSING RISK AND VULNERABILITY

This step of the RAMSES framework aims to develop a comprehensive picture of current and future risks in a given urban area as well as further stress factors to be expected. It is also important to note that this step will also help identify not only risks but also opportunities arising from climate change.

This step is based on the reasoning that adaptation cannot be planned solely on the basis of climate projections; information on risk and vulnerabilities is also needed to determine how the climate interacts with socio-economic issues. RAMSES is following the risk and vulnerability framework defined by the IPCC in the SAR (IPCC, 2014).

In this phase of the process the idea is addressing the following questions:
- How is climate change going to affect my city?
- Which areas and sectors of activity would potentially be more affected?
- Which are more vulnerable?
- To what extent is the city capable to cope with it and react?

Steps to follow

Figure 5: Phase II: Assessing risks and vulnerabilities

Example Box 5:
Flood to built environment impact chain

“For dealing with future risks we have to come up with new ways forward, and collaboration is key. This is not only collaboration across sectors or between business, governments and science – it means also collaboration between professionals and people.”

Henk Ovink, Special Envoy for International Water Affairs, Kingdom of the Netherlands
Methods and tools applied in RAMSES

HIGH LEVEL “TOP-DOWN” HAZARD ANALYSIS

RAMSES has carried out a high level climate hazard analysis for urban areas that provides a broad top-down view of climate risks to cities across Europe. The approach takes advantage of the increasing availability of European and global datasets and computing power to apply the method to 421 cities in the EU’s Urban Audit database. For this high level city hazard analysis, the following methods and tools have been used (Table 2).

This high level approach is used only for comparative purposes among cities at a high level, allowing cities to compare their future risks with the current day, and to network with other cities facing similar future threats.

DETAIL LEVEL HAZARD ANALYSIS

In order to gain a deeper knowledge of the spatial patterns of risk faced within a city we need to take a bottom-up approach. In this sense, the bottom-up hazard and exposure analysis implies the use of more refined climate projections and modeling tools of impacts, driven by higher resolution data. RAMSES analysed the bottom-up impact analysis related to flooding and heat.

Refined climate projections: 11 GCM (Global Climate Models) are used to develop future climate projections (for the end of the century, 2081-2100) and drive impact models. For all GCM, the business as usual scenario (RCP8.5) has been considered. Then, a bias correction has been done which reduces the differences between (1) the urban climate simulated with ERA-interim meteorological input, and (2) the urban climate simulated with the GCM as a driver, for the reference period. The bias correction has been done at 0.5° resolution for temperature, 0.25° resolution for precipitation.

The refined climate projection has been developed for 9 cities: Antwerp, Bilbao, London, Rio de Janeiro, Hydrabad, New York, Skopje, Berlin, and Almada in Portugal. Table 3 describes the models and methods used for the flood and heat hazard analysis at city scale. It presents a list of models/methods for impact analysis indicating the main characteristics and the model needs for climate change impact analysis.

Table 2: Methods and tools for the high level hazard analysis

<table>
<thead>
<tr>
<th>HAZARD</th>
<th>METHOD/TOOL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat</td>
<td>Intensity and frequency of heatwaves (a heatwave being defined as three consecutive days where both the maximum and the minimum temperatures are above their respective historical 95 percentiles)</td>
</tr>
<tr>
<td>Pluvial flood</td>
<td>CityCat (hydrodynamic surface water flood model and the 25m resolution DEM, forced with future hourly rainfall for a 10 year return period)</td>
</tr>
<tr>
<td>Pluvial flood</td>
<td>Output of peak levels of annual maximum daily discharge</td>
</tr>
<tr>
<td>Drought</td>
<td>Drought Severity Index (it is based on cumulative monthly precipitation anomalies and is calculated for a 12-month timescale)</td>
</tr>
</tbody>
</table>

Table 3: Flood and heat models/methods

<table>
<thead>
<tr>
<th>HAZARD</th>
<th>PLUVIAL FLOOD</th>
<th>COASTAL FLOOD</th>
<th>HEAT</th>
<th>HEAT</th>
<th>HEAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name of the model/method</td>
<td>CityCAT</td>
<td>EUROSURGE</td>
<td>UrbClim</td>
<td>UrbClim High Res</td>
<td>ENVI-met</td>
</tr>
<tr>
<td>Type</td>
<td>Hydrodynamic surface water flood model with linked hydraulic subsurface simulation.</td>
<td>The model combines extreme value statistics of sea-levels with flood damage functions. It is a transferable top-down approach.</td>
<td>Urban climate model</td>
<td>High resolution modelling of human comfort</td>
<td>ENVI-met is one of the first models to reproduce the major processes in the atmosphere – including air flow, turbulence, radiation fluxes, air temperature and humidity – on a well-founded physical basis.</td>
</tr>
<tr>
<td>Short description</td>
<td>Simulates surface water flow from extreme rainfall.</td>
<td>Core to the model are the flood damage functions for cities, which base on the urban extent and simple bathtub-flood modelling.</td>
<td>UrbClim downscales large scale weather data to agglomeration scale, and calculates the effect of urban development on the most important weather parameters.</td>
<td>Combination of UrbClim meteorological output with high resolution incoming solar radiation, taking into account shading effects of buildings and vegetation.</td>
<td>ENVI-met is a 3D microclimate modelling software, used to calculate numerous of the meteorological factors (surface temperature, mean radiant temperature, relative humidity, air temperature) as well as thermal comfort quality (PET/PMV) within an urban area.</td>
</tr>
<tr>
<td>Output</td>
<td>Flood water depth and velocity in the domain at multiple time steps.</td>
<td>Expected damage</td>
<td>Temperature maps and maps of the number of heatwave days in urban agglomerations for current and future climate</td>
<td>Maps of human exposure indices (WBGT, Tmrt, PET) at very high resolution (few meters)</td>
<td>ENVI-met is a 3D microclimate modelling software, used to calculate numerous of the meteorological factors (surface temperature, mean radiant temperature, relative humidity, air temperature) as well as thermal comfort quality (PET/PMV) within an urban area.</td>
</tr>
<tr>
<td>Time resolution</td>
<td>One rainfall event – can be from 30 minutes to 6 hours, depending on spatial resolution and rainfall data.</td>
<td>Annual</td>
<td>Periods of 20 years</td>
<td>1 hot moment during a summer (noon of the warmest day of the summer).</td>
<td>30° resolution for a domain of approximately 50km by 50km. Within RAMSES, a map of Antwerp has been composited.</td>
</tr>
<tr>
<td>Coverage / resolution</td>
<td>City-scale, 5-10m resolution.</td>
<td>European coasts, 140 coastal cities, CORINE resolution.</td>
<td>European coasts, 140 coastal cities, CORINE resolution.</td>
<td>250m or 100m resolution, for a domain of approx 50km x 50km. Within RAMSES, maps of 102 European cities have been made.</td>
<td>It has a high spatial resolution (about 0.5 x 0.5 m). Used for simulating the urban climate interactions. ENVI-met has been composited.</td>
</tr>
</tbody>
</table>
The required input data for the hazard analysis is summarized in Table 4: the required information related to climate (e.g., downscaled and bias corrected precipitation/temperature of the CGM or RCM), and the required inputs for the model (e.g., DEM, building stock ...).

### Table 3: Flood and heat models/methods

<table>
<thead>
<tr>
<th>HAZARD</th>
<th>PLUVIAL FLOOD</th>
<th>COASTAL FLOOD</th>
<th>HEAT</th>
<th>HEAT</th>
<th>HEAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name of the model/method</td>
<td>CityCAT</td>
<td>EUROSURGE</td>
<td>UrbClim</td>
<td>UrbClim High Res</td>
<td>ENVI-met</td>
</tr>
<tr>
<td>Benefits</td>
<td>High speed, high resolution, considers urban characteristics.</td>
<td></td>
<td>High resolution maps of urban climatic fast model, hence time periods of 20 years can be considered. Both current and future climates, easy to assess the influence of large green spaces in the city (parks...).</td>
<td>Very high resolution maps of human exposure and discomfort during extreme heat episodes; assessment of shading effect of individual buildings and trees.</td>
<td>In ENVI-met, buildings are represented explicitly as obstacles; this feature is completely different to the approach followed in UrbClim, in which the urban substrate is represented as a rough slab.</td>
</tr>
<tr>
<td>Type</td>
<td>Computationally- and data-intensive (runs on Cloud).</td>
<td>Compared to case studies, lower level of detail.</td>
<td>Not suited for very high resolution (individual trees, small ponds...).</td>
<td>Only a short time frame can be dealt with (hour with maximal heat stress in a summer).</td>
<td>Time consuming in the simulation and the elaboration of the data through other software (e.g., Leonardo).</td>
</tr>
</tbody>
</table>

### Table 4: The required input data for the flood and heat models/methods

<table>
<thead>
<tr>
<th>HAZARD</th>
<th>PLUVIAL FLOOD</th>
<th>COASTAL FLOOD</th>
<th>HEAT</th>
<th>HEAT</th>
<th>HEAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name of the model/method</td>
<td>CityCAT</td>
<td>EUROSURGE</td>
<td>UrbClim</td>
<td>High Resolution module of UrbClim (“UrbClim High Res”)</td>
<td>ENVI-met</td>
</tr>
<tr>
<td>Climate input</td>
<td>Time series for rainfall event during duration of flood simulation in mm/h. This can also vary spatially across the model domain.</td>
<td>Extreme value parameters of sea level records at sites close to the considered cities.</td>
<td>Same as UrbClim</td>
<td>Location Longitude Latitude</td>
<td>Meteorological parameters: temperature, wind speed, solar radiation, heat fluxes, humidity, precipitation, soil temperatures</td>
</tr>
<tr>
<td>Uplifting factors are currently being tested (see Kendon et al., 2012) to scale current return period intensities to future climate projections.</td>
<td>Future climate: output of global climate models (GCMs)</td>
<td>Meteorological parameters: temperature, wind speed, solar radiation, heat fluxes, humidity, precipitation, soil temperatures and moisture</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model input</td>
<td>DEM data (high resolution required), building footprints, gully locations (if drainage networks included), transport link locations with speed and capacity information, observed trips (e.g., census journey-to-work).</td>
<td>Land-cover and -use data, elevation model</td>
<td>DEM, land use, soil sealing, vegetation. All of these can be taken from open source datasets.</td>
<td>3D building information, Location of trees</td>
<td>The main model is designed in 3D with two horizontal dimensions (x and y) and one vertical dimension (z), localization of vegetation elements, materials of building and soils.</td>
</tr>
</tbody>
</table>
EXPOSURE ANALYSIS

The exposure assessment can be done in two ways:
1) Through indicators: selecting the indicators that represent the exposed assets (e.g. population, residential buildings, critical infrastructures etc.)
2) Through a model that localizes the exposure

In a heat effect analysis, there is actually no generally accepted, well-defined indicator for the number of heat waves, nor for the urban heat island effect. In general, heat wave definitions make use of running average temperatures considering a couple of consecutive days, but the exact number of days may vary. Within RAMSES, we have defined some indicators, based on temperature and the number of heat-wave days. We have experienced, in a project for the city of Antwerp, that municipalities are especially interested in the occurrence of heat-waves and the difference in number of heat waves in the city centre and the rural surroundings.

Also when referring to daytime human comfort, many indices are used (PET, WBGT, Tmrt, UTCI). Each comes with their own advantages and disadvantages. For general understanding, it is best to convert these technical indices into a single scale (ranging from "no heat stress" over "moderate heat stress" to "severe heat stress"), as policy makers prefer these kinds of scales over somewhat abstract numbers that are not directly related to measurable quantities.

When heat-health effects are analysed, the exposure indicators can be used to characterize and assess causal relations between environmental hazards and health outcomes. In this case, temperatures and other indicators are used as proxies to understand individuals’ exposure to high temperatures and thermal stress.

In a pluvial flood analysis, when we analyse the flood-traffic disruption impact chain, the exposure is measured by the number of users of a road segment. This is dependent on the location of the road network in relation to the hazard, the importance of each link in the network, and the number of people using the link. This assessment can be done in two ways:
1) Through observation (e.g. in-road sensors) or analysis (e.g. measuring properties of the network links mathematically) to assess the importance of a road link and the level of exposure, or
2) Through a transport model that assigns trips to links in the road network.

THRESHOLD ANALYSIS

The thresholds analysis links the impacts of climate change (hazards) to their potential outcomes. These thresholds can be defined through research or through stakeholder consultation or both, and they contribute to the development of a vulnerability framework (Agnew M. and Goodess, C., 2016).

Example boxes

Example Box 6:
UHI-map of Antwerp and high resolution heat stress in Brussels

Antwerp is a medium-sized town in the northern part of Belgium. It is the capital of the province of Antwerp and has approximately 500,000 inhabitants. To the north of the city lies one of the largest ports of Europe. In 2014, the city signed Mayors Adapt (the Covenant of Mayors initiative on adaptation to climate change). By signing up to Mayors Adapt, Antwerp commits to contributing to the overall aim of the EU Adaptation Strategy by either developing a comprehensive local adaptation strategy or integrating adaptation to climate change into relevant existing plans. Subsequently, the city got involved in several EU-funded projects concerning climate change adaptation, including several case studies concerning heat effects in the city.

The map shows the number of heat-wave days per year in the city of Antwerp for the current timeframe (1986 – 2005) and the far future (2081 – 2100), using the RCP8.5 climate warming scenario and the results of 11 GCMs. A period is considered as a heat-wave if the three-day running minimal and maximal temperature exceed the 98th percentile of the historic rural temperatures during summer period. While for the timeframe 1986 – 2005, the whole area reports values lower than 5, for the timeframe 2081-2100 the number of heat-wave days increases by a tenfold. Values tend to be generally lower (between 15 and 20) in peripheral areas and the countryside, and a mitigating effect seems to exist along rivers also in urban areas, with values between 10 and 20. The highest values are observed close to entirely sealed areas, such as the port of Antwerp, the dense inner city and the locations of traffic infrastructure.
Example Box 7: Pluvial flooding disruption to traffic

Extreme rainfall events, caused by convective storms, are likely to become more frequent and intense as the climate warms. This will lead to greater disruption in the future. Cities are particularly vulnerable to these events due to the number of sealed surfaces in urban areas, and the concentration of people and assets. The vulnerability of the system is a function of the traffic volumes on the transport network, the mode of transport, and the location of residential and employment areas (e.g. the urban form). Adaptation options include improvements to drainage systems, protection of buildings and infrastructure, and green measures such as green roofs or SUDS. The combination of a flood hazard and transport network vulnerability can be used to assess disruption from surface water flooding due to delayed or interrupted journeys. The impact of this disruption can be measured in terms of total time delay for commuters across the transport system, or converted to monetary units to allow cost-benefit analysis of adaptation options which may reduce that delay.

Example Box 8: Coastal flood map – Bilbao case

Bilbao - Flood damage (Euro/)

The maps show estimated damage for a hypothetical flood of given maximum flood level. Therefore, the local inundation depth has been combined with land cover/use information. The local damage in Euro per square-meter is color-coded as resolved by the color-bar. The estimated damage can be displayed for different flood levels.
Example Box 9: Threshold analysis in RAMSES

1) Relationship between heat and human health

RAMSES studied the relationship between temperature indicators and selected outcomes (e.g., all-cause mortality) focusing on the warm seasons (1 May–30 September). The outcome variable was the daily death count. The analysis was based on a generalized estimating equations (GEE) approach, without robust adjustment of the standard errors, as recommended in the presence of few large clusters. Other dummy variables have been considered in the models like holidays, day of the week and calendar month, the yearly long-term trend, dew point, and the average of the current and the previous day concentration of PM10. This information was used to determine thresholds for alert levels. There can be more than one threshold in the relationship between temperatures and the selected health indicator; which can be used to define alert levels. However, these alert levels can be based on a combination of temperature thresholds and heat spell duration. In the practice, alert levels are based on multiple considerations, sometimes they are based only on statistical considerations (e.g., maximal temperature beyond percentile X). While that is acceptable in the absence of health-based evidence, the epidemiologically observed population-level thresholds should ideally be central to the definition of heat-health alert levels.

2) Heat to work productivity

As an international standard, RAMSES used ISO standard 7243:1989 on heat stress at different work intensities to estimate worker productivity loss functions (ISO 1989). Following Kjellstrom et al. (2009), we estimate the WBGT (wet bulb globe temperature) at which the ISO recommends an average, acclimatised worker should perform work at 100%, 75%, 50% and 25% productivity, as well as the threshold WBGT above which workers are performing at or very close to zero capacity. Using the method set out by Kjellstrom et al. (2009) the WBGT for each type of work and for each work/rest ratio has been estimated. From the standards described above, productivity loss functions for five different work intensities were calculated. RAMSES additionally used functions estimated from alternative standards: the US national standard provided by the National Institute for Occupational Safety and Health (NIOSH).

3) Flood to traffic disruption

In RAMSES a curve linking flood depth to travel speed has been developed. This does not define a threshold as such, but more a fragility curve. There is a final threshold of 300mm above which a road is closed, based on the sill height of the average car. An alternative approach would be a threshold of rainfall intensity above which a warning is sent out, but the likelihood of flooding occurring depends very much on the characteristics of each urban area.

4) Flood to built environment

The threshold is given by existing dikes. In case the existing protection levels is unknown a literature survey has been carried out and some values have been found (which are often expert judgment). If necessary, it is assumed that in countries for which the values are known, similar values also hold true for other cities.

Example Box 10: Heat and health threshold: The relationship between $T^\circ$ and mortality

The relationship between mean temperature and mortality in Skopje.

The figure below is the relationship between mean temperature (defined as a moving average of three days before measured outcome) and mortality in Skopje. Its interpretation is not completely straightforward, but put simply it serves to define safe temperature thresholds at the population level. The shape of this curve is similar in almost every city in temperate climates.

The principles of both the high level and the detailed risk analysis are similar in that we are looking to understand both the likelihood of an extreme weather event occurring and how that likelihood might change in the future as a result of climate change.”

Richard Dawson, Newcastle University

Worksheet 4a of the RAMSES Training Package provides guidance on how to use the tool developed by WHO to estimate the effects of climate change on health [follow this link to know more]
Step II: Vulnerability assessment - hotspot detection

Methods and tools applied in RAMSES case studies

**HIGH LEVEL ANALYSIS**

RAMSES undertook a high level climate vulnerability analysis (VA) for urban areas that provides a top-down, and broad, view of climate risks to cities across Europe. Based on freely available data from the Urban Audit database and an additional set of newly-developed indicators.

Vulnerability = (sensitivity, adaptive capacity)

The sensitivity or susceptibility is the degree in which a system or species is affected in a positive or negative way by the variability of the climate variables.

The adaptive capacity makes reference to the capacity of socio-ecological systems, institutions, human beings and wildlife to adapt to the potential damages of climate change, seize opportunities or respond to its consequences.

Therefore, the characterization of vulnerability is crucial in order to understand how the socio-ecological system at city level could be affected by certain hazards, and so establish and deploy the adequate mechanisms and effective policies to respond and adapt. This characterization is highly spatially explicit and depends on the physical, biological, ecological, economic and social features of a certain territory, so the role of local governments in the identification and assessment of climate risks is crucial (also known as hotspot detection).

The following activities will be needed:

- Definition of the data model and selection indicators for the evaluation of sensitivity and adaptive capacity
- Aggregation of indicators and results of vulnerability assessment per every threat (optional)
- Formulation of vulnerability to a threat or hotspot detection

**DETAILED ANALYSIS**

In order to gain a deeper knowledge of the vulnerability of a city, a bottom-up approach has been carried out in RAMSES to detect the hotspots in the cities. The hotspot detection aims detecting the most vulnerable areas in a city.

This analysis is carried out through indicator analysis. Many hotspots mapping efforts are affected by the spatial scale and uncertainties in the available data sets. Some authors point out that there is a gap between local vulnerability assessment, which address context-specific situations with more detailed data (detailed analysis), and the kinds of analyses possible for global vulnerability analysis (high level analysis), which are based on aggregated data and rather crude assumptions (Sherbinin, A., 2013). Therefore, it is important to identify the aim of the VA and then decide whether a high level or detailed analysis is most applicable.

Example Box 11:

“Hotspot analysis in RAMSES in the 5 impact chains”

1) Heat to human health

Determining the location of the hotspots in city centres is mostly done by a visual inspection of the maps (the stakeholders like this much more than mathematical criteria). Alternatively, authorities could analyse the vulnerability of specific groups of residents through proxy indicators available through secondary data (e.g. Censuses, or Demographic and Health Surveys). Combined with heat exposure variables, a geo-referenced heat vulnerability index can be calculated. A possible methodology is detailed by Wolf & McGregor (2013).

2) Heat to urban comfort

The hotspots inside urban areas are detected by analyzing urban configuration and land use together with its interaction with regional climate. Urban land use is classified from a climate perspective. These are called Local Climate Zones (LCZ) as defined by Stewart & Oke (2012). On the other hand regional climate is analyzed considering the geographical location and ventilation potential of the urban area. The methodology considers urban heat accumulation (depending on urban land characteristics) and the ventilation potential (the possibility to remove of urban heat). All the required information is included in several geographical information layers (GIS) with a resolution of 100 meters that include all the aspects that condition the urban climate (Acero et al. 2013, Ren et al. 2011). The combination of the GIS layers derives in an Urban Climate Analysis Map (UCA-MAP) where the urban area is classified in zones with similar impact on thermal comfort. Together with urban climate expert knowledge to interpret dynamic and ventilation potential inside the urban area, climate measurements in different locations of the urban area are used to validate the results of the UCA-MAP. Determination of hotspots in urban areas is crucial from an urban planning perspective. This information is used by stakeholders that only require clear and simple information for decision making.

3) Heat to work productivity

Three indicators have been considered for the hotspot detection which are 1) the energy intensity of the work performed, 2) whether work is performed indoors or outdoors, 3) labour intensity of the work performed, elasticity of substitution between labour and capital in different sectors. For the first indicator, productivity loss functions are defined for activities from intensity 1 (least energy intensive) to 5 (most energy intensive), where 1 has the least productivity losses and 5 the most; then economic sectors are attributed each of these classifications (e.g. manufacturing has intensity 2, construction has intensity 4, etc.) For the second indicator, RAMSES assumes certain sectors (construction and agriculture) are only performed outdoors, and that all the others are only performed indoors. For the third indicator, this was calibrated with data from several studies by sector (eg. the construction sector has low elasticity – difficult to exchange labour for capital – and high labour shares – more labour relative to capital). The true indicators are considered in order to analyse the vulnerability: for example a city with a large construction sector is more vulnerable, as it combines outside work, energy intensive work (in terms of human energy dispended to perform tasks), and low elasticity and high labour shares.

4) Flooding to traffic disruption

RAMSES uses a combination of methods for hotspot analysis: 1) network topology metrics, by looking at matrices key links in the network can be identified; 2) flow analysis, by examining the flow along the network important links are identified; and 3) combining with flood hazard, putting together those roads with the highest important and highest flood depths gives us hotspots of important roads where adaptation should be targeted. From this hotspot identification, the links in the highest category of risk have been selected (See Pregniolato, M. et al., 2016, for full details: http://oss.royalsocietypublishing.org/content/3/5/160203)

5) Flood to built environment

The flood analysis includes the spatial distribution of land cover and the inundation depth which shows the most affected urban areas.
Step III Risk definition

The last step in this phase is identifying the risk and assessing the likelihood of being affected by a specific climate threat.

Traditionally, risk assessment is undertaken by quantifying the probability of climate hazards occurring and their consequences. Usually expressed as

\[ \text{Risk} = \text{probability} \times \text{consequences} \]

That same framework remains valid to incorporate the concepts presented earlier in the sequence analysis, since the probability of occurrence is derived on the one hand from the analysis of climate scenarios and the impact modelling, and on the other from the analysis exposure and vulnerability.

\[ \text{Risk} = \text{probability (threat)} \times \text{consequence (exposure, vulnerability)} \]

Therefore, recently and according to the latest IPCC 2014 definition, risk is expressed as the function of threat, vulnerability and exposure (IPCC, 2014).

\[ \text{Risk} = f(\text{hazard, exposure, vulnerability}) \]

Traditionally in risk assessment, the consequences have been valued according to economic estimates of damages and losses by an extreme event. However, the non-monetary evaluation of consequences may be considered in line with the most recent IPCC report focussed on adaptation.

It is important to consider the possibility of conducting risk assessments in a qualitative way, which can be very useful particularly when the information resulting from the previous steps may be incomplete or insufficient.

The following activities are needed:

- Description of the components of risk and generating information. The first task in the risk assessment is the generation of information on the components of the potential risks and description. It involves identifying threats, potentially impacted areas and their possible causes and consequences. All this information we obtain from the above-described phases.

- Construction of the model and risk analysis. There are different approaches to risk analysis, which can even be combined. Independently of the approach or methodology adopted (quantitative and/or qualitative), it is important to consider the uncertainty associated with the quality of data used and inherent to the methods themselves. Considering the level of confidence in our risk assessment, and incorporating it as additional attribute of our analysis could be one way to make explicit the management of uncertainty.

- Risk estimation. In order to provide a systematic way to summarise, compare and prioritise risks, the results of a risk analysis are often classified according to an ordinal scale for example, a value from 1–5, low, medium, high. Having analyzed the risks and estimated its risk importance profile, the next step is to assess the need for action, where and how urgently. This assessment will probably not be taken solely on the basis of risk assessment, it is likely to depend on how the risks relate to other priorities within an organization, its legal and regulatory requirements, and resources available for action.

Methods and tools applied in RAMSES case studies

The analysis done in RAMSES follows the conceptual framework proposed by the IPCC on the WAsI AR5 (IPCC, 2014).

The hazard, exposure and vulnerability indicators have been combined to inform on the relative level of risk faced by each city under each impact chain (Figure 6). A risk score, \( R \), for each city, \( C \), and climate change threat, \( T \), is calculated as:

\[
R_{ct} = \sqrt{H_{ct} \times E_{ct} \times V_{ct}}
\]

where the standardised hazard score \( H^2 \), standardised exposure score \( E^2 \), and standardised vulnerability score \( V^2 \) are aggregated as a risk score \( R^2 \). It is standardised and re-scaled for visualisation as \( R \).

Thus, the risk indices have been generated as the interaction of hazard, exposure and vulnerability scores.
Example Box 12: High level risk analysis for Europe

“High level quantified assessment of key vulnerabilities and priority risks for urban areas in the EU” provides an assessment of key vulnerabilities and priority climate-related risks for 571 cities in the EU’s Urban Audit database. This assessment combines hazard, exposure and vulnerability information in a coherent, flexible, stable, scalable, transparent and integrated risk analysis.

In terms of heatwave risk, the study provides evidence that the cities with higher potential heatwave risks under the three climate scenarios are mainly located between central France to Romania and Bulgaria, with a few ramifications to the UK, southern Greece, and the Baltic Republics. Conversely, most cities on the Iberian Peninsula, Scandinavia and the Mediterranean regions show medium to lower levels.

Worksheet 4 of the RAMSES Training Package provides guidance on how to assess and prioritise risks for your city [follow this link to know more].

“The climate risks that we are most aware of are of events that effect large numbers of people. And large numbers of people live in cities.”

Frans Berkhout,
King’s College London

3.3 PHASE III: IDENTIFYING ADAPTATION OPTIONS

Phase description and key objectives

This phase of the RAMSES framework aims to identify a wide range of adaptation options to address the previously identified concerns, in order to bring negative impacts at an acceptable level, or to take advantage of any positive opportunities that arise from climate change.

At this stage, the aim is to identify alternatives and possibilities to respond to challenges and opportunities, among which subsequently can choose those that best suit the nature of the threats that affect us and our territorial and institutional context.

This section facilitates an exploration of potential adaptation options and helps identifying relevant actions, and their potential co-benefits.

Steps to follow

Step I Vision construction and setting up adaptation objectives

This step aims to define what are the adaptation objectives in each specific research (which at the end will be related to solving the impacts detected in the impact chain) [e.g.: have a maximum 4-meter water level in the river, have a reduction of 30% in the morbid-mortality in the next 10 years …]

The following activities will be needed:

• Identifying and prioritizing direct and indirect impacts of climate change. This activity is crucial to efficiently structure the adaptation process and the development of specific adaptation actions [Prutsch, A. et al., 2014] by analysing the previous vulnerability and risk information.

• Setting up the adaptation objectives.

• Consultation of available inventories of adaptation options to respond to the expected impacts

• Adaptation options, characterization of the options, benefits and potential uses

Step II Identifying adaptation options

• Setting up the adaptation objectives

• Identifying and prioritizing direct and indirect impacts

• Consultation of available inventories of adaptation options to respond to the expected impacts

• Adaptation options, characterization of the options, benefits and potential uses

Step III Risk definition

• Identifying and prioritizing direct and indirect impacts

• Setting up the adaptation objectives

• Consultation of available inventories of adaptation options to respond to the expected impacts

• Adaptation options, characterization of the options, benefits and potential uses

Steps to follow

Figure 7: Phase III: Identifying adaptation options
Table 5: Objectives and evaluation criteria defined in RAMSES for each impact chain

<table>
<thead>
<tr>
<th>IMPACT CHAIN</th>
<th>MAIN ADAPTATION OBJECTIVES DEFINED IN RAMSES</th>
<th>EVALUATION CRITERIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human health to heat</td>
<td>• Avoid all heat-related mortality and morbidity; however, this seems unfeasible in light of the existing evidence e.g. (Toloo et al., 2013).</td>
<td>• Reduction in heat-related mortality</td>
</tr>
<tr>
<td></td>
<td>• Maximizing human comfort</td>
<td>• Reduction in heat-related hospital admissions</td>
</tr>
<tr>
<td></td>
<td>• Reduction in selected heat-related morbidity outcomes (depending on the information available)</td>
<td>• Reduction in selected heat-related morbidity outcomes (depending on the information available)</td>
</tr>
<tr>
<td></td>
<td>• Human comfort indices (WBGT, PET...)</td>
<td>• Human comfort indices (WBGT, PET...)</td>
</tr>
<tr>
<td>Urban comfort to heat</td>
<td>• Maximal decrease in the nightly temperature difference between city and rural surroundings</td>
<td>• Temperature reduction in the city centre</td>
</tr>
<tr>
<td></td>
<td>• To reduce the thermal stress in the urban environment about 1 or 2 PET thermophysiological assessment classes during the daily maximum values</td>
<td>• Reduction in PET level thanks to the mitigation actions such as green infrastructure (i.e. green corridors, green roof) and vegetation element (i.e. trees)</td>
</tr>
<tr>
<td></td>
<td>• Benefits in reducing the Mean Radiant Temperature and Surface temperature level in the urban environment.</td>
<td>• Benefits in reducing the Mean Radiant Temperature and Surface temperature level in the urban environment.</td>
</tr>
<tr>
<td>Work productivity to heat</td>
<td>• Decrease or avoid productivity reductions because of high temperatures</td>
<td>• Reduction in production (through reduction in productivity losses) because of each adaptation measure</td>
</tr>
<tr>
<td></td>
<td>• Lower cooling demands in office buildings</td>
<td>• Cooling costs in office buildings</td>
</tr>
<tr>
<td>Traffic disruption to flood</td>
<td>• Reduction in overall traffic delay</td>
<td>• Compare the reduction in overall traffic delay with the cost of the adaptation (e.g. the cost of a water tank or improved drainage) for various severities of events.</td>
</tr>
<tr>
<td>Built environment to flood</td>
<td>• Reduce damages from coastal floods</td>
<td>• Given a planning horizon, investment (and maintenance) costs can be compared with upcoming damage</td>
</tr>
</tbody>
</table>

Example boxes

From the 5 impact chains analysed in RAMSES, the following objectives and evaluation criteria have been identified (Table 5).

Methods and tools applied in RAMSES case studies

Figure 8: The methodology and steps followed in the exercises

After vulnerabilities had been identified for a particular city, the next step consisted of converting the previous hotspots/challenges of the impact chain into positive statements (combining elements inspired in the different generic visions). Then these are translated into a vision. This step might be done in the following way:

1. City vulnerability
   - Framework description in order to identify:
   - Hotspots/key problems/challenges
   - Related to city functions/functionalities (beyond impacts)

2. Backcasting
   - To detect triggers of change: conditions for reaching future city vision

3. Vision
   - Framework of generic visions and elements
   - Combined in order to convert previous hotspots into positive statements about the future resilient city

Example boxes

Worksheet 5a of the RAMSES Training Package provides guidance on how to carry out a backcasting exercise to set long term goals for a more sustainable city development (follow this link to know more)
“There are also policy instruments that are usually not considered as part of the adaptation strategies: These include social policies towards most vulnerable groups or participatory processes in the decision-making. But green spaces and local gardens can also be part of the adaptation solution.”

François Gemenne, Sciences Po

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**Step II Characterization of potential adaptation options**

Adaptation measures cover a wide range that can range from those aimed at strengthening the resilience (e.g. sharing information, building institutional support etc.) to concrete adaptation measures and technical solutions, insurance mechanisms, etc.

The following activities will be needed:

- Consultation of available inventories of adaptation options to respond to the expected impacts. Sources: Climate-ADAPT, ClimWatAdapt Inventory of Measures, ADAM Digital Adaptation Compendium, Global and local Adaptation Support Action
- Adaptation Options, characterization of the options, benefits and potential uses

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**Table 6: Grey adaptation options for heat waves**

<table>
<thead>
<tr>
<th>TITLE OF THE ADAPTATION OPTION</th>
<th>GENERAL DESCRIPTION</th>
<th>CLIMATE THREAT</th>
<th>TYPE IPCC CLASSIFICATION</th>
<th>GEOGRAPHY</th>
<th>STUDY LOCATION</th>
<th>SCALE</th>
<th>TYPE OF ASSET (TARGET)</th>
<th>SECTOR</th>
<th>TYPE OF URBAN CONFIGURATION</th>
<th>PERFORMANCE ANALYSIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased ventilation</td>
<td>Increase in the rate of mechanical ventilation (from 22 m$^3$/h/p to 50 m$^3$/h/p)</td>
<td>Heat waves</td>
<td>Structural/Physical (Grey)</td>
<td>Northern - western Europe</td>
<td>London, Antwerp, Bilbao</td>
<td>City/village</td>
<td>Building</td>
<td>No specific sector</td>
<td>Other</td>
<td>Benefit</td>
</tr>
<tr>
<td>Air conditioning</td>
<td>Use of air conditioning set to the point where there are no losses for indoor work</td>
<td>Heat waves</td>
<td>Structural/Physical (Grey)</td>
<td>Northern - western Europe</td>
<td>London, Antwerp, Bilbao</td>
<td>City/village</td>
<td>Building</td>
<td>No specific sector</td>
<td>Other</td>
<td>Benefit</td>
</tr>
<tr>
<td>Solar blinds</td>
<td>Blocking screens outside the building that automatically lower if the irradiance on the windows is larger than 75 W/m$^2$</td>
<td>Heat waves</td>
<td>Structural/Physical (Grey)</td>
<td>Northern - western Europe</td>
<td>Antwerp</td>
<td>City/village</td>
<td>Building</td>
<td>No specific sector</td>
<td>Other</td>
<td>Benefit</td>
</tr>
<tr>
<td>Increased insulation</td>
<td>Reduction in the heat transfer through the glazing by decreasing the standard U-value of 1.2 W/m$^2$K to 0.8 W/m$^2$K</td>
<td>Heat waves</td>
<td>Structural/Physical (Grey)</td>
<td>Northern - western Europe</td>
<td>Antwerp</td>
<td>City/village</td>
<td>Building</td>
<td>No specific sector</td>
<td>Other</td>
<td>Benefit</td>
</tr>
</tbody>
</table>

More information can be found in Costa, H. and Floater, G., 2015.

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**RAMSES ADAPTATION MEASURES REPOSITORY**

RAMSES has compiled a collection of possible adaptation measures adequate to the urban context and consonant with the defined objectives (available in: www.ramses.cities.eu/index.php?id=tx_nawsecured&u=0&fe=fckeditor/tex_Fe__Repository/02_Workpackage_2_Delivery%202_D_2.4&id= f1&n=14866186177368987873e4f07757a2e7e5d555e86a9f84e1e6e22e6).

In the following table, additional adaptation measures assessed (effectiveness or cost-assessment) in RAMSES are presented.
Table 7: Green and awareness adaptation options to heat waves

<table>
<thead>
<tr>
<th>TITLE OF THE ADAPTATION OPTION</th>
<th>GENERAL DESCRIPTION</th>
<th>CLIMATE THREAT</th>
<th>TYPE (IPCC CLASSIFICATION)</th>
<th>GEOGRAPHY</th>
<th>STUDY LOCATION</th>
<th>SCALE</th>
<th>TYPE OF ASSET (TARGET)</th>
<th>SECTOR</th>
<th>TYPE OF URBAN CONFIGURATION</th>
<th>PERFORMANCE ANALYSIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greening (neighbourhood)</td>
<td>Greening at the scale of neighbourhoods within the city</td>
<td>Heat waves</td>
<td>Ecosystem based: green - blue</td>
<td>Southern Europe</td>
<td>Bilbao (Basque Country)</td>
<td>Street</td>
<td>Pedestrian street</td>
<td>No specific sector</td>
<td>Compact low rise</td>
<td>Effectiveness</td>
</tr>
<tr>
<td>Greening (park)</td>
<td>Impact of parks on the surface (i.e. radiative temperature)</td>
<td>Heat waves</td>
<td>Ecosystem based: green - blue</td>
<td>Southern Europe</td>
<td>Bilbao (Basque Country)</td>
<td>Street</td>
<td>Pedestrian street</td>
<td>Vehicular street / pedestrian street</td>
<td>No specific sector</td>
<td>Compact mid-rise</td>
</tr>
<tr>
<td>Changing working hours</td>
<td>Changing working hours from baseline (11h-13h, 14h-17h) to (17h-11h, 20h-17h)</td>
<td>Heat waves</td>
<td>Behavioural</td>
<td>Northern Europe</td>
<td>London, Bilbao</td>
<td>City/ village</td>
<td>Population</td>
<td>No specific sector</td>
<td>Outdoor thermal comfort inside</td>
<td>Effectiveness</td>
</tr>
</tbody>
</table>

Table 8: Grey, green and technological adaptation options to flood (pluvial, sea level rise)

<table>
<thead>
<tr>
<th>TITLE OF THE ADAPTATION OPTION</th>
<th>GENERAL DESCRIPTION</th>
<th>CLIMATE THREAT</th>
<th>TYPE (IPCC CLASSIFICATION)</th>
<th>GEOGRAPHY</th>
<th>STUDY LOCATION</th>
<th>SCALE</th>
<th>TYPE OF ASSET (TARGET)</th>
<th>SECTOR</th>
<th>TYPE OF URBAN CONFIGURATION</th>
<th>PERFORMANCE ANALYSIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grey roofs, road re-engineering</td>
<td>Implement 100% of green roofs in a city vs projection of a single key road junction from flooding</td>
<td>Pluvial flooding</td>
<td>Ecosystem based: green - blue</td>
<td>Northern Europe</td>
<td>Newcastle</td>
<td>City/ village</td>
<td>Vehicular street</td>
<td>Critical infrastructure</td>
<td>Open mid-rise</td>
<td>Effectiveness</td>
</tr>
<tr>
<td>Full permeability</td>
<td>Increasing city permeability from fully impervious to fully permeable</td>
<td>Structural flooding / Physical (Grey)</td>
<td>Northern Europe</td>
<td>London</td>
<td>City/ village</td>
<td>Parking, land cover</td>
<td>No specific sector</td>
<td>Other</td>
<td>Benefit</td>
<td></td>
</tr>
<tr>
<td>Demountable doors, manual</td>
<td>Manual activation with height protection of 0.6 m above the threshold of the property (current industrial standard)</td>
<td>Pluvial flooding</td>
<td>Technological</td>
<td>Northern Europe</td>
<td>England</td>
<td>Building block</td>
<td>Building construction</td>
<td>na</td>
<td>Benefit</td>
<td></td>
</tr>
<tr>
<td>Beach nourishment</td>
<td>Beach nourishment is sandy beach. The length of the examined area is 6.75m. It was assumed a replenishment of 154 m³/m and 3.3 replenishments until 2010. Beach nourishment involves the replenishment of the lost sediment (usually sand) due to the effects of longshore drift or erosion with additional quantity of sediment. The nourishment material should be similar with the indigenous sediment.</td>
<td>Beach flooding</td>
<td>Structural flooding / Physical (Grey)</td>
<td>Mediterranean region</td>
<td>Greece</td>
<td>City/ village</td>
<td>Construction</td>
<td>na</td>
<td>Benefit</td>
<td></td>
</tr>
</tbody>
</table>

3.4 PHASE IV: ASSESSING AND SELECTING ADAPTATION OPTIONS

Phase description and key objectives

When adaptation options have been identified, the next steps are to assess and prioritize the compilation of options based on a detailed description and criteria.

Based on the outcomes of the previous phase the aim here is to assess and prioritize the most efficient and appropriate measures to be implemented for climate change adaptation in the city. The selection of preferred adaptation options should be done in close interaction with all actors involved in the adaptation process.

Steps to follow

Figure 9: Phase IV: Assessing and selecting adaptation options

Step I Establishing the evaluation criteria

The aim of the step is to set the evaluation criteria in order to see how much the adaptation objectives are covered through the adaptation options (e.g. reduction in T° thanks to the adaptation measure, reduce in vulnerability, cost reduction, benefit increase ...)

Different performance criteria can be applied to assess adaptation options, which can be classified based on economic, environmental, social and institutional criteria.

Step II Methodology for cost assessment

Methods and tools applied in RAMSES case studies

The effectiveness methodology used in RAMSES (simulation through models) will be explained (in a short way) organizing the information in the following tables.

The effectiveness analysis identified in the literature are: empirical studies based on field measurements (Armson et al., 2012) and simulation through modelling software (Lu, 2014). Both approaches are applied by other authors (Lin et al., 2015; Tan et al., 2016). The applicability of empirical studies to the urban context is limited as it requires major resource inputs, particularly at district level, to consider the mentioned variables and processes. Simulation models offer an acceptable and economical solution to deal with the challenges of effectiveness measurement, and may be the proper tool use to compare among different solutions (Abajo, B. et al., 2015).
Adaptation measures effectiveness in heat health and urban comfort

**Table 9:**

<table>
<thead>
<tr>
<th>EFFECTIVENESS</th>
<th>HEAT – HEALTH AND URBAN COMFORT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characteristics of the study</td>
<td>For local measures: regarding the simulation, usually one specific day has been taken into account in each simulation. It could be the typical summer/winter day or the hottest summer/winter day etc. However, as it is recommended by Gerry (2015), the time of the simulation need to be set at least about 44 h given that the first 20 h are used to spin up the model and only the last 24 h can be taken in consideration. The first 20 h of the simulation serve to overcome the initial transient conditions in order to obtain reliable results unaffected by the thermal initialization of the model. For city scale measures: it is best to focus on a periods of consecutive days on which the temperature is high (heat-wave days), as health effects have been related to periods of multiple days with elevated temperatures. Especially the lack of cooling at night is important. (hence the focus on nightly temperatures). As there are large inter-annual differences (and especially since those increase in the future), it attains of good practice to perform simulations for long time frames (typically at least 20 y) in latest IPCC reports) to correctly assess the urban climate.</td>
</tr>
<tr>
<td>Main components to take into account</td>
<td>- Details of the case study city (location, climatic zone, urban configuration, location of green and blue in and around the city) - Meteorological situation and future climatic scenario: Time period (hot summer days for human discomfort, periods up to 20 years for nighttime temperature), Time frame (current-day, future climate), Climate warming scenario (RCP 8.5)</td>
</tr>
<tr>
<td>Scenario description</td>
<td>Comparison of situation with and without adaptation measure: adding an extra park or water body in the city, planting extra trees in a street</td>
</tr>
<tr>
<td>Expected outcomes or results</td>
<td>- Local scale: The study provides the difference in human exposure between the reference situation and the adapted case. There are many indices related to heat stress (PET, WBTG, Tmrt, UTCI). Each comes with their own advantages and disadvantages. For general understanding, it is best to convert these indices to a simple scale (ranging from “no heat stress” over “moderate heat stress” to “severe heat stress”), as policy makers often get lost with the many difficult (and subtle) definitions. - For the city scales we focus on thermal differences between the city and thermal differences between the city center and the rural surroundings. Again, the outcomes are differences between the reference situation and the adapted case.</td>
</tr>
<tr>
<td>Problems we can have</td>
<td>- Effects on different scales require different models, and different adaptation measures have an effect on different scales. - Each case study is different, it is thus hard to provide general statements regarding cost effectiveness of measures (planting a tree in a different street has a different effect). - Providing a detailed assessment is time and data consuming. We hence have to rely on many assumptions, which reduce the similarity between the case study and the actual adaptation plan. - Estimation of the effectiveness of the measures comes with large uncertainties, because of - The large uncertainties related to future climate (different scenarios, different models) - It is difficult to quantify the effectiveness in monetary values</td>
</tr>
<tr>
<td>Model recommendation</td>
<td>Combination of building energy models (e.g. Energy Plus) and meso-scale weather models / weather data</td>
</tr>
</tbody>
</table>

**Table 10:**

<table>
<thead>
<tr>
<th>EFFECTIVENESS</th>
<th>HEAT – WORK PRODUCTIVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characteristics of the study</td>
<td>Calculation of indoor productivity loss by combining climate change studies with building energy models.</td>
</tr>
<tr>
<td>Main components to take into account</td>
<td>All details regarding the office building (number of floors, height, surroundings, ventilation devices, internal load and much, much more)</td>
</tr>
<tr>
<td>Meteorological input</td>
<td>Meteorological input (current climate and climatic change)</td>
</tr>
<tr>
<td>Scenario description</td>
<td>Adaptations concerning the building design (solar blinds, increased natural ventilation… and behavioral change (relocation office workers in the building, adapted working hours)</td>
</tr>
<tr>
<td>Expected outcomes or results</td>
<td>Number of lost working hours inside office buildings: comparison between base case and scenario</td>
</tr>
<tr>
<td>Problems we can have</td>
<td>- Each case study is different, it is thus hard to provide general statements regarding cost effectiveness of measures (planting a tree in a different street has a different effect). - Providing a detailed assessment is time and data consuming. We hence have to rely on many assumptions, which reduce the similarity between the case study and the actual adaptation plan. - There are many regulations related to heat stress at the workplace. Most of them (for instance the international ISO-guidelines and the Belgian legislation) make use of the WBGT (wet bulb globe temperature). Hence it’s best to focus on this measure. Lost working hours can then be calculated using productivity loss functions - Estimation of the effectiveness of the measures comes with large uncertainties, because of - The large uncertainties related to future climate (different scenarios, different models) - It is difficult to quantify the effectiveness in monetary values</td>
</tr>
</tbody>
</table>

For very high resolution analyses for short time scale (for instance effects of trees on wind speed and temperature in street canyons / on squares): CFD models (Fluent, EnviMet, OpenFOAM). Provides very high resolution results. These models are very time-consuming, and errors are easily made (especially by open source programs). Alternatively, one could couple a 3D exposure model to a meso-scale climate model (for instance: UrbClim high res).
Adaptation measures effectiveness in flood traffic disruption

**PHASE IV**

**Assessing and selecting adaptation options**

**Step II**

**Methodology for effectiveness assessment**

<table>
<thead>
<tr>
<th>Adaptation measure</th>
<th>Flood</th>
<th>Traffic disruption</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Characteristics of the study</strong></td>
<td>It is important to first understand the baseline of the system which we’re studying. In the case of transport delay, this means travel time between origins and destinations in ‘normal’ conditions. This includes congestion effects, where road traffic is slowed by flows over capacity. Knowledge of the capacity of local roads is therefore needed.</td>
<td></td>
</tr>
<tr>
<td><strong>Main components to take into account</strong></td>
<td>Analysis of the effectiveness of adaptation is therefore dependent on local geography (i.e. topography, building locations, green space/sealed surfaces), local network conditions (i.e. importance of impacted roads, existing congestion, spare capacity), and location/scale of the adaptation. The adaptation is simulated over a single event, but a number of events under different conditions (different rainfall return periods) are simulated. This effectiveness is tested under rainfall of different severity. In Antwerp these are driven by rainfall scenarios produced by Leuven University (Ford, A. et al., 2015) and in London by stochastic simulations or uplifting factors.</td>
<td></td>
</tr>
<tr>
<td><strong>Scenario description</strong></td>
<td>Scenarios: the baseline is the current day configuration of the city in terms of green space, roof materials, transport networks, building locations etc. The 2011 census journey-to-work observations are tested for baseline traffic flow. The scenarios to be tested are still under discussion with stakeholders, as the adaptation testing deliverable is due in summer 2017. These will be selected based on the interests of Antwerp and London authorities.</td>
<td></td>
</tr>
<tr>
<td><strong>Expected outcomes or results</strong></td>
<td>The results will be reduction in delay to travel during the morning peak (e.g. when people are attempting to travel to work). This is because this time gives the maximum disruption to business and thus an upper-bound. These delays are calculated for various rainfall scenarios, both with and without adaptation.</td>
<td></td>
</tr>
<tr>
<td><strong>Problems we can have</strong></td>
<td>• The location of adaptation options is difficult to assess (this is part of what we are doing). • The simulations of traffic disruption are very data intensive and take a long time to run. • There are many possible rainfall scenarios, depending on return period and climate simulation used.</td>
<td></td>
</tr>
<tr>
<td><strong>Model recommendation</strong></td>
<td>An urban hydrodynamic model is needed to capture the high-resolution topography of urban areas, and the effect of features such as buildings and permeable surfaces on flood water. Transport models can be either macro-scale equilibrium models which will allow a general overview of disruption effects, or more detailed agent-based models allowing analysis of impacts to individual travellers at a more detailed level.</td>
<td></td>
</tr>
</tbody>
</table>

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**Example Box 13:** Effectiveness of adaptation to UHI in Bilbao

The study conducted in Bilbao (Spain), implies a comparative analytical review of green mitigation actions to improve outdoor thermal comfort in the hotspots areas of the city. The evaluation was performed in three typical urban street canyons characterized by urban density defined by the ratio between the surface covered by all buildings in the analyzed urban district (B) and its total surface (T), as well as the average values of the height of the buildings (H) and the width of the streets (W) per urban district have been calculated. According to the urban density (B/T) and the aspect ratio of the urban canyons (H/W), the city districts have been classified in three urban classes (Lobaccaro & Acero, 2015): compact low-rise: L 2 {B/T > 0.60 H/W < 1.5}; compact mid-rise: M 2 (0.40 < B/T ≤ 0.60 A 1.3 < H/W ≤ 1.5); and open-set high-rise: H 2 {B/T ≤ 0.40 H/W > 1.5}. Based on this classification, three urban districts which represented the hotspot areas of the City of Bilbao, have been selected: Casco Viejo (B/T = 0.8; H/W = 3.5) for the compact low-rise class; Abando/Industrias (B/T = 0.6; H/W = 1.5) for the compact mid-rise class; Txurdinaga/Miribilla (B/T = 0.4; H/W = 1.3) for the open-set high-rise class.

The analysed scenarios were run on 6th and 7th August in order to simulate typical summer day conditions in Bilbao. In the first part of the study a simulation was run using ENVI-met in order to analyze the level of PET for the initial scenario, different ground materials and greening scenarios using grass, tree-lined streets and green roofs as mitigation green elements; while in the second part of the study a generalization of the first part of the work was conducted. The effects of different orientation, aspect ratio H/W, ground surface materials and vegetation elements (maintaining the following constant ratios: H/H_{urban}, W/W_{urban}) on human thermal stress inside typical urban canyons have been studied.

The outcomes were used to provide urban design recommendations and guidelines for urban planners and decision makers to be implemented in the General Masterplan of the City of Bilbao as mitigation actions to reduce the impact of heat wave.

For each of the three urban canyon types selected, there were seven scenarios: the scenario of the current initial situation (S0 – Initial), the scenario in which the ordinary traffic road was converted to a pedestrian promenade (S1 – Pedestrian) and five scenarios using green actions (S2 – Grass, S3 – Grass + Trees, S4 – Green roofs, S5 – Grass + Green roofs, S6 – Grass + Trees, S7 – Grass + Trees + Green roofs) (Figure 9). Regarding the ground surface material, in scenario S0, a set of simulations considering the actual ground surface of the street in asphalt has been conducted, while from scenario S1 to S6, a ground material of decorative red brick stone has been set in all urban areas.

Definition of the geometry of the urban canyons (on top) and their visualization in Google Street View (in the middle); (on the bottom) The seven scenarios and the green actions analyzed in this work.
“We can look at hard engineering, like building walls or better drainage system on the road network. But there are also soft measures. Think about where people travel to and from. Is one particular transport link in your city really important and why is it important. Because everybody has to go through it to get from home to work or to school. Is there a way to maybe move the school, the work, the homes, so that that link is no longer quite as important as it was before?”

Alistair Ford, Newcastle University

### Step III Methodology for cost assessment

The main indicators of economic criteria are economic efficiency and feasibility. Efficiency in economic terms refers to whether the benefits of making the change exceed the costs of implementing the adaptation measure. Feasibility expresses whether an adaptation option would be feasible given the economic circumstance of a stakeholder or stakeholders.

Both environmental and economic criteria are outcome evaluation approaches, the objective of which is to measure effectiveness in relation to the avoidance of climate change impacts. They can also be used to measure adaptation progress because their metrics can be monitored over time (Ford and Bierrang-Ford, 2013).

#### Methods and tools applied in RAMSES case studies

**EFFICIENCY ANALYSIS**

The cost-assessment is the second performance criteria considered into the RAMSES project for the adaptation measures appraisal. The efficiency methodology use will be explained in a short way organizing the information in the following tables.

### Table 12: Adaptation measures cost-assessment in heat-health impact chain

<table>
<thead>
<tr>
<th>COST-ASSESSMENT</th>
<th>HEAT-HEALTH ADAPTATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost analysis: elements considered</td>
<td>List of variables to be considered: Adaptation actions, Service / Resource use actions, Responsible implementing agent, % of final cost incurred by Actual resource use and unit cost, Allocation of cost to activity, Period undertaken and costs incurred</td>
</tr>
<tr>
<td>Benefit: elements considered</td>
<td>Benefits of health adaptation in this tool stem from averted health damage. The elements considered are: morbidity attributable to climate change, premature mortality attributable to climate change, outpatient consultations, outpatient visit rates, inpatient admissions, length of inpatient stay, full unit cost of outpatient care, full unit cost of inpatient care, value of productive time loss, days off productive activities, value of life</td>
</tr>
</tbody>
</table>

#### Scenario comparison

Different scenarios stem from sensitivity analyses regarding incidence of the health outcomes considered, as well as vulnerable groups. In turn, these depend on climate change forecasts affecting exposures in the health impact assessment.

#### Method

- **Cost assessment**
- **Problems we can have**
  - Insufficient disaggregation of health indicators at baseline
  - Insufficient information on resource unit costs for health adaptation interventions by actor
- **Other existing approaches**
  - While other existing approaches (e.g. macroeconomic) exist for accounting for health adaptation, their usefulness for actual local health adaptation is very limited
### Table 13: Adaptation measures cost-assessment in heat work productivity impact chain

#### Cost-assessment: Heat / Work Productivity

| Cost analysis: elements considered | Direct cost: investment expenditure (adaptation equipment expenditure, installation expenditure). Operational costs (e.g. Energy costs of air conditioning units) |
| Benefit: elements considered       | Monetary (numerical: float): measured in averted losses to GVA (gross value added), which is a measure of city production. |
| Scenarios                          | The baseline year (2005) and a warm and cold year in the near (2026-2045) and far future (2081-2100); only RCP8.5 |
| Method                            | Cost assessment. Cost-benefit relation: cost-benefit analysis, adaptation cost curves |
| Problems we can have              | Related to the lack of data |
| Other existing approaches         | Benefit transfer, cost-effectiveness, multi-criteria, Life-Cycle Cost Analysis (LCCA) |

### Table 14: Adaptation measures cost-assessment in flood hazards

#### Cost-assessment: Flood

| Cost analysis: elements considered | Direct costs: monetary flood damage |
| Benefit: elements considered       | Avoided damage due to flood protection. |
| Scenario                          | Dikes measures of different protection levels. |
| Method                            | RAMSES uses CBA because it is probably the most basic way to quantitatively evaluate protection levels. |
| Problems we can have              | Planning horizon needs to be defined, e.g. for how many years should the dike be operational. This is relevant when comparing investment/maintenance and avoided loss. |
| Other existing approaches         | • Diva model: HinkelJ_PNAS_2014 (dike segments, not explicit for cities, adaptation is dimensioned from some kind of Production Function)  
• FankhauserS_EnvPlanA_1995: economics of protection vs. retreat.  
• A more general "macroeconomic" approach could be used for the costs of adaptation. |

### Example Box 14: Losses in London, Antwerp and Bilbao

RAMSES has developed a cost methodology that integrates urban climate modelling with labour productivity and economic production. The methodology has been validated in three case study cities: Antwerp, Bilbao and London.

The methodology has been designed to be tailored by policy makers and transferable from one city to another. The methodology examines the impact of urban heat waves on productivity loss and how the reduction in productivity leads to production losses across sectors of the city economy. Our approach allows us to assess various characteristics of urban production, including the flexibility of the productive system in terms of the degree of substitution between labour and capital, its labour intensity, and the relative importance of different sectors in the economy.

**Note:** Warm year in the far future (2081-2100). Values in million €. Gross averted losses not including implementation costs.

The figure presents the averted losses (i.e., benefits) of using alternative adaptation measures. It accounts only from averted losses due to productivity losses because of heat stress. It is estimated for a warm year in the period 2081-2100. The four adaptation measures compared are: behaviour adaptation, in the form of changing working hours; installation of solar blinds (exterior solar blinds); installation of air conditioning; increasing mechanical ventilation.

Under the assumptions used, air conditioning, increased ventilation and solar blinds all resulted in substantial reductions in productivity losses from heat stress. For London, solar blinds seem to have almost the same effect of air conditioning without many obvious drawbacks. For both Antwerp and Bilbao, solar blinds provide similar benefits to those of increased ventilation, without requiring energy. Furthermore, behavioural change presents itself in London as a viable alternative to the other measures, as it is able to protect both indoor and outdoor workers. However, its costs are more difficult to measure than those of other adaptation measures.

Worksheet 6 of the RAMSES Training Package provides guidance on how to identify and assess resilience indicators with particular reference to architecture and infrastructure. [Follow this link to know more.](#)
Step IV Prioritisation of the options

This last step aims to select the most efficient and adequate measures to face the challenges and cope with the adaptation in the city.

To do so, firstly, selecting the most suitable method to perform the prioritization is key.

→ The most commonly used method in the context of strictly economic assessment are: Cost-Benefit Analysis (CBA) and Cost-Effectiveness Analysis (CEA). When the decision rules exceed the economic dimension, the most utilized tool is the Multi-Criteria Analysis (MCA), which has the capacity to incorporate several dimensions in the decision-making.

→ Other methods for prioritizing the adaptation measures are focused on the management of uncertainty. The most popular of these are Robust Decision Making (RDM) and Adaptive Management (AM).

Methods and tools applied in RAMSES case studies

Cities are particularly vulnerable to heat stress. Despite this, no comprehensive methodology has been developed to assess the costs of heat stress on city economies. In this context, RAMSES provided a method for cities to measure costs and compare benefits of adaptation measures depending on the specific characteristics of each city.

The cost-benefit assessment (CBA) has been used in the coastal flood-built environment impact chain. The reason for using this approach in RAMSES is that CBA is the simplest quantitative approach. Also for explaining to stakeholders. Nevertheless, non-monetary (intangible) aspects should not be neglected.

In the heat-work productivity impact chain, different cost-assessment approaches have been used: ranking of costs of heat through worker productivity, adaptation cost curves and cost benefit analysis.

In the heat-health impact chain, there is no actual need for prioritization regarding heat-health adaptation, since there are no practical alternatives to heat-health action plans for adaptation.

Therefore, the prioritization methods used in RAMSES (if used) are based on the economic assessment (cost-benefit and the cost assessment). Nevertheless, for the planning (pathway design) other criteria will be used for prioritize adaptation alternatives (e.g. effectiveness).

Example Box 15:

Adaptation cost curves

Adaptation cost curves can be useful for decision makers to evaluate the relative efficiency of different adaptation policies. They plot the total benefit (averted loss) from different adaptation measures against their cost/benefit ratio. They allow for a visual comparison of different adaptation measures.

We perform the analysis accounting only for climate change losses created by productivity losses due to heat stress. The estimated benefit of adaptation (averted loss) assumes installed air conditioning and solar blinds lasting for ten years; in each year the averted loss (benefit) is assumed to be the same. The cost of adaptation includes only installation costs. We produce one graph for each case study city, Antwerp, Bilbao, and London, assuming losses are the same as those estimated for a warm year in the period 2081-2100.

The graphs show one column for each adaptation measure. The width of the column measures the benefit of the measure in million €. The height of each column measures the cost per euro of benefit of each measure (that is, the cost-benefit ratio). The columns are organized by most to least costly per euro of benefit.

The curves show that the total benefit of air conditioning tends to be higher, but that the cost per unit of benefit of solar blinds is always lower than that of air conditioning. This is particularly striking given that we do not account for any maintenance costs or energy costs, which can be substantial for the case of air conditioning. Thus, even though the total benefit from air conditioning is higher, its relative efficiency tends to be lower.
3.5 PHASE V: IMPLEMENTING

Phase description and key objectives

It is important to conceive adaptation as a systemic perspective and therefore it does not conclude with a set of actions or measures. It is necessary to consistently integrate them as part of the national/regional adaptation strategy plans taking into account the existing policies and instruments. Therefore, this phase has the objective to define and implement a robust action plan integrated within other municipal policies.

Steps to follow

Figure 10: Phase V: Planning and implementing

Step 1 Pathway design

During this first step, it is necessary to define the strategic objectives and the approach to be followed, that is, definition of the nature and scope of the Adaptation Plan, whether it has to be developed autonomously, or can incorporate a large number of municipal policies, or be developed within the framework of another policy such as urban planning. The goal of this step is the definition of specific/recommended adaptation pathways.

The following activities will be needed:

- Seek agreements with stakeholders
- Sequence in time the previous adaptation options
- Definition of adaptation paths
- Identifying key instruments for adaptation
- Mainstreaming adaptation in existing instruments
- Develop new instruments if required

Definition of a flexible plan.

One important aspect for adaptation planning is the flexibility. It means that the adaptation planning needs to consider measures to be implemented in near-term, while leaving the option open to scale up action in the future. There exist different tools for this which cope in a different way with the uncertainty and has different nature: the Dynamic Adaptive Policy Pathways approaches produce dynamic robust plans (covering anticipatory, concurrent and reactive adaptation), while Robust Decision Making produces a static robust plan (focusing on anticipatory adaptation) (Walker et al., 2013). What the urban system needs under the climate change uncertainty is to develop a dynamic robust plan. In this context the Adaptation Pathway approach emerges.

Adaptation pathway is a policy-first approach to decision-making that targets analysis at the adaptation challenge (Kingsborough et al., 2016). The pathway is considered to be a chain of actions, where a new action is activated once its predecessor is no longer able to meet the definition of success.

The adaptation pathway can be designed in 2 levels: in a high level in which the stakeholders use the available information and their knowledge to design the high level pathway, and the detailed pathway which contains more detailed analysis and involves more experts and goes deeper into the pathway design.

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Methods and tools applied in RAMSES case studies

The Adaptation Pathway approach has been selected in RAMSES for the planning phase, as it is a suitable approach to developing a flexible adaptation plan under uncertainty.

The adaptation pathway approach takes the information elaborated in the previous phases and develops possible pathways. The main methodological steps that need to be covered for this pathway design are:

- The authorship and the owner of the pathway need to be identified as a first step. Different stakeholders and experts need to be involved. A high level approach can be done as a first step with a small group, which will help identify other stakeholders and experts that need to be involved in the future.
- This approach is based on a cyclical process and takes the information developed in the previous phases: the adaptation measures and the assessment of them together with the timing are considered to assemble pathways of responses that will tackle the previously defined thresholds.
- Resulting of the grouping and sequencing of the measures over the time several adaptation pathways are developed. The performance of each adaptation pathway can be assessed (how much are reducing the risk the different pathways, how much they cost etc.).
- Prioritisation/ranking of the pathway alternatives. It is possible to do a multi-criteria analysis (MCA) for prioritising the options depending other criteria like: acceptability of the measure (acceptability among stakeholders and wider society), barriers and requirements for implementation, maintenance, co-benefits (if an option has benefits in a single-hazard or more hazards, multi-hazard), combinability or synergies with other options (Flörke, 2013; Weiland, S. and Tröltzsch, J., 2015). As a concluding step, a recommended adaptation pathway will be developed which provides a pathway or roadmap for implementation.

Two main activities were undertaken in RAMSES in order to validate the adaptation pathway approach. One was a massive open Stakeholder Dialogue (workshop held on 27th November 2016 in London). The adaptation pathway was analysed during these events in order to validate the methodological approach. Three real adaptation pathways were analysed: the Heat-related Adaptation Pathway, the Water Supply Adaptation Pathway and the Tidal Flood Risk Pathway, all in the context of London.

The following Adaptation Pathway cycle was elaborated following the validation exercises:

- Although the pathway design is presented as step-by-step methodology, after starting with own objectives and understanding vulnerability, the other steps can be iterative and go in any order.

Example Box 16:
Adaptation pathways London. Validation process

Heat risk will become increasingly important in London and its management will require the application of new and innovative approaches. Adaptation pathways can be a good approach for this. To further develop adaptation pathways in response to heat-risk in London, there is a need to identify adaptation portfolios that are proportionate to the projected future levels of risk. Adaptation pathways have demonstrated potential to contribute to developing a long-term plan for heat-risk in London.

The figures show the pathway “Greening & Building” (50% increase area of green roofs, 50% design measures to reduce overheating & 25% increase area of green space). The projections show a reduction in the risk in the future thanks to the adaptation options (Readar, 2016). The results from the validation process suggest that there is a need to further discuss the threshold levels. How the acceptable threshold or risk threshold is defined requires a standardized methodology. Further, the parameter and the metrics in which the thresholds are defined and presented need to be harmonized.
Methods and tools applied in RAMSES case studies

GOVERNANCE

Considering a social dimension is critical for successful adaptation

Infrastructure changes and technical solutions are a large part of the response to present and future climate risks, but understanding human dimensions related to vulnerability is essential for a more resilient society. Adaptation should be primarily people-centered, meaning that the well-being of the urban population and the rights of vulnerable people are respected as critical elements of success.

A society cannot be perceived as a passive receiver of adaptation strategies. Instead, it has to be an active player in this process and an accelerator of sustainable practices through a participatory approach in decision-making, which can enhance innovative co-creating thinking. A greater inclusiveness in decision-making can help to enrich and add value to governance systems in contrast to the current dominant approaches that emphasize management control (Pelling, 2011).

Adaptation is always a political matter

Climate change adaptation is a question of governance and behavior. Eriksen et al., (2015) claims that what is “adaptive” is always political and contested, and the insistence of the authors on “power not only as a means of repression or domination but also, simultaneously, as a source of innovation and transformation”.

Adaptation can be a window for opportunities

Adaptation is not always a burden. Starting an adaptation plan can also be an opportunity for cities to rethink their growth strategies and urban planning and to address present and future challenges holistically. Without considering climate change, investment plans in infrastructures and human capital risk to lose effectiveness and credibility. At the same time, new opportunities are opening up for investors, businesses, and local authorities to cope with climate change risks.

This section is based on the RAMSES deliverables 7.1 (Van De Puy et al. 2014), 7.2 (Nâzâ Aliouate Domingues et al. 2015), 7.3 (Nâzâ Aliouate Domingues et al. 2016).
example for which participation of several sectors are required for effective health adaptation (e.g. water supply and wastewater service providers; industry and energy suppliers; transportation; urban planning and land-use; housing and infrastructure; meteorological services; emergency services; and social welfare services).

**Adaptation is not a separate field**

The central thesis that we defend in RAMSES is that viewing adaptation as a separate field is missing important links (between different but related fields) and disregards significant potential for the contribution of civil society to complex issues like climate change policy and action. Rather than attempting to create civic capacity from scratch, specifically for adaptation, it seems more relevant to rely on existing civil society mobilization potential, albeit by widening its scope.

Overall, the existence of adaptation plans is only one indicator of the willingness of some cities to act against climate change. Its absence, however, does not indicate that other actions could not be working in favor of adaptation needs. Adaptation activities cover a wide range of policies that are not necessarily labelled as adaptation policies. Mitigation policies and other development plans could assist with the reduction of GHG emissions and, consequently, help with adaptation.

Then, there are cross-cutting actions likely to have protective effects across the board, for several or all climate-sensitive outcomes.

**IDENTIFICATION OF DRIVERS RELATED TO THE INSTITUTIONAL CONTEXT**

There are some drivers more closely linked to soft measures, which can act as successful enablers of an effective adaptation plan, with particular focus on: community-based adaptation processes, restoration of ecosystems, community gardens, etc.; citizen empowerment; bridging organizations; co-beneficial adaptation measures; and social learning.

**Participatory processes and community-based adaptation**

Participatory engagement is important for several reasons, notably the creation of ownership among participants, which can improve the likelihood of effective implementation of policies since the communities will better understand how certain decisions are impacting their lives. Beyond improving awareness regarding climate change, participatory engagement also has a positive effect on equity and helps to resolve social conflicts. Moreover, it reinforces local capacities, knowledge and trust, the latter of which, tends, in the long run, to help citizens to tackle vulnerabilities individually or collectively (UNEP, 2013). It is fundamental to acknowledge that participatory processes can be a tool to prepare communities to make informed decisions about adaptation in a scenario of constant change (Keys et al., 2016).

In our two case study cities, New York and Paris, officials insisted on their efforts to obtain as much input form stakeholders and the public, participation may be instrumental beyond the decision-making phase, contributing to policy implementation (maybe even assessment), which cannot be reduced to a simple technical process.

Sarzynski (2015) indicates that there are multiple ways in which the public participates in the governance of urban climate adaptation: he lists on the benefits of co-production: "With urban climate adaptation co-production indicates that governments and community participants are involved intensively in the implementation of adaptation response, not just in planning, and that all actors contribute substantive resources to the effort." Community-based adaptation approaches (CBA) were identified as an example of co-production. The nature of such approaches recognizes the capability to pursue change that directly serves the needs of individuals thereby delivering community-wide benefits.

In essence, what could be highlighted is the importance of the "empowerment" component in participatory approaches, which should be understood as gaining power over decisions, choices, and about goals that are valued (Biekas, 2009).

**Phenomena at urban scale.**

Most of the existing energy and planning models and tools neglect the importance of complex phenomena at urban scale. Generating science that will effectively include qualitative and quantitative data requires the information to be timely and relevant for both municipal decision makers and users. Models should be useful support decision-making by providing comprehensive visualization of real-time computing data and the predicted consequences of near future scenarios.

**Typical barriers for adaptation**

Typical barriers for adaptation at the local level: 1) Lack of awareness; 2) Lack of data and of specialized knowledge, and of platforms to exchange experiences; 3) Lack of human and financial resources; and 4) Lack of a multi-level adaptation framework. An additional challenge for health adaptation in particular can be seen in the fact that literature with regard to health adaptation is still relatively scarce (Hess et al., 2012).

In our experience, guidance and resources made available by national and regional-level administrations are an important enabler for local health adaptation. This observation has not yet been elaborated and is needed for future scenarios.

**MAINSTREAMING: STRATEGIES FOR INTEGRATING THE ADAPTATION OPTIONS INTO OTHER PLANS**

There is no a single strategy, but rather a wide range of different approaches, methods and tools available for mainstreaming adaptation. If adaptation plans and implementation strategies are, in the end, unique, their effectiveness tends to depend on principles, such as participatory and inclusive measures, the recognition both of local and scientific knowledge, accountability, and stakeholder engagement. The Heat Health Plans are one
Bridging organizations

The concept of bridging organizations has been proposed in the field of adaptation (Berkes, 2009). Rather than simple knowledge brokers, according to Berkes, these “… provide an arena for knowledge coproduction, trust building, sense making, learning, vertical and horizontal collaboration, and conflict resolution”. In the urban setting, they can be viewed as enhancing connectivity and thus, resilience.

Co-beneficial adaptation measures

It is often considered in the adaptation literature, that win-win or no-regret solutions are privileged, due to the high costs of measures and uncertainties in future predictions (examples can be seen in the UK Climate impacts program).

The case study of New York shows that adaptation measures that target ecosystem services seem to follow that line of reasoning. Costs of measures are then counterbalanced by everyday benefits, ecological, recreational, and potentially increasing resilience.

SOCIAL ACCEPTANCE

Social acceptance is critical for any adaptation strategy. The failure of policies and practices lacking societal acceptance is acknowledged (Shindler, B., 2004).

The combined mobilization of local actors and researchers can generate individual and collective learning processes on current situations and the sharing of existing knowledge i.e., scientific, local or traditional knowledge. Social learning is believed to be an initial and essential step in order to negotiate and initiate changes, a necessary condition for a socio-ecological system to have the ability to adapt (Folke, 2006). This process leads to an exchange of information and knowledge on which solutions can be developed instead of only using a top-down approach where a researcher or an expert dictates what should be done. Participatory processes promote the emergence of partnerships and stimulates dialogue (Brydon-Miller et al., 2011). Solutions can be co-constructed and co-produced by an alliance between researchers and actors as adaptation actions can only be sustainable if they are socially and ecologically sound. Through social learning, local actors can better understand the issues, take greater ownership, and so better accept political decisions.

“Talking about adaptation is not about defining a completely new policy, it is making use of that what we are already manage – integrating a new perspective which is an additional uncertainty related to what will happen with the climate evolution.”

Efrén Feliu, Tecnalia

3.6 PHASE VI: MONITORING AND EVALUATION

Phase description and key objectives

Monitoring, Reporting and Evaluation (MRE) is a key aspect of an iterative adaptation process. This phase can help us to understand progress and performance, learn and communicate lessons and inform future policy and practices. It therefore plays a critical role enabling adaptation to evolve and improve over time.

Steps to follow

Figure 11: Phase VI: Monitoring and evaluation

Step I Establishing the basis for the monitoring and evaluation system

Measuring successful adaptation planning remains a challenge and much of adaptation actions are so far reactive, deriving from the need to compensate damage caused by natural disasters. It might be difficult to assess an adaptation measure before an extreme event will take place. For instance, if a city intends to adapt to projected intense rainfall events through green space for flood retention, storage and infiltration or new drainage infrastructure, effectiveness could only be fully evaluated when such an event happens.

› Definition of the objective of the evaluation
› Definition of the object of the evaluation
› Definition of the conceptual model of evaluation
› Definition of the type of evaluation

Step II Implementing Political framework

Phase V: Implementation

Stakeholders Engagement & Knowledge Management

• Definition of the type of evaluation: quantitative, qualitative, or combined?
Methods and tools applied in RAMSES case studies

Measuring successful adaptation planning. RAMSES proposes to use the effectiveness indicators as part of monitoring. Nevertheless, the effectiveness indicators will differ from case to case as they depend, among other factors, on nature and on specified objectives of an adaptation option. Effectiveness refers to the capacity of an adaptation action to achieve its previously determined objectives, usually in terms of reducing risk and avoiding danger related to climate change (Adger et al., 2005). For instance, the number of houses retrieved from a certain area could measure this, since they would have an impact on the level of risks in vulnerable areas.

Two basic types of indicators could be employed to measure and evaluate successful adaptation actions. One is a process indicator, which measures progress in a process leading to a desired outcome (for example, the number of people trained in a disaster risk reduction policy) and the other is an outcome indicator, which defines a specific gain (i.e., change in post-flood disaster). Since the adequate analysis of the latter requires a longer time due to its complexity as well as the long term horizon of climate change, both sets of indicators should be developed (UNDP, 2010).

Overall, measuring adaptation engenders several steps and its level of success could be related to six “guiding principles” (DEFRA, 2010):

- Sustainable: ensure that sustainable development is being promoted as way to minimize the threats posed by climate change;
- Proportionate and Integrated: climate change assessment must become “business-as-usual” and taken at the most appropriate level and timescale;
- Collaborative and open: ensure that adaptation is involving a wide range of stakeholders and promoting a cross-sectoral vision;
- Effective: Actions should be context-oriented, implementable and enforceable, but should also ensure flexibility to adjust to changing scenarios;
- Efficient: Actions should take cost-benefit analysis into account;
- Equitable: Actions should ensure that proportionate share of costs and benefits are distributed, paying particular attention to vulnerable groups.

Heat–health action plans are extremely difficult to evaluate for several reasons:

1. They vary widely in structure and interventions;
2. They tend to change from year to year in response to events and changing priorities;
3. The impacts of heat-waves vary widely;
4. The non-specific nature of heat-related deaths, which makes attribution complex.

For these reasons, there is little published information on formal (quantitative or qualitative) assessments of the effectiveness of systems as a whole or on individual intervention measures (WHO 2013).

That being said, monitoring and evaluation of HHAPs is crucial, both in terms of process and in terms of outcomes. While we cannot provide a formal M&E framework, there are a couple of examples we can draw from (i.e. England, Catalonia).

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**Step II Designing the monitoring and evaluation system**

This step has two goals: firstly, identifying appropriate indicators to assess the level of implementation, the extent to which objectives are achieved and the degree to which evidence has evolved, and secondly, to design the monitoring and evaluation tools needed to assess compliance with adaptation policies.

To do so the following activities are needed:

- Take advantage of existing indexes and monitoring schemes
- Definition of indicators
- Definition of baseline measurement
- Definition of periodicity of monitoring and evaluation
- Definition of alerts and threshold mechanisms if necessary

**Worksheet 6 of the RAMSES Training Package**

Provides guidance on how to identify and assess resilience indicators with particular reference to architecture and infrastructure (follow this link to know more).

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**Step III Communicating results to inform policy and practice**

The results generated during this last phase of monitoring and evaluation can play a key role in informing the continuous improvement adaptation policy and practice.

For this to happen successfully, findings need to be communicated effectively to a range of decision-makers, at the right time and in an appropriate manner.

The possibility to quantify the achievements of adaptation through indicators is attractive to policymakers and decision makers as they provide an “unequivocal” measure of progress and performance. The visualization/communication of the resulting indicators is crucial. Therefore, the indicators must be presented in a understandable way for policy makers and citizens.

During this dialogue with policy makers, new types of indicators could be defined and therefore need to be added to the process.

The adaptation pathway approach is a cyclical process. The monitoring system is composed by different indicators that come from the previous steps (e.g. threshold definition, risk and vulnerability assessment). These monitoring and communicating steps are therefore linked to the previous steps of the cyclical process and allow for changes, making this a flexible approach.

**Worksheet 7 of the RAMSES Training package**

Provides guidance on how to develop a communication strategy to share accomplishments and results with different stakeholder groups (follow this link to know more).
Introducing the Training Package

The Training Package complements the slideset on the main results of the RAMSES project to make up the completed "Toolbox and Training for Policy-making". While the Handbook summarises and presents the RAMSES findings to municipal staff and policy-makers and explains how to approach the adaptation process, the training package proposes concrete activities to operationalise the RAMSES findings into a support mechanism for local decision-making.

Consistently with the Handbook, the Training Package frames the proposed activities in the Urban Adaptation Support Tool (UAST), the official methodology followed by the Covenant of Mayors for Climate and Energy Initiative, which provides step-by-step guidance through the adaptation planning and implementation cycles.

The Training Package is composed of 9 worksheets. For clarity and consistency, each worksheet applies to a corresponding step of the UAST methodology, so that the role of each topic and activity as part of a broader climate adaptation planning process is clear. Nevertheless, the aim of this Training Package is not to present a comprehensive set of activities for each of the steps of the UAST methodology, but rather to empower cities to implement practical activities that are closely connected to the research developed by the RAMSES Project, and that might fall under one or the other steps of the methodology. Each worksheet briefly presents a topic linked to the RAMSES Project findings, which is a crucial milestone for local adaptation planning, lays out key messages that should guide cities in their climate action and presents tools and guidance on how to use such knowledge to progress on climate adaptation and resilience.

Given the plethora of tools that have already been produced as part of numerous projects and initiatives, the training package is not intended to create new materials but rather to take stock of existing state-of-the-art tools, and tailor them to fit its scope and aim. Specifically, ICLEI - Local Governments for Sustainability has built on its extensive experience in developing support tools for local governments in becoming more resilient and sustainable and has tailored materials produced in the framework of various projects and initiatives to the scope of this training package. Table 15 presents some of the tools that were used and readapted to compile the exercises in the different worksheets. These tools can be always consulted as a reference and to gather additional information on climate adaptation and sustainability planning processes.

Furthermore, additional publicly available tools and resources will be added as references for further readings so that users will be able to access additional materials that can support their decision-making at a glance.

Table 15: List of tools most used to develop the training package worksheets

<table>
<thead>
<tr>
<th>TOOL</th>
<th>REFERENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICLEI Canada – Changing Climate, Changing Communities – Guide and Workbook for Municipal Climate Adaptation</td>
<td><a href="http://icleicanada.org/resources/item/2-adaptation-tool">http://icleicanada.org/resources/item/2-adaptation-tool</a></td>
</tr>
<tr>
<td>CHAMP Project – Integrated Management for Local Climate Change Response – Capacity Development Package</td>
<td><a href="http://www.localmanagement.eu">www.localmanagement.eu</a></td>
</tr>
</tbody>
</table>
### 4.1 THE RAMSES SLIDESTECK

In order to provide local municipal staff with a complete collection of resources to make the wide-reaching results of the RAMSES Project accessible and usable, a slideset summarising the most policy relevant project findings has been developed. This is meant to support cities (including municipal staff, policy makers and other stakeholders) to explain the importance of climate adaptation to different stakeholders. The slideset is available in PPT format so that it can be downloaded and tailored to practitioners’ needs. For example, the slideset could be used during a workshop to introduce a topic on which a city would like to work practically using the training package, or just to raise awareness on crucial aspects linked to urban climate adaptation. For a high usability, slides are accompanied by long notes further detailing and explaining their content and referencing it to the corresponding project deliverables so that these can be easily consulted in case additional information is needed.

The slideset can be consulted and downloaded from the RAMSES website at [www.ramses-cities.eu/results](http://www.ramses-cities.eu/results).

### 4.2 HOW TO USE THE TRAINING PACKAGE

Each worksheet of the training package follows a clear structure, which is laid out below. The training package is intended to support local municipal staff in developing adaptation action and in involving a set of different stakeholders in adaptation building activities. Specific relevance is given to findings that arise from the RAMSES Project research but crucial overarching aspects for municipal staff to progress on their adaptation journey. The identification of stakeholders can be structured according to different engagement routines should be identified for different target groups, depending on the stakeholders’ roles and responsibilities.

- Stakeholder burnout should be avoided. To this end, ways should be identified in which stakeholders can be kept involved without taking too much of their time. This should be done through specific agreements with different stakeholders. Communication after meetings should always followed up on to create a sense of purpose and keep engagement high.


## 4.3 WORKSHEETS

### 4.3.1 Worksheet no. 1: Stakeholder mapping and engagement

**INTRODUCTION**

Climate adaptation is a cross-cutting issue. Therefore, in order to correctly identify climate risks and adaptation options and ultimately to develop an adaptation strategy, different competencies need to be brought together – environmental science should be combined with social sciences, financial know-how and urban planning. For this reason, different actors and stakeholders, including, for example, the private and insurance sector, community groups and academia, should be consulted and actively involved in the adaptation building process.

Stakeholders coming from different sectors might need different involvement strategies. Correctly identifying which stakeholders should be involved in the adaptation process is crucial and essential to a successful engagement.

Therefore, throughout the local climate adaptation building process, stakeholders should be first mapped and categorised, and finally engaged.

The identification of stakeholders can be structured according to different criteria. Those stakeholders should be identified who are most affected by or can most affect adaptation decision-making. As well, factors like their influence on the adaptation process, the knowledge they hold that is necessary to progress on adaptation and at which scale they operate (local, regional national, etc.) should be mapped. This worksheet presents an approach to map stakeholders and to engage them in the adaptation process.

**KEY MESSAGES**

- At different stages in the adaptation process, the involvement of different stakeholders may be needed and their role might change over time.
- Therefore, stakeholder identification should be carried out at different points in time, at different stages of the adaptation planning process and with different focus.
- While the initial stakeholder identification should be quite broad, the more progress is made and priorities identified, the more the analysis should be repeated in relation to different service areas.
- The stakeholders engaged should be kept active throughout the process. They should participate in regular meetings and/or be assigned specific functions, and should receive regular updates on the progress of the work. In order to effectively engage the large number of stakeholders needed to develop an adaptation strategy, different engagement routines should be identified for different target groups, depending on the stakeholders’ roles and responsibilities.

**NOTES**

- A service area refers to the areas in which a government or community delivers, manages, plans, or makes policy. Source, ICLEI Canada

**3 RESIN DEL 1: www.ramses-cities.eu/resources/sector-analysis
4 RESIN DEL 1: www.ramses-cities.eu/resources/sector-analysis
5 Adapted from ICLEI Canada – Changing Climate, Changing Communities – Guide and Workshop for Municipal Climate Adaptation**
Table 16: Examples of stakeholder groups (adapted from ICLEI Canada)

<table>
<thead>
<tr>
<th>Stakeholder Category</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community groups, local neighbourhood associations</td>
<td>Hospitals, Universities, Local businesses and the private sector</td>
</tr>
<tr>
<td>Media</td>
<td>Other municipal departments, staff and department heads (urban planning,</td>
</tr>
<tr>
<td></td>
<td>social affairs, public health, emergency response, etc.)</td>
</tr>
<tr>
<td>Mayor and Council</td>
<td>Other levels of government (national, regional)</td>
</tr>
<tr>
<td>Utilities</td>
<td>Different transport authorities (local transport, airports, etc.)</td>
</tr>
<tr>
<td>Local universities and other knowledge providers</td>
<td></td>
</tr>
<tr>
<td>Hospitals</td>
<td></td>
</tr>
</tbody>
</table>

**Instructions**

- Using the influence matrix (Figure 13), identify which stakeholders should be part of the adaptation core team, and which should not be part of the team but can have a direct influence on the adaptation building process (e.g., because they manage a key asset or because they can provide financing or data).
- Then pass onto analyzing who can have an "indirect" influence on your adaptation work (e.g., stakeholders that can have a potential interest in starting cooperation with the municipality on building adaptation, stakeholders that can help the municipality reach the wider public, etc.).
- Finally, fill the outer circle with stakeholder groups from the wider community. These are stakeholders that need to be kept informed on the process but not directly involved (because they have little or no influence on it), at least at your current stage of knowledge.

**INFLUENCE**

- **WIDER COMMUNITY**
  - Indirect
  - Direct
  - Core team

**Table 17: Stakeholder table**

<table>
<thead>
<tr>
<th>Sector I.E.E.</th>
<th>Public Administration, Private Sector, Academia, etc.</th>
<th>Organization</th>
<th>Title</th>
<th>Name - Surname</th>
<th>Existing Relationship with the Municipality</th>
<th>Email</th>
<th>Phone</th>
<th>Information Needed from Stakeholder</th>
<th>Influence (Team Member, Direct, Indirect, Wider Community)</th>
<th>What Would Incentivise the Stakeholder to Participate?</th>
</tr>
</thead>
</table>

**Figure 13: Influence matrix. Adapted from ICLEI Canada**

- **INDIRECT**
  - Core team
  - Influence

- **DIRECT**
  - Influence

- **WIDER COMMUNITY**
  - Influence

**4.3.2 Worksheet no. 2: Urban climate projections and climate impact detection**

**Introduction**

Currently, climate projections are mostly available at the global, national or regional scale, but not at the local one. In order to better understand the local impacts of climatic changes, the RAMSES project has carried out climate change simulations at the local scale for the cities of Antwerp, Bilbao and London using the UrbanClim simulation model. The results of the simulations can be found in D4.3. The RAMSES research shows that it is crucial for cities to identify and predict future climatic changes and how these will affect their territory. In fact, the data provided by on-site measurements, numerical modeling, simulations and other urban climate analyses provides significant information that could influence the future decisions on the configuration of the urban environment, such as the choice of the finishing material of facades, roofs and paving, and the type of urban vegetation and urban fabric.

Unfortunately, in many European cities, such accurate information is still lacking. Nevertheless, the absence of accurate down-scaled data and simulations should not
prevent cities from acting on climate change. In fact, cities can start identifying how climate will change on their territory by taking stock of existing data that can support them in estimating future climatic trends in their region and the negative effects deriving thereby on their territory.

**KEY MESSAGES**

- In order to understand the consequences of climate change, cities need to gather information on macro-regional climatic changes, starting with information that is publicly available.
- In the absence of downscaled climate projections, cities should start acting by developing no-regret measures\(^{17}\) that respond to predicted regional climatic variations.
- Whenever possible, cities should partner with local universities and/or knowledge providers to develop detailed studies on the impact of projected changes in climate at neighborhood scale.
- Further to physical damage, cities should also map local socio-economic vulnerabilities to understand if climate change impacts will exacerbate them.\(^{18}\)

**GETTING TO WORK**

The following exercise is re-adapted from the ICLEI Canada workbook, Changing Climate, Changing Communities. It intends to provide a methodology to carry out a first assessment and keep track of the climatic changes in a city and to understand how these changes will impact the urban and social fabric.

**INSTRUCTIONS**

1. **Gather information from different stakeholders**
   
   The information requested to fill Table 18 (below) should be compiled in cooperation with different stakeholders. This will make sure that the knowledge available for identifying climatic changes is tracked and taken stock of. Municipal staff working in relevant departments, as well as critical infrastructure operators, utilities, universities and research centres should be involved (see Worksheet no. 1 on stakeholder mapping).

2. **Source identification**
   
   The following Table 18 should be completed with a list of relevant data sources for the city to understand projected climatic change on its territory.

3. **Expected change**
   
   The third step in the process is to identify the climatic variables, such as average temperature or precipitation, that are projected to change in your region (or the amount of change that occurs by a specified future date, relative to the average for a range of years in the past). The “expected change” is often expressed as a range of increase or decrease. Often, using a range helps to document any uncertainty in the projection or seasonal variability (where one season is expected to see an increase and another season will see a decrease). Where possible, define the climatic change clearly so as to avoid statements which indicate both an increase and a decrease. For example, define “average summer precipitation” and “average winter precipitation” instead of “average yearly precipitation” in cases where the seasonal variability results in both increases and decreases.

   Table 19 can be used to record the climatic changes that are expected to happen in your region. Be sure to record all climatic changes that will affect your city when you fill in this table.

   **4. Identify impacts and service areas**

   Based on the climatic changes identified, list which impacts those changes will have on your community during a brainstorming activity. A description of an impact includes the identification of the “someones” or “something” that will be impacted, the specific way in which it will be impacted, and the reason for which the impact may occur. For example, “summer drought” is not immediately a strong climate impact, but “increased demand on water supply due to summer drought” would be. Be as specific as you can, including whatever level of detail you research can provide.

   If your team is finding it difficult to determine appropriate impact-statements, consider the following questions:

   - What is the climatic change you are looking at? (e.g., decreased precipitation).
   - What is the outcome of that change? (e.g., summer drought).
   - What are the impacts associated with that outcome? (e.g., increased demand on water supply).

   **5. Identify relevant service areas**

   For each impact, consider the relevant service areas and how the function of each might be affected by the impact. A service area refers to the areas in which a government or community delivers, manages, plans, or makes policy.

   See the table below for a list of some possible service areas:

   - Agriculture
   - Biodiversity
   - Coastal Zone Management
   - Community development
   - Corporate services
   - Culture and tourism
   - Economic Development
   - Emergency management
   - Energy management
   - Engineering
   - Environment
   - Fire services
   - Finance
   - Flood control
   - Housing services
   - Insurance
   - Legal services
   - Natural resources
   - Parks and recreation
   - Planning and zoning
   - Port and harbour management
   - Police
   - Public health
   - Storm-water management
   - Transportation
   - Water
   - Waste management
   - Forestry and forest services

---

\(^{17}\) These are defined as measures that have limited additional costs, in comparison to no adaptation and that provide numerous co-benefits (for example better air quality, quality of life for citizens, biodiversity, etc.) so that implementing them would also provide benefits in the absence of climate change

\(^{18}\) INSTRUCTIONS 2nd Policy Brief
Identify the service areas that are relevant for your city and include those across the top of the table below. Multiple service areas may be affected by one impact, so be sure to identify all that will be impacted. Create a table for each of the climatic changes and list the relevant impacts down the left hand side and your community’s service areas across the top.

As you consider how climate change impacts will affect your community and how it functions, it is important to differentiate between the key service areas that will be affected and those areas which are important to keep in mind but which are not the primary area to be affected. In the table below, identify which service areas will be affected either directly (with an "D") or indirectly (with an "I").

After you have completed your research and these tables (for each climatic change identified) take a moment to review them, make sure that the list of impacts is as comprehensive as possible.

This process of identifying service areas will be useful when completing your vulnerability assessment as you will need to assess the vulnerability of specific service areas to a given impact (see worksheets 3 and 4).

---

**Table 20: Direct and indirect impacts on service areas**

<table>
<thead>
<tr>
<th>CLIMATIC CHANGE</th>
<th>IDENTIFIED SERVICE AREAS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DECREASED PRECIPITATION IN SUMMER</strong></td>
<td>Agricultural Services</td>
</tr>
<tr>
<td>Increased demand on water supply due to summer drought</td>
<td>D</td>
</tr>
<tr>
<td>Increased irrigation needs due to decreased water supply</td>
<td>D</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CLIMATIC CHANGE</th>
<th>IDENTIFIED SERVICE AREAS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INCREASED TEMPERATURES IN SUMMER</strong></td>
<td>Agricultural Services</td>
</tr>
<tr>
<td>Increased demand on energy due to increased cooling needs in summer</td>
<td>D</td>
</tr>
<tr>
<td>May experience longer growing seasons which increases potential to double crop</td>
<td>D</td>
</tr>
</tbody>
</table>

---

**READ MORE**

- **RAMSES D4.1** - Validation of agglomeration-scale climate projections
- **RAMSES D4.2** - Agglomeration-scale urban climate and air quality projections
- **RAMSES D4.3** - Urban adaptation effects on urban climate

**FURTHER MATERIALS**

- ICLEI Canada – Changing Climate, Changing Communities – Guide and Workbook for Municipal Climate Adaptation
- ICLEI ACCCRN Process – Building urban climate change resilience: A toolkit for local governments
- CHAMP Project - Integrated Management for Local Climate Change Response – Capacity Development Package
- **STORM EU Project** 2016 - Safeguarding Cultural Heritage through Technical and Organizational Resources Management

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**LINK TO HANDBOOK**

Phase II: Assessing risk and vulnerability

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For more information on climate projections and climate impacts, please visit:

- http://on-urban-resilience.eu/#Local_climate_change_models
- http://on-urban-resilience.eu/#What_is_a_model

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**RAMSES AUDIO-VISUAL GUIDANCE**

To find out more about climate projections and climate impacts, please watch:
4.3.3 Worksheet no. 3: Vulnerability assessment

**INTRODUCTION**

Vulnerability can be defined as the propensity or predisposition of a given system to be affected by a threat. The vulnerability of a territory depends on the sensitivity to a certain damage and the ability of a system to cope and adapt to potential threats.

To summarise: vulnerability can be defined as a function of sensitivity and adaptive capacity.

\[
\text{Vulnerability} = f (\text{sensitivity, adaptive capacity})
\]

The assessment of different vulnerabilities in a city, region or community is crucial in order to understand how economic or socio-ecological systems at city level could be affected by certain hazards, and therefore to establish and enact the adequate mechanisms and effective policies to respond and adapt to them.¹⁰

Identifying vulnerabilities correctly is crucial to understand how the effects of climate change will impact a city system. The exercise below presents a methodology that cities can use to identify their vulnerabilities to present and future climate change hazards.

**KEY MESSAGES**

- The specific characteristics and vulnerability of a city or region is spatially defined and depends on the physical, biological, ecological, economic and social features of a certain territory. Therefore the role of local governments in the identification and assessment of local hotspots is crucial.
- Vulnerability and risk assessments require a thorough knowledge of city systems and sectors and of the real life conditions of different neighbourhoods. Therefore, a city's adaptation team should gather knowledge from different stakeholders (e.g., infrastructure operators, civil protection, etc.) and involve local populations in the hotspot detection process.²¹

**GETTING TO WORK**

The vulnerability assessment of a city should consider the element of sensitivity to climate change, as well as the city's adaptive capacity (which reduces the city's vulnerability).

The information required to conduct such an analysis comes from three different domains, and is obtained through consultation with stakeholders. The three domains are:

- **Technical domain**: Focuses on the functionality and vulnerability of “hard” systems.
- **Climate and biophysical science**: Focuses on climate change manifestations and impacts.
- **Socio-economic domain**: Focuses on ‘soft’ systems, particularly the governance and management system as well as socio-economic systems.²²

**INSTRUCTIONS**

1. **Engage the right stakeholders**
   - First, it is essential to bring together a group of stakeholders that has the knowledge needed to carry out the exercise (see Worksheet 1 on how to identify the right stakeholders).

2. **Identify service areas**²³
   - Referring to the list of impacts on worksheet 2, identify all the service areas affected by each impact. List the impacts and identify which service areas will be influenced using table 21.

**Example impact and directly affected service areas**

<table>
<thead>
<tr>
<th>IMPACT</th>
<th>SERVICE AREAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased demand on water supply due to summer drought</td>
<td>Environment, Corporate Services, Water</td>
</tr>
<tr>
<td>Contamination of streams and/or lakes due to sewer overflow</td>
<td>Waste Management, Parks and Recreation, Engineering, Water</td>
</tr>
</tbody>
</table>

In order to assess the service areas sensitivity to an impact:

- Determine which climatic changes affect the impact in question.
- Identify how the service area is affected by these changes.
- Assess whether the service area is, at present, subject to any existing stress and whether the impact will exacerbate that stress.
- Assign a value (from 1 of 5) representing the sensitivity of the service area to the climate change impact. See the Sensitivity scale below which answers the following question:

**Table 22: Sensitivity scale. Adapted from ICLEI Canada**

<table>
<thead>
<tr>
<th>Scale</th>
<th>Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Functionality will stay the same</td>
</tr>
<tr>
<td>2</td>
<td>Functionality will likely stay the same</td>
</tr>
<tr>
<td>3</td>
<td>Functionality is likely to get worse</td>
</tr>
<tr>
<td>4</td>
<td>Functionality will get worse</td>
</tr>
<tr>
<td>5</td>
<td>Functionality will become unmanageable</td>
</tr>
</tbody>
</table>

¹⁰ RESIN project D11
¹¹ RAMSES 2 Policy Brief
²² Q4AMP Project: Integrated Management for Local Climate Change Response – Capacity Development Package
²³ Methodology adapted from the ICLEI Canada, Changing Climate, Changing Communities workbook

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Table 21: Example impact and directly affected service areas
In order to appropriately assess the sensitivity of a particular service area to an impact, you should determine a timeline (i.e., determining the sensitivity of a service area over the next 25 years). The timeline criterion can be adjusted according to the needs of your city as it may be relevant to consider how this assessment fits into broader municipal plans e.g., 100 year sustainability plan, 30 year official plan, etc.

As guidance, consider a previous extreme weather event (i.e., storm, heavy rain event, etc.) and apply the same questions. This provides an opportunity to integrate your community’s past sensitivities into the planning process.

Table 23 assesses the sensitivity of three sample impacts and service areas: water, environment, and energy services. The assessment is made by four questions:

- Which climate changes affect the functioning of this service area?
- How would the service area be affected by these changes today?
- Is the service area subject to any existing stress?
- If the impact occurs, will it affect the functionality of the service area?

4. Adaptive Capacity

The next step in determining vulnerability is to identify the adaptive capacity of a given service area. Adaptive capacity refers to the ability of built, natural, or human systems to accommodate to changes in climate (including climate variability and climate extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. In other words, adaptive capacity reduces the vulnerability of a system.

To measure adaptive capacity, consider the projected impacts for your community and assess how those impacts will affect the systems in your service areas. Also consider the extent to which current plans, policies and regulations account for the identified set of climate variables and their future changes.

Use the information from your sensitivity assessment to frame the linkages between the climatic change, the effect on the service area and whether that service area can adapt. Based on that information, your team can assess the ability of the service area to accommodate these changes with little or no cost or disruption.

Use the Adaptive Capacity Scale below to assign a value to represent the adaptive capacity of the service area and be sure to explain the reason for that assigned value.

Table 23: Sensitivity assessment example. Adapted from ICLEI Canada

<table>
<thead>
<tr>
<th>IMPACT</th>
<th>SERVICE AREA</th>
<th>Functionality will likely stay the same</th>
<th>Functionality is likely to get worse</th>
<th>Functionality will get worse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Supply</td>
<td>Environment</td>
<td>1. Temperature (warmer temperatures expected across all seasons under climate change scenarios, especially during summer months)</td>
<td>1. Precipitation (more rain in summer and snow in winter)</td>
<td>Temperature (warmer temperatures expected across all seasons under climate change scenarios, especially during summer months)</td>
</tr>
<tr>
<td>Environment</td>
<td>Energy Services</td>
<td>2. Precipitation (less rain in summer and snow in winter)</td>
<td>1. Increased rainfall in summer and quantities of melting snow in spring causes sewers to overflow into streams and/or lakes, contaminating marine ecosystems with domestic waste</td>
<td>1. Increased number of hot days in summer months leading to increased demand for cooling centres</td>
</tr>
<tr>
<td>Energy Services</td>
<td></td>
<td>3. Lower winter precipitation lowers winter snowpack, reducing water supply</td>
<td>2. Large flow variations between wet and dry weather can cause contamination issues.</td>
<td>2. Increased temperatures leading to increased household use of air-conditioning.</td>
</tr>
</tbody>
</table>

Table 24: Adaptive capacity scale. Adapted from ICLEI Canada

<table>
<thead>
<tr>
<th></th>
<th>AC1</th>
<th>AC2</th>
<th>AC3</th>
<th>AC4</th>
<th>AC5</th>
</tr>
</thead>
<tbody>
<tr>
<td>No, will require minimal cost and staff intervention</td>
<td>No, will require significant costs and staff intervention</td>
<td>Maybe, will require some costs and staff interventions</td>
<td>Yes, but will require some slight costs and staff intervention</td>
<td>Yes, no to little costs and staff intervention are necessary</td>
<td></td>
</tr>
</tbody>
</table>

Table 25: Assessment of the adaptive capacity of three sample impacts and service areas. Adapted from ICLEI Canada

<table>
<thead>
<tr>
<th>IMPACT</th>
<th>SERVICE AREA</th>
<th>Explain Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased demand on water supply due to summer drought</td>
<td>Water Supply</td>
<td>No: Will require substantial costs ($$$) and staff intervention (AC1)</td>
</tr>
<tr>
<td>Contamination of streams and/or lakes due to sewer overflow</td>
<td>Environment</td>
<td>No: Will require significant costs ($$$) and staff intervention (AC2)</td>
</tr>
<tr>
<td>Increased demand on energy due to increased cooling needs in summer</td>
<td>Energy Services</td>
<td>No: Will require significant costs ($$$) and staff intervention (AC4)</td>
</tr>
</tbody>
</table>

**Unsuitable to “adapt” snowpack to warmer temperatures, limited options for expanding water supply and summer demand is already greater than supply**

**Explain Response:**

Unable to adapt with minimal cost and disruption due to the costs and scale of operation required to clean up streams and/or lakes.

Able to adapt with minimal disruption and cost as many solutions are educational and knowledge based.
5. Vulnerability Assessment

Using the sensitivity and adaptive capacity ratings allocated for each impact and service area, vulnerability can then be assigned to each service area.

Use the matrix below to determine the vulnerability of each service area to the impact identified and record the impacts according to their vulnerability rating in Table 27:

<table>
<thead>
<tr>
<th>ADAPTATION CAPACITY</th>
<th>SENSITIVITY SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC1</td>
<td>S1</td>
</tr>
<tr>
<td>AC2</td>
<td>S2</td>
</tr>
<tr>
<td>AC3</td>
<td>S3</td>
</tr>
<tr>
<td>AC4</td>
<td>S4</td>
</tr>
<tr>
<td>AC5</td>
<td>S5</td>
</tr>
</tbody>
</table>

- Those impacts with high sensitivity (S4 and S5) and low adaptive capacity (AC1 and AC2) are highly vulnerable (V5 and V4);
- Those with low sensitivity (S1 and S2) and high adaptive capacity (AC5 and AC4) have low vulnerability; and
- Those that have both high sensitivity (S4 and S5) and high adaptive capacity (AC5 and AC4), or low sensitivity (S1 or S2) and low adaptive capacity (AC1 and AC2) have medium vulnerability (V3).

Table 27: Vulnerability ratings. Adapted from ICLEI Canada

- **HIGH VULNERABILITY (S5 – AC1) = V5**
- **MEDIUM – HIGH VULNERABILITY (S4 – AC2) = V4**
- **MEDIUM VULNERABILITY (S2 – AC2 OR S3 – AC3) = V3**
- **MEDIUM – LOW VULNERABILITY (S2 – AC1 OR S2 – AC2) = V2**
- **LOW VULNERABILITY (S1 – AC3) = V1**

**Impact** | **Service Area** | **Impact** | **Service Area** | **Impact** | **Service Area** | **Impact** | **Service Area**
---|---|---|---|---|---|---|---
Increased demand on water supply due to summer drought | Water Supply | Contamination of streams and/or lakes due to sewer overflow | Environment | Increased demand on energy due to increasing cooling needs in summer | Energy | ... | ...

To find out more about vulnerability assessments in cities, please watch:
- [Ramses D3.1](http://on-urban-resilience.eu/#Adaptation_strategy_for_a_city_-_how_to_start)
- [CHAMP Project](http://on-urban-resilience.eu/#The_concepts_resilience_and_vulnerability)
4.3.4 Worksheet no. 4: Determining key climate risks for cities

INTRODUCTION

Climate monitoring and modeling, vulnerability and risk assessment methods have improved significantly over the last two decades. Nevertheless, there are still limits to our understanding of future climate risks.

RAMSES has developed a top-down vulnerability assessment of 571 cities in the EU’s Urban Audit database. The results provide information on hazard, exposure, vulnerability and risks and can be used by national and EU policy makers to inform investment prioritization for particular risks and across European regions. Furthermore, RAMSES has also developed detailed bottom-up vulnerability assessments for the cities of London, Antwerp and Bilbao, which shed light on local climatic challenges with a high degree of resolution. The figure below presents a visualization of the concept of risk in the face of climate change as a function of vulnerability and exposure to different hazards on different scales.

The figure below presents a visualization of the concept of risk in the face of climate change as a function of vulnerability and exposure to different hazards on different scales. Each one of the smaller cubes shown in the figure represents a tri-dimensional space where the climate change threats, vulnerability components and elements at risk can be identified and understood which other cities are exposed to the same risks. In order to more precisely identify which risks cities are exposed to locally, detailed bottom-up analyses are required.

Table 28 shows how different data sources at different scales and with different resolutions can support local decision-making.

The following exercise aims to support cities in assessing, evaluating and prioritising local risks.

KEY MESSAGES

- Prioritized risks are a fundamental step towards moving to selecting appropriate adaptation options and actions.
- An up-to-date and detailed risk assessment can help cities attract funding for adaptation and foster buy-in from local politicians and the general public about the need of adaptation action.
- It is important to create focus groups composed by different stakeholders to gather the information required to conduct a thorough risk assessment.

Table 28: Hierarchy of methods and decisions they might be used to inform (RAMSES, D3.1)

<table>
<thead>
<tr>
<th>DECISIONS TO INFORM</th>
<th>DATA AND METHODS SOURCES</th>
<th>METHODS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benchmarking</td>
<td>Satellite observations</td>
<td>Indicator and checklists</td>
</tr>
<tr>
<td>Regional and urban planning</td>
<td>Energy generation</td>
<td>GIS overlays</td>
</tr>
<tr>
<td>Detailed planning</td>
<td>Strategic assessments</td>
<td>Global and regional climate model outputs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Accounting tools</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Integrated assessment models</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High resolution simulation and process models of selected urban functions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Industrial ecology and life cycle analysis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Engagement with individuals, community groups and other stakeholders</td>
</tr>
</tbody>
</table>

GETTING TO WORK

Natural hazards, and in particular climate change impacts tend to occur either simultaneously or consecutively. An up-to-date and detailed risk assessment can help cities attract funding for adaptation and foster buy-in from local politicians and the general public about the need of adaptation action.

It is important to create focus groups composed by different stakeholders to gather the information required to conduct a thorough risk assessment.

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[1] Adapted from [ICLEI Canada, Changing Climate and Changing Communities](http://www.iclei.org)
[2] Adapted from [ICLEI ACCCRN – Tool 2.3 Risk Assessment, Brief](http://www.iclei.org)
[3] Adapted from [ICLEI ACCCRN – Brief](http://www.iclei.org)
[4] Adapted from [ICLEI ACCCRN – Brief](http://www.iclei.org)
### Table 29: Linkages of natural hazards and climate change impacts (Cabinet Office 2011)

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>INITIAL CONSEQUENCES</th>
<th>KNOCK-ON CONSEQUENCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storm and gales</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Strong winds</td>
<td>River and coastal flooding</td>
<td></td>
</tr>
<tr>
<td>- Tidal surge</td>
<td>Surface water flooding</td>
<td></td>
</tr>
<tr>
<td>- Snow</td>
<td>Land instability</td>
<td></td>
</tr>
<tr>
<td>- Lightning</td>
<td>Wildfires</td>
<td></td>
</tr>
<tr>
<td>- Heavy Rainfall</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Tornadoes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Hail</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prolonged period of hot weather</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Heat</td>
<td>Thunderstorms</td>
<td></td>
</tr>
<tr>
<td>- Drought</td>
<td>Land instability</td>
<td></td>
</tr>
<tr>
<td>- Dust/Smog/Haze</td>
<td>Wildfires</td>
<td></td>
</tr>
<tr>
<td>Prolonged period of dry weather</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Reduced Rainfall</td>
<td>Dust/Smog/Haze/Fog</td>
<td></td>
</tr>
<tr>
<td>- Reduced ground water flow</td>
<td>Water quality</td>
<td></td>
</tr>
<tr>
<td>- Water quality</td>
<td>Land instability</td>
<td></td>
</tr>
<tr>
<td>- Drought</td>
<td>Wildfires</td>
<td></td>
</tr>
<tr>
<td>Excessive cold with snow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Cold</td>
<td>Ice</td>
<td></td>
</tr>
<tr>
<td>- Snow</td>
<td>Wind chill</td>
<td></td>
</tr>
<tr>
<td>- Surface water and river flooding</td>
<td>snow melt</td>
<td></td>
</tr>
</tbody>
</table>

Risk can be considered a function of the consequence of an impact and the likelihood of its occurrence or more simply:

**RISK = LIKELIHOOD x CONSEQUENCE**

The purpose of this exercise is to prioritize different climate change impacts according to the level of risk they pose to a city. Its results will inform and support the development of adaptation options and actions.

The exercise should be conducted during a workshop where different municipal departments, as well as relevant stakeholders are involved. This approach will:

- Allow different informed opinions to be gathered on local risks;
- Generate greater discussions;
- Build a broad consensus on the final risk prioritization.

### Table 30: Climate Risk. Adapted from ICLEI ACCCRN publication: Building urban climate change resilience: A toolkit for local governments

<table>
<thead>
<tr>
<th>CLIMATE RISK PRIORITIZATION</th>
<th>LIKELIHOOD</th>
<th>CONSEQUENCE</th>
<th>RISK SCORE</th>
<th>RISK STATUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>E.g., increased precipitation cause water to freeze in the pipelines</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

### Table 31: Likelihood rating and scoring. Adapted from ICLEI ACCCRN publication: Building urban climate change resilience: A toolkit for local governments

<table>
<thead>
<tr>
<th>LIKELIHOOD RATING</th>
<th>DESCRIPTION</th>
<th>SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Almost certain</td>
<td>Is highly likely to occur, could occur several times per year. Probability greater than 50%</td>
<td>5</td>
</tr>
<tr>
<td>Likely</td>
<td>Reasonable likelihood may arise once per year. Likelihood 50/50 chance</td>
<td>4</td>
</tr>
<tr>
<td>Possible</td>
<td>May occur, perhaps once in 10 years. Likelihood less than 50% but still quite high</td>
<td>3</td>
</tr>
<tr>
<td>Unlikely</td>
<td>Unlikely but should still be considered, may arise once in 10 or 25 years</td>
<td>2</td>
</tr>
<tr>
<td>Rare</td>
<td>Likely probability significantly greater than zero. Unlikely in foreseeable future – negligible probability</td>
<td>1</td>
</tr>
</tbody>
</table>
4. Assess the consequences of each risk
Next, for each climate risk, assess the consequence or impact, if the risk does occur. Consequence refers to the known or estimated consequences (e.g. to public safety, local economy and growth, community and lifestyle, environment and sustainability, and public administration) of a particular risk, and it can range from Catastrophic to Moderate to Insignificant. Assign a score from 1 to 5 for each risk based on the table below.

<table>
<thead>
<tr>
<th>CONSEQUENCE RATING</th>
<th>IMPACT ON SYSTEM</th>
<th>IMPACT ON POOR AND VULNERABLE</th>
<th>SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catastrophic</td>
<td>System fails completely and is unable to deliver critical services, may lead to failure of other connected systems.</td>
<td>Severe impacts on poor and vulnerable groups in the city leading to situations of extreme destitution.</td>
<td>5</td>
</tr>
<tr>
<td>Major</td>
<td>Serious impact on the system’s ability to deliver critical services, however not complete system failure.</td>
<td>Loss of confidence and criticism in city government; ability to achieve city vision and mission seriously affected. Significant impacts on poor and vulnerable groups in the city that seriously affects their lives and livelihoods</td>
<td>4</td>
</tr>
<tr>
<td>Moderate</td>
<td>System experiences significant problems, but is still able to deliver some degree of service.</td>
<td>Moderate impacts on the lives and livelihoods of the poor and vulnerable groups in the city.</td>
<td>3</td>
</tr>
<tr>
<td>Minor</td>
<td>Some minor problems experienced, reducing effective service delivery, possibly affecting other systems or groups.</td>
<td>Minor impacts on the lives and livelihoods of the poor and vulnerable groups in the city.</td>
<td>2</td>
</tr>
<tr>
<td>Insignificant</td>
<td>Minimal impact on system; may require some review or repair, but still able to function.</td>
<td>Minimal impacts on the lives and livelihoods of the poor and vulnerable groups in the city.</td>
<td>1</td>
</tr>
</tbody>
</table>

5. What is the risk score for each Climate Risk Statement?
Having assigned a “Likelihood” and “Consequence” score to each of the identified climate risks, now multiply both these values to arrive at the “Risk Score” for each Climate Risk Statement.

\[ \text{Risk Score} = \text{Likelihood} \times \text{Consequence} \]

The interpretation of the risks levels, broadly speaking, is as follows:

- **Extreme risks** demand urgent attention at the most strategic level and cannot be simply accepted as a part of routine operations.
- **High risks** are the most severe that can be accepted as part of routine operations but they will be the responsibility of the most senior operational management and reported upon at the executive level.
- **Medium risks** can be expected to form part of routine operations but they will be explicitly assigned to relevant managers for actions, maintained under review and reported upon at senior management levels.
- **Low risks** will be maintained under review but it is expected that existing controls will be sufficient and no further actions will be required to treat them unless they become more severe."

Table 32: Likelihood rating and scoring. Adapted from ICLEI ACCCRN publication: Building urban climate change resilience: A toolkit for local governments

Table 33: Summary of a risk matrix. Adapted from ICLEI ACCCRN publication: Building urban climate change resilience: A toolkit for local governments

**Methodology adapted from the ICLEI ACCCRN publication: Building Urban Climate Change Resilience: A Toolkit for Local Governments**
6. Prioritization process

Once you have the total risk score for each impact, place each impact in the table according to the risk score. Place the extreme risks in the first rows and subsequent risks in the following rows.

Table 34:
Prioritisation of climate risks. Adapted from ICLEI ACCCRN publication: Building urban climate change resilience: A toolkit for local governments

<table>
<thead>
<tr>
<th>CLIMATE RISK PRIORITY</th>
<th>LIKELIHOOD</th>
<th>CONSEQUENCE</th>
<th>RISK SCORE</th>
<th>RISK STATUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased precipitation causes water to freeze in the pipes</td>
<td>4</td>
<td>4</td>
<td>16</td>
<td>High</td>
</tr>
<tr>
<td>Increased precipitation disrupts/damages water supply infrastructure</td>
<td>3</td>
<td>3</td>
<td>9</td>
<td>Medium</td>
</tr>
<tr>
<td>Risk 3</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

Once you have completed the table and organized the rows according to their risk scores, your team may want to consider re-securing the support from your stakeholders as you can now inform them about the most pressing risks and discuss how to move forward.29

READ MORE

- RAMSES D2.1 – Synthesis review on resilient architecture and infrastructure indicators
- RAMSES D2.2 – Physical and cost typology for buildings and infrastructure/project database
- RAMSES D3.1 – High level quantified assessment of key vulnerabilities and priority risks for urban areas in the EU

4.3.5 Worksheet no. 4a; Calculating the economic costs of health impacts and adaptation

INTRODUCTION

Climate change has already affected human health over the last few decades, both directly by changing weather patterns and indirectly by shifting patterns of disease transmission and disrupting basic elements of health such as safe drinking-water, clean air and food security. Besides their inherent human costs, ill health and premature mortality represent real and significant economic costs to society. Economic evidence of the health impacts of climate change is important as a basis to support local decision-making in the assessment of adaptation priorities and ultimately to advance climate adaptation.

For this purpose, the World Health Organization (WHO) has developed a tool for the economic evaluation of climate-related health impacts and adaptation at local level in the framework of the RAMSES project, which can be applied both prospectively and retrospectively.31 The tool consists of four steps:

1. Calculating the economic cost of the health impacts considered, including the cost of premature mortality, the cost of additional healthcare and the cost of lost workdays associated with illness;

2. Calculating the cost of health adaptation, that is, of the interventions planned and necessary to avert or minimize the health impacts considered;

FURTHER MATERIALS

- ICLEI Canada – Changing Climate, Changing Communities – Guide and Workbook for Municipal Climate Adaptation
- ICLEI ACCCRN Process – Building urban climate change resilience: A toolkit for local governments
- CHAMP Project – Integrated Management for Local Climate Change Response – Capacity Development Package

RAMSES AUDIO-VISUAL GUIDANCE

To find out more about vulnerability assessments in cities, please watch: [http://en-urban-resilience.eu/effrisk_analysis_explained](http://en-urban-resilience.eu/effrisk_analysis_explained)

3. Bimating the economic benefits of health adaptation, by monetizing the avoided cases of the health impacts considered; and

4. Choosing and reporting against indicators needed for planning and decision-making, such as cost-effectiveness estimates and benefit-to-cost ratios.

The following example box 17 provides an overview of the cost assessment tool structure.32
Example Box 17:
Methodological framework of climate change and health economic evaluation

### KEY MESSAGES

- Strategies for mitigating and adapting to climate change can prevent illnesses and premature deaths now, while also protecting the environment and health of future generations.
- Targeted adaptation activities can directly improve human health through ameliorating public health and health care infrastructures.  

### GETTING TO WORK

The cost assessment tool developed by the WHO is operationalized through a simple model based on a Microsoft® Excel™ spreadsheet. The tool is based on a limited number of inputs, which makes it applicable even in cases where little data is available. The cost-assessment tool can be found at this [link](www.ramses-cities.eu).

The spreadsheet features the following individual sheets:

- **Read me**: An explanation of the structure of the tool, its components and the colour-coding of the input and output cells;
- **Health costs**: A step-wise calculation of the costs due to the health damage evaluated, including the social cost of premature mortality and of morbidity;
- **Economic values**: A summary of the main general economic parameters used in the calculations;
- **Adaptation costs**: A template for the costing of individual health adaptation actions, both general and specific; and
- **Outputs**: Summary indicators of cost, cost-effectiveness and comparisons of costs and benefits.

A general overview of the data inputs needed for the estimation of the economic cost of health damage is listed in the following table, which can be found in RAMSES D6.2.

### Table 35: Main variables for health damage costing

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>LABEL</th>
<th>VARIABLE</th>
<th>DEFINITION (UNIT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health impact</td>
<td>D1</td>
<td>Morbidity attributable to climate change</td>
<td>Incident cases (number)</td>
</tr>
<tr>
<td></td>
<td>D2</td>
<td>Premature mortality attributable to climate change</td>
<td>Deaths (number)</td>
</tr>
<tr>
<td>Health service use</td>
<td>D3</td>
<td>Outpatient consultations</td>
<td>Proportion of cases seeking care (%)</td>
</tr>
<tr>
<td></td>
<td>D4</td>
<td>Outpatient visit rates</td>
<td>Average number of visits per case seeking care (number)</td>
</tr>
<tr>
<td></td>
<td>D5</td>
<td>Impatient admissions</td>
<td>Proportion of cases admitted from within all cases seeking care (%)</td>
</tr>
<tr>
<td></td>
<td>D6</td>
<td>Length of inpatient stay</td>
<td>Average number of days per inpatient admission (number)</td>
</tr>
<tr>
<td>Health care unit costs</td>
<td>D7</td>
<td>Full unit costs of outpatient care</td>
<td>Full cost per outpatient service provided (Local Currency Units: LCU)</td>
</tr>
<tr>
<td></td>
<td>D8</td>
<td>Full unit cost of inpatient care</td>
<td>Full cost per inpatient service provided (LCU)</td>
</tr>
<tr>
<td>Cost of lost productive time</td>
<td>D9</td>
<td>Value of productive time lost</td>
<td>Opportunity cost of productive time lost (LCU)</td>
</tr>
<tr>
<td></td>
<td>D10</td>
<td>Days of productive activities</td>
<td>Days of productive time lost to disease (LCU)</td>
</tr>
<tr>
<td>Cost of mortality</td>
<td>D11</td>
<td>Value of life</td>
<td>Relevant value of a statistical life (LCU)</td>
</tr>
</tbody>
</table>

A detailed description of the preparatory work necessary for filling in the input and interpreting the outputs of the tool is explained in the RAMSES report D6.2 and is accessible via the project website. This should be consulted before completing the Excel sheet.
INSTRUCTIONS

1. Engage the right stakeholders

First, it is essential to bring together stakeholders who have a sound understanding of the different fields of knowledge necessary to fill out the tool, e.g., climate adaptation, health, economics, public works and environment. If you haven’t done so yet, please use see Worksheet 1 to identify the stakeholders that should contribute to the tool filling.

This methodology and the accompanying tool are mainly intended to support local policy-makers in planning and implementing climate change health adaptation policies, however, other stakeholders involved in planning and implementing such policies can also use this material.

2. Data input and “Read me” spreadsheet

List the impacts identified during the exercise contained in Worksheet 3 in the table below.

At this stage, a template for the costing of individual health adaptation actions, both general and specific, must be filled. Once the required inputs have been added into the corresponding cells, some interim outputs are calculated:

3. “Health costs” and “Economic values” spreadsheets

The first steps before using the tool are explained in the “Read me” spreadsheet, where you will find an explanation of the structure of the tool, its components and the following colour-coding of their input and output cells.

The table below specifies the type of information required and possible sources:

At this step, the team should start filling the different tables from the tool. The “Health costs” sheet is a step-wise calculation of the costs due to the health damage evaluated, including the social cost of premature mortality and of morbidity. On the other hand, the “Economic values” sheet brings a summary of the main general economic parameters used in the calculations.

Health outcomes considered: Estimation of the impacts on health of climate change or specific climate-related exposures is needed as basis for the cost assessment.

Timeframe of analysis and discount rates: Applicable prospectively and retrospectively (the start cost assessment can be in the past and the timeframe can lead up to the present or future). For prospective timeframes longer timeframes (e.g. by end of century) are more appropriate.

The table below specifies the type of information required and possible sources:

Table 36: Health service parameter needs and possible sources

<table>
<thead>
<tr>
<th>HEALTH SERVICE USE PARAMETER</th>
<th>POSSIBLE DATA SOURCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportion of patients who seek treatment</td>
<td>Health service data, health surveys, local studies, other published literature, assumption of sensitivity analysis</td>
</tr>
<tr>
<td>Outpatient visit rates</td>
<td>Health service data, interview with health providers, local studies, other published literature</td>
</tr>
<tr>
<td>Inpatient admission rates</td>
<td>Health service data, interview with health providers, local studies, other published literature</td>
</tr>
<tr>
<td>Length of inpatient stay</td>
<td>Health service data (including reimbursement reports), interview with health providers, local studies, other published literature</td>
</tr>
<tr>
<td>Length of illness (for calculation of loss of productive time)</td>
<td>Health service data, employment medical leave records, health survey, interview with health providers, local studies, other published literature</td>
</tr>
</tbody>
</table>

Obviously, locally relevant data are always preferable if they are reliable. The order of preference in Table 36 above does not intend to grade the quality of the sources, but rather to order them according to their local relevance: In absence of local data sources or locally relevant literature, national data on health service can be used.

4. “Adaptation costs” spreadsheet

At this stage, a template for the costing of individual health adaptation actions, both general and specific, must be filled. Once the required inputs have been added into the corresponding cells, some interim outputs are calculated:

Table 37: Interim outputs of adaptation cost calculation

<table>
<thead>
<tr>
<th>LABEL</th>
<th>VARIABLE</th>
<th>ITEMS</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A6</td>
<td>Full costs</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>A7</td>
<td>Financial costs</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>A9</td>
<td>Full costs allocated to activity</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>A10</td>
<td>Financial costs allocated to activity</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>A13</td>
<td>Full allocated cost by year</td>
<td>N/A</td>
<td>LCU</td>
</tr>
<tr>
<td>A14</td>
<td>Financial allocated cost by year</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>A15</td>
<td>Costs incurred by financing agent</td>
<td>Full allocated cost to implementing agent</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Full allocated cost to household/beneficiary</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Full allocated cost to other agent</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Before starting the exercise, the team should discuss and define the following characteristics:

- Geographic scope: All levels of application are possible (e.g. local, provincial, regional etc.), however the main geographic scope tool is the local level.
- Determine the focus area: Urban agglomerations or administrative boundaries?
- Population: Decide whether you consider the whole population or parts of it (and if relevant, the type of disaggregation e.g. by age, by income etc.).

Image: ICLEI
5. "Outcomes" spreadsheet

Ultimately, the goal of this health adaptation costing exercise is to obtain summary indicators for promoting and/or planning adaptation policy.

For this reason, a "Cost of adaptation summary" table is presented in the output spreadsheet. It lists both "total costs using budget and health system resources" and "total costs to be met from additional (new) budget sources". The costs are disaggregated by year, by type (revenue or investment) and by implementing agent.

In addition, several summary outputs are generated that can support decision-making. These are usually outputs of cost-effectiveness and/or cost-benefit analysis. As applied to this case, they would be:

- **BRC** = Benefits from averted damage through adaptation activity / Cost adaptation activity

- **CER** = Cost of adaptation activity / Outcome cases averted by adaptation activity

Where:
- BCR: Benefit to cost ratio
- CER: Cost-effectiveness ratio

Moreover, in the "Outcomes" spreadsheet five "Final summary outputs" are presented:
1. Total cost of health damage attributed to climate change for the selected outcomes;
2. Health damage cost avertable through adaptation;
3. Benefit-cost ratio;
4. Cost per case averted;
5. Cost per death averted.

6. Final discussion

Once the results are available, the team should discuss their meaning and impact and define the next ideal steps in investments and in the development of health policies. The results should be compiled in a layman’s report and presented to relevant decision-makers in order to influence future strategic decisions.

**READ MORE**

- **RAMSES D6.1** - Review on economic assessment of damage or adaptation costs of health effects of climate change
- **RAMSES D6.2** - Assessment tool to estimate the economic costs of health impacts of climate change

**FURTHER MATERIALS**

- WHO 2013a. Climate change and health: a tool to estimate health and adaptation costs. Copenhagen, Denmark: World Health Organization Regional Office for Europe
- **RAMSES AUDIO-VISUAL GUIDANCE**

To find out more about vulnerability assessments in cities, please watch:
http://on-urban-resilience.eu/estimate_health_impacts_costing
http://on-urban-resilience.eu/health_costs_tool_explained

**LINK TO HANDBOOK**

Relase a step in contextualization of the city in relation to climate change

**4.3.6 Worksheet no. 5: Identifying and prioritizing different adaptation options**

**INTRODUCTION**

Once cities have assessed their risks and vulnerabilities, they need to identify and prioritise the different adaptation options that can support them in mitigating them.

Adaptation options can be divided into three main categories:

- **"Grey"** infrastructure corresponds to engineered physical interventions to make the city more resilient to extreme events (e.g. dykes, water tanks, etc.)
- **"Green and blue"** infrastructure makes the city more resilient and achieves sustainability through the maintenance, restoration and addition of nature into the urban space (e.g. greenways, open spaces, green belts, urban green spaces, cultural landscapes etc.) by improving wellbeing and the environmental conditions of urban areas.
- **"Soft"** measures are those that facilitate the implementation of "grey" and "green" measures and include the design and application of policy procedures, such as: land-use controls, information dissemination, economic incentives to reduce vulnerability and measures that try to avoid maladaptation. These measures can be perceived as "success factors" for the effective implementation of an adaptation plan

**Adaptation measures should not only be considered in light of their response potential vis-à-vis determined climate threats here and now. When thinking about adaptation, it is also worth reflecting on the potential of different measures to generate a long-term positive development for a city as a whole. According to this line of thought, three types of adaptation approaches can be identified (EEA, 2016):**

- **Coping adaptation** mostly means responding to the damage arising from a disaster and recovery afterwards. Purely coping approaches bring short-term benefits that decrease to zero with each new disaster. They therefore imply high costs over time.

Figure 16: Coping adaptation. Retrieved from EEA, 2016.
Incremental adaptation builds on existing adaptation measures and known solutions by improving them bit by bit and increasing their capacity to avoid damage under future levels of risk. Incremental approaches work effectively up to certain risk levels. Benefits level off over time and higher risk levels will require additional coping.

Transformative adaptation follows a broader and more systematic approach, by addressing the root causes of vulnerability to climate change which is often the result of human actions such as setting in risk-prone areas, inadequate building design or other behaviours that aggravate the impact of climate change (EEA, 2016). Transformative approaches need some time and effort at the beginning but then benefits increase and are stable. Very little coping is needed to buffer extremely high risk levels.

When selecting adaptation measures, cities should think of a long-term improvement in the city development. Short and long-term costs and benefits of different adaptation measures should be considered in order to select a combination of measures mitigating high risks in the present and reducing cities’ vulnerability in the future. In other words, disaster risk reduction and adaptation should be planned contextually and in a coordinated process.

When selecting adaptation measures, "low hanging fruits" and no-regret measures should be identified. These are measures that can be realized at little or no cost or that build upon existing city development plans that should be implemented regardless of climate adaptation. "Soft" measures, such as social empowerment through participatory stakeholder processes, can foster positive behavioural change and represent successful enablers of an effective adaptation plan.44

Getting to Work

This worksheet45 will support cities in creating a list of adaptation options and in prioritising these options. The options identified should be broken down according to the timeframe needed for their implementation (long vs. short) and should contribute to achieving a long-term vision and objectives already identified in urban development plans and strategies.

Adaptation options may be considered, for example:

- Modifying policies, plans, practices and procedures;
- Building new or upgrading existing infrastructure;
- Improving community awareness and public education.

As you identify adaptation options, please keep in mind that these actions should not only address the climate change impacts which your community is facing right now, but should also contribute to a sustainable city development in the future (Please see Worksheet 2).

Key Messages

- When selecting adaptation measures, city decision-makers should not only evaluate their effectiveness in responding to short-term challenges, but also their potential to contribute to a long-term improvement in the city development.
- Short and long-term costs and benefits of different adaptation measures should be considered in order to select a combination of measures mitigating high risks in the present and reducing cities' vulnerability in the future. In other words, disaster risk reduction and adaptation should be planned contextually and in a coordinated process.
- When selecting adaptation measures, "low hanging fruits" and no-regret measures should be identified. These are measures that can be realized at little or no cost or that build upon existing city development plans that should be implemented regardless of climate adaptation. "Soft" measures, such as social empowerment through participatory stakeholder processes, can foster positive behavioural change and represent successful enablers of an effective adaptation plan.

Instruction

1. Engage the right stakeholders

First, it is essential to bring together relevant stakeholders holding competences for example in infrastructure, public works, health, civil protection, environment, etc. (see Worksheet 1).

2. List and classification of adaptation options

Using the prioritized list of risks (based on risk scores) from Worksheet 4 your team can now identify options to address each risk.

Before carrying out further studies, do a baseline assessment of the data that is already available through public research or even through the databases of different municipal departments and of all the projects, initiatives and regulations that directly or indirectly contribute to climate adaptation in your city. This will save you time and money and support you in creating partnerships and synergies with relevant stakeholders for implementing the adaptation options eventually selected.

The IPCC Climate Change Synthesis Report of 2007 presents a selection of possible adaptation actions by sector, along with policy considerations, constraints and opportunities. They can be used as guidance. However, every city is unique and care should be taken to ensure that chosen actions are appropriate for local conditions and will be understood and "owned" by local stakeholders.


As you identify adaptation options, please keep in mind that these actions should not only address the climate change impacts which your community is facing right now, but should also contribute to a sustainable city development in the future (Please see Worksheet 2).
3. Evaluation of adaptation options

Finally, in order to evaluate adaptation options, describe each of them individually and value them against the criteria provided by the following checklist (Table 39). This list will support you in assessing measures for adaptation, identifying advantages and disadvantages and defining whether and under which circumstances a measure can be applied.

Table 38: List of adaptation options

<table>
<thead>
<tr>
<th>RISK</th>
<th>ADAPTATION OPTION</th>
<th>CLASSIFICATION (GREY, GREEN OR SOFT OPTION)</th>
<th>APPROACH (COPING, INCREMENTAL OR TRANSFORMATIVE ADAPTATION)</th>
<th>CO-BENEFITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk 1</td>
<td>Diversify water supply sources</td>
<td>Grey - Soft</td>
<td>Transformative</td>
<td>Water Emergency Response Public Health Communication</td>
</tr>
<tr>
<td></td>
<td>Implement conservation measures</td>
<td>Green</td>
<td>Coping</td>
<td>Water Public Health Communications</td>
</tr>
<tr>
<td></td>
<td>Increase drought preparedness</td>
<td>Soft</td>
<td>Incremental</td>
<td>Emergency Response Water Public Health</td>
</tr>
<tr>
<td>Risk 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. Evaluation of adaptation options

Finally, in order to evaluate adaptation options, describe each of them individually and value them against the criteria provided by the following checklist (Table 39). This list will support you in assessing measures for adaptation, identifying advantages and disadvantages and defining whether and under which circumstances a measure can be applied.

Table 39: Checklist to evaluate adaptation options

<table>
<thead>
<tr>
<th>CRITERION</th>
<th>INDICATORS / SUB-CRITERIA</th>
<th>QUESTIONS TO BE ASKED</th>
<th>YES / NO</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effectiveness of adaptation</td>
<td>Adaptation function</td>
<td>Does the measure provide adaptation in terms of reducing impacts, reducing exposure, enhancing resilience or enhancing opportunities?</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Robustness to uncertainty</td>
<td>Is the measure effective under different climate scenarios and different socio-economic scenarios?</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Flexibility</td>
<td>Can adjustments be made later if conditions change again or if changes are different from those expected today?</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Co-benefits</td>
<td>No regret</td>
<td>Does the measure contribute to more sustainable water management and bring benefits in terms of also alleviating already existing problems?</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Win-win (or win-lose)</td>
<td>Does the measure have side-benefits for other social, environmental or economic objectives? If yes, does it: • Contribute to closing the gap between water availability and demand? • Affect the delivery of other WFD objectives (e.g. river flow)? • Create synergies with mitigation (e.g. does it lead to decreased GHG emissions)?</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Spill-over effects</td>
<td></td>
<td>Does the measure affect other sectors or agents in terms of their adaptive capacity?</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Does the measure cause or exacerbate other environmental pressures?</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Efficiency/costs and benefits</td>
<td>Low-regret</td>
<td>Are the benefits the measure will bring high relative to the costs? If possible, consider also distributional effects (e.g. balance between public and private costs), as well as non-market values and adverse impacts on other policy goals.</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Equity and legitimacy</td>
<td></td>
<td>Who wins and who loses from the adaptation measure?</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Are those affected by the measure consulted and involved in the decision-making procedures and in the design of the measure?</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feasibility of implementation</td>
<td></td>
<td>What barriers are there to implementation?</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Technical</td>
<td></td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Social (number of stakeholders, diversity of values and interests, level of resistance)</td>
<td></td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Institutional (conflicts between regulations, degree of cooperation, necessary changes to current administrative arrangements)</td>
<td></td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Framework conditions for decision-making</td>
<td>Alternatives</td>
<td>Are there alternatives to the envisaged adaptation measure that would e.g. be less costly or would have fewer negative side-effects?</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Priority and urgency</td>
<td>How severe are the climate impacts the adaptation measure would address relative to other impacts expected in the area/country?</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>When are the climate change impacts expected to occur?</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>At what timescales does action need to be taken?</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Adapted from the CHAMP Project
4. Prioritisation of adaptation options

After having evaluated each adaptation option, list them putting the most urgent ones first. For each adaptation option, please specify the time frame needed for its implementation, so as to have a clear overview of which measures can be implemented immediately and which will need to be embedded in a longer process.16

\[
\text{Table 40: Prioritised adaptation options}
\]

<table>
<thead>
<tr>
<th>PRIORITISED ADAPTATION OPTIONS</th>
<th>TIME FRAME</th>
<th>FOR IMPLEMENTATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved drought preparedness</td>
<td>Long Term</td>
<td></td>
</tr>
<tr>
<td>Heat Health action plan</td>
<td>Short Term</td>
<td></td>
</tr>
</tbody>
</table>

Further Reading

- RAMSES D2.1 - Synthesis review on resilient architecture and infrastructure indicators
- RAMSES D2.2 - Climate resilience in architecture, infrastructure and urban environments; analysis of RAMSES case study cities
- RAMSES D2.4 - Adaptation measures and corresponding indicators for resilient architecture and infrastructure
- RAMSES D2.7 - Typology of the tools available to policy-makers and assessment of their efficiency
- RAMSES D8.2 - Stimulating European urban strategies for transition

4.3.7 Worksheet no. 5a: Backcasting to Identify long-term climate adaptation goals

**INTRODUCTION**

Backcasting is defined as "generating a desirable future, and then looking backwards from that future to the present in order to strategize and to plan how it could be achieved" (Van Oordt and Quist, 2011). In a backcasting planning method, different stakeholders brainstorm to create a vision about their city or community in the future taking into account their current or future resilience building efforts. In the process, they are asked to work backwards and identify policies, indicators and programs that allow building pathways that will lead to realising a given vision.

**KEY MESSAGES**

- A successful transformation towards resilience must be cross-sectoral, cut across vertical levels of government and needs to be based on a long-term vision. To achieve a formulated vision, transition pathways composed of specific milestones need to be identified and formulated.
- In the context of sustainability and climate adaptation, different scenarios can be drawn to generate a transition into a more climate-friendly and resilient society. Backcasting is a planning method complementary to forecasting of potential challenges, as the latter usually tends to produce less options and planned activities. In fact, forecasting is based on known information and knowledge, while backcasting changes over time and produces continuous input.
- Using backcasting for climate adaptation can support cities in thinking according to a systemic perspective and help them understand constraints, challenges and opportunities. By involving stakeholders and enabling a co-creation process for problem solving, change can be made throughout the process and lead to a more climate resilient and sustainable society.
- Triggers of change or transition factors should be identified to sustain local transitions. These include, among others, public consent and political leadership in order to achieve innovation and change (both must be ensured in the long term), education and awareness (accessibility of data and the ability to use them is key for this), enhanced public-private interfaces and participation of a broad range of actors and institutions; and a multi-level governance that goes beyond contingency planning.49

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16 Methodology re-adapted from the ICLEI Canada – Changing Climate, Changing Communities – Guide and Workbook for Municipal Climate Adaptation

49 RAMSES 2nd Policy Brief
INSTRUCTIONS

1. Baseline Review
This exercise can target different stakeholders depending on the scope for which it is carried out. As a general rule, different stakeholders should be brought together during a workshop so as to gain a broad perspective on the goals to be realised (please see Worksheet 1 on stakeholder mapping).

As a first step, participants are asked to draw a baseline of the current state of their city in terms of adaptation and resilience. In particular, they will be asked to review and suggest those projects, initiatives and activities at city (or neighbourhood) level that strengthen the city’s preparedness for climate change.

Goals identified should be collected and clustered. Participants should formulate and then agree on max. 3 desirable future scenarios. Consensus is needed on what is actually most significant about these future states/scenarios and their characteristics.

2. Definitions of goals
As a second step, the participants will be asked to individually list 3 goals for the city. Everyone should think of a common time frame (e.g., 35-50 years) and answer the following question.

In terms of adaptation and resilience, what would you consider to be desirable goals for 2050?

Table 42:
List of long-term goals

<table>
<thead>
<tr>
<th>GOAL 1</th>
<th>GOAL 2</th>
<th>GOAL 3</th>
</tr>
</thead>
</table>

3. Steps and Milestones
Participants will work backwards to figure out the necessary actions to achieve each outlined scenario. Step by step, the participants should fill out the table for each scenario.

- The column “STEPS” refers to specific plans, actions and activities that would define success in achieving progress towards the goal in the proposed date.
- Successively “MILESTONES” should be identified that allow tracking the progress made towards achieving the goal.

Table 44:
Steps and milestones to achieve a desired scenario

<table>
<thead>
<tr>
<th>SCENARIO</th>
<th>STEPS</th>
<th>MILESTONES</th>
</tr>
</thead>
</table>

4. Assigning roles and responsibilities
Finally, as a last step to this exercise, participants reflect on the scenarios identified and set roles and responsibilities in pursuing the identified steps and milestones.

Table 43:
Characteristics of the 3 scenarios identified

<table>
<thead>
<tr>
<th>SCENARIO CHARACTERISTICS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCENARIO 1</td>
</tr>
<tr>
<td>SCENARIO 2</td>
</tr>
<tr>
<td>SCENARIO 3</td>
</tr>
</tbody>
</table>

READ MORE
- RAMSES D8.1 Factors of transition and their dynamics
- European Commission, 2008; Backcasting approach for sustainable mobility
- Neuvonen et al. 2014; Metropolitan Vision Making – Using Backcasting as a Strategic Learning, Process to Shape Metropolitan Futures

FURTHER MATERIALS
- Scientific Workshop: Pathways, scenarios and Backcasting for low-carbon lifestyles, Proceedings of SCORAI Europe & InContext Workshop, October 2019, Rotterdam
- European Commission, 2008; Backcasting approach for sustainable mobility
- Neuvonen et al. 2014; Metropolitan Vision Making – Using Backcasting as a Strategic Learning, Process to Shape Metropolitan Futures

RAMSES AUDIO-VISUAL GUIDANCE
- http://on-urban-resilience.eu/incooperating, the adaptation perspective
4.3.8 Worksheet no. 6: Identifying Indicators for resilient architecture and infrastructure

INTRODUCTION

Designing architecture and infrastructure that will be resilient to the consequences of climate change depends strongly upon a shift in our current understanding of what constitutes good architectural design and sound, robust building practices. The purpose of this exercise is to enable planning measures and solutions that will increase the resilience of infrastructure, architecture, and urban design.

The exercise proposal is based on the knowledge produced by the RAMSES project. Municipal staff and selected stakeholders with key knowledge of architecture and infrastructure development should come together to identify and evaluate indicators to assess the resilience of their city’s architecture and infrastructure. An additional purpose of this exercise is to provide basic knowledge of these indicators and categorize them according to their relevance and effectiveness. This will also form a basis to assess the attributes of selected indicators to guide actions and investments at city level related to climate adaptation and resilience and to set monitoring criteria for the performance of the architecture and infrastructure in question.

These indicators will enable cities to follow adequate building design principles and architectural solutions to increase resilience at the city scale.

KEY MESSAGES

- Indicators for monitoring and evaluating architecture and infrastructure resilience are needed to support cities’ climate action;
- Collaboration between city staff, different stakeholders and infrastructure/architecture operators and designers is needed to create a taxonomy of indicators and design guidelines for resilient architecture, infrastructure, and urban environments;
- Climate resilient architecture and infrastructure should focus on grey as well as blue/green options, as the latter provide several co-benefits (see Worksheet 5).

GETTING TO WORK

Indicators play a crucial role in monitoring and evaluating adaptation and resilience measures. Indicators should be designed:

- To monitor action; to compare places and situations;
- To provide early warning information; and
- To anticipate future conditions and trends (Moldan and Billharz, 1997).

In practical terms, effective indicators should be robust, precise, objective and transparent, rely on data that is easily accessible and available at a reasonable cost (Boulanger, 2008; Harley et al., 2008).

In a nutshell, the design of a specific set of indicators depends on the following questions:

- What should be monitored?
- How should the monitoring process take place?
- Why and which would be the most important issues to consider?

In addition to these general challenges, the cross-cutting nature of resilience introduces new aspects which make it particularly challenging to monitor programs and evaluate actions, including the need for multi-stakeholder agreement on the levels of acceptable risk for architecture and infrastructure; the multi-sectoral nature of resilience and the large number of stakeholders responsible for different assets; the long time horizon posed by climate change; and the still limited experience in resilience indicators’ design.

Furthermore, resilience indicators can be used for very different purposes, e.g.:

- To target and monitor funding and investments;
- To evaluate policy interventions;
- To inform future policy development;
- To compare achievements across regions or countries;
- To anticipate future conditions and trends (Harley et al., 2008).

In practice, two broad categories of resilience indicators can be recognized:

- Process-based indicators monitor the progress in the implementation adaptation measures and the progression in the different steps of an adaptation management system (such as the UAST).

Outcome-based indicators are needed to measure the effectiveness of adaptation policies and activities in general (Harley et al., 2008).8

To sum-up, the parameters, variables, metrics, or indicators chosen for cities will depend on the specific impacts which can be expected for each individual architectural, sectoral, or societal element for each individual region. Any set of indicators will need to be organized along with a flow chart defining which indicators should be implemented and at what stage in the assessment/development cycle.10

To support the effort of identifying valid resilient architecture and infrastructure indicators, Table 45 presents the core dimensions of resilient systems identified during the RAMSES project (through literature review and interactions with stakeholders) and their potential positive impact, regeneration and co-benefits for urban quality.

Table 45 provides guidance and background information for subsequently identifying indicators by showing how morphological and socio-economic factors and appropriate building and infrastructure design can enhance climatic vulnerability in cities.

These results are categorized according to four main topics:

- Grey infrastructure (ICT, water, waste, energy etc.)
- Green and blue infrastructures
- Land use, mobility, urban-rural interface
- Architecture, public space, urban regeneration
### Table 45: Core dimensions of resilient systems, characteristics and benefits for urban quality (RAMSES D2.1)

<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
<th>DESCRIPTION</th>
<th>GREY INFRASTRUCTURE</th>
<th>GREEN AND BLUE INFRASTRUCTURES</th>
<th>LAND USE, MOBILITY, URBAN-RURAL INTERFACE</th>
<th>ARCHITECTURE, PUBLIC SPACE, URBAN REGENERATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adaptable, flexibility</td>
<td>Capacity or ability to: change while maintaining or improving functionality; evolve; adopt alternative strategies quickly, respond to changing conditions in time, design open and flexible structures (in general)</td>
<td>How robust are infrastructures to last 80 years? How adaptable is the infrastructure in the future?</td>
<td>If public spaces are necessary in risk-prone areas, design them for variable use and accessibility according to weather conditions (e.g., a park with pond can tolerate occasional flooding and help during stormwater management)</td>
<td>Embedding measures in the existing city (design + management)</td>
<td>Flexible structures, multiple uses, symbiosis and exchange</td>
</tr>
<tr>
<td>Connectivity, feedbacks, scale, failure</td>
<td>Functional interdependence of system components and processes (effect of change in one part of the system on other parts of the system). Capacity or ability to: • absorb shocks • absorb cumulative effects of slow-onset challenges • avoid catastrophic failure if thresholds are exceeded • fail progressively rather than suddenly • fail without cascading impacts (domino effect) • analyse and implement across spatial scales (city to site) • analyse as human-technology coupled system • identify lock-in effects and potential conflicts with mitigation • identify synergies with other city policies, added value assessment • balance clear distribution of responsibility with concerted action</td>
<td>Look at the whole system not just parts of it – interrelations</td>
<td>Settlement hierarchy</td>
<td>Maximise use of industrial ecology</td>
<td></td>
</tr>
<tr>
<td>Dependence on local ecosystems</td>
<td>Local control over services provided by local and surrounding ecosystems. Maintaining health and stability of green and blue infrastructure, providing: flood control; temperature regulation; pollutant filtration; local food production etc.; bioclimatic design and management (adjusted to local conditions)</td>
<td>Green-blue infrastructures provide water retention, storage and stormwater management, passive cooling and shading, and protection from noise and air pollution, capacity of green structures to mitigate effects of storm surge in tidal rivers, trees (most effective green infrastructure under heatwaves)</td>
<td>Ensure connectivity of rural and urban ecosystems for services provided to cities</td>
<td>The compact city in the ecological net (mitigation + adaptation)</td>
<td></td>
</tr>
<tr>
<td>Spatial Diversity</td>
<td>Spatial diversity – Key assets and functions physically distributed to not all be affected by a given event at any time • Functional diversity – Multiple ways of meeting a given need balance diversity with potential cascading effects</td>
<td>Location of critical parts of infrastructure</td>
<td>Create street and footpath networks that allow for different choices, with clear and multiple connections (avoid dead ends) and sufficient capacity</td>
<td>Accessibility of the open spaces and services</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Location of networks</td>
<td>Design urban form and density to allow for integration of decentralised renewable energy systems, for energy security during excessive weather events</td>
<td>Accessibility index for buildings of various functions,polycentric development vs centrised concentration (existing settlements) Number of mixed-use zones</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Different types of green infrastructure (public, private, green etc.) can serve different purposes in different ways. E.g., private green is still important for climate, less for recreation</td>
<td>Number of functions for land parcels Land use diversity</td>
<td>Economic diversity</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Sewage systems: split grey water and rainfall</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHARACTERISTIC</td>
<td>DESCRIPTION</td>
<td>BENEFITS AND CHARACTERISTICS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Learning, memory, foresight</td>
<td>Capacity or ability to: • learn from past experiences and failures • use information and experience to create novel adaptations • avoid repeating past mistakes • accumulate, store, and share experience • build on long-term cultural value and history of the city • integrate resilience in long-term development scenarios</td>
<td>Grey infrastructure: Historical data saving Land use, mobility, urban-rural interface: Avoid building in risk-prone areas</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Performance</td>
<td>Following a disruptive event, the capacity or ability to: • contain losses, including mortality and illness • reorganise • maintain and re-establish function • reinstate structure • restore basic order • avoid future disruption</td>
<td>Green and blue infrastructures: Recovery of vital infrastructure Land use, mobility, urban-rural interface: Vulnerability of electricity units in public space for functioning of rail transport (train, tram…) + restore capacity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rapidity, responsiveness</td>
<td>Following a disruptive event, the capacity or ability to: • contain losses, including mortality and illness • reorganise • maintain and re-establish function • reinstate structure • restore basic order • avoid future disruption</td>
<td>Grey infrastructure: Security of energy supply Land use, mobility, urban-rural interface: Ability to bring food and services into the city</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Redundancy, modularity</td>
<td>The capacity or ability to: • substitute systems, or elements of systems • buffer from external shocks or demand changes • replace components with modular parts • balance redundancy with potential cascading effects</td>
<td>Grey infrastructure: Ensure diverse and redundant energy supply and distribution, including local, decentralised systems Land use, mobility, urban-rural interface: Redundancy of infrastructure to cope with extreme events (e.g., transport)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resourcefulness</td>
<td>The capacity, ability, resources and infrastructures to: • identify (and anticipate) problems • establish priorities • mobilise resources • visualise, plan, collaborate and act • re-evaluate • integrate resilience in governance and working processes • involve and co-create with citizens (e.g., crowd-sourcing and funding)</td>
<td>Building code: Building code Land use, mobility, urban-rural interface: Use spatial planning as a tool to stop urban development in current and future risk-prone areas, risk factor per area for flooding</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 45:**
Core dimensions of resilient systems, characteristics and benefits for urban quality (RAMSES D2.1)
### Core dimensions of resilient systems, characteristics and benefits for urban quality (RAMSES D2.1)

<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
<th>DESCRIPTION</th>
<th>BENEFITS AND CHARACTERISTICS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robustness</td>
<td>The capacity or ability to:</td>
<td>Regular maintenance, reconstruction of vulnerable buildings</td>
</tr>
<tr>
<td></td>
<td>- withstand excessive weather conditions using appropriate location, design, materials</td>
<td>Reduce on-site energy demand by means of energy-efficient buildings and infrastructures,</td>
</tr>
<tr>
<td></td>
<td>and detailing, and regular maintenance, e.g., spare storage capacity in sewage systems before</td>
<td>use energy and resource efficient devices, and promote on-site integration of renewable</td>
</tr>
<tr>
<td></td>
<td>overflow into surface water; number and capacity of drains; ground permeability</td>
<td>energy generation to increase self-sufficiency and depend less on external supply</td>
</tr>
<tr>
<td></td>
<td>Prioritise vital infrastructures, e.g., railtrack materials (buckling etc.), metro vulnerability</td>
<td>Design for changes in temperature and relative humidity to avoid pests (fungus, bacteria</td>
</tr>
<tr>
<td></td>
<td>to floods, temperature level ICT datacentres can cope with</td>
<td>and insects) that threaten the integrity of built structures and health</td>
</tr>
<tr>
<td></td>
<td>Reconstruction of vulnerable structures</td>
<td>Prioritise bioclimatic design of buildings and open space: adaptation to local climate and</td>
</tr>
<tr>
<td></td>
<td>Ensuring sewage systems can cope with heavier precipitation, separate treatment of rainwater,</td>
<td>topography to provide a comfortable microclimate with natural ventilation, solar access</td>
</tr>
<tr>
<td></td>
<td>disconnected from sewage</td>
<td>and shading, and green surfaces in open space. Design of buildings with sufficient insulation,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>wind and rain resistance, solar access and shading, natural ventilation, and green roofs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>and walls rather than relying solely on mechanical systems such as air conditioning.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Design public spaces for protection from excessive weather events. Excessive heat, storm,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>flooding, drought and humidity will reduce the use of public spaces, and thus constrain life.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Appropriate selection of geographical location and topography, taking into account for</td>
</tr>
<tr>
<td></td>
<td></td>
<td>example soil instability and other exposure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Make buildings flood proof by appropriate design and material use, such as elevated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>entrances, building on poles, floating houses, temporary water storage, green roofs etc.</td>
</tr>
<tr>
<td>Co-benefits</td>
<td>Added value assessment of resilience</td>
<td>Synergies with resilient concepts to other changes (e.g., demographic, financial, crisis...)</td>
</tr>
<tr>
<td></td>
<td>No/low regret measures</td>
<td>- use it!</td>
</tr>
<tr>
<td></td>
<td>Coordination of mitigation and adaptation</td>
<td>Link to identity</td>
</tr>
<tr>
<td></td>
<td>Level of ITS (Intelligent Transport Systems)</td>
<td>Quality indicators too (e.g., not only km of bike lanes, but actual quality of lanes, safety</td>
</tr>
<tr>
<td></td>
<td></td>
<td>and awareness of cyclists and pedestrians.</td>
</tr>
<tr>
<td></td>
<td>Waste reduction as preventive measure for extreme events; recycling facilities; Pollution</td>
<td>Connectivitiy in the aim of sustainable transport (e.g., bike facilities), daily travel</td>
</tr>
<tr>
<td></td>
<td>and consumption; Reuse and recycle - less dependency</td>
<td>distance, time required for regular trips, to get out of the city</td>
</tr>
<tr>
<td></td>
<td>Annual energy imports, energy consumption and conservation; self-sufficiency, insulation</td>
<td>Local economy</td>
</tr>
<tr>
<td></td>
<td>density; renewables</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Demand side management, smart grids</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Greenhouse gas emissions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ocean acidification, biodiversity loss, invasives, number of species</td>
<td></td>
</tr>
</tbody>
</table>

Table 45: Core dimensions of resilient systems, characteristics and benefits for urban quality (RAMSES D2.1)
INSTRUCTIONS

1. It is essential to bring adaptation, infrastructure, architecture, public works and environment competences together by involving the corresponding municipal departments and previously identified external stakeholders (see Worksheet no. 1).

2. Once this group has been identified, a workshop should be organized to establish a list of indicators to create a baseline and monitor the effectiveness of your resilience architecture and infrastructure actions. As guidance, keep in mind the data provided in Table 45.

3. As there may already be some indicators which are used in your city that indirectly relate to adaptation, before developing more indicators, your team should assess your city’s familiarity with indicators and their current use in policies and actions that contribute to adaptation so as to avoid duplication or indicator overload.

4. Fill Table 46 for each indicator identified to successfully manage data related to the selected indicators. Please keep in mind that the more information you can gather at this stage, the better equipped your city will be to communicate the successes to your adaptation actions.

Name: Trivial Name
Resource: Indicate the resp. Resource
Definition: How do you verbally define the indicator?
Unit: What is the unit of measure/physical unit?
Target: Describe the desired/intended direction of the indicator development. What is a “good development”?
Value: Describe the reasons, why the indicator and the issue were selected for inclusion in the Climate Strategy. Why is it important?
Aim: What does use of indicator aim at?
Base data: What sort of basis data do you need to apply for the indicator?
Source: What are the sources of data? Who owns the data?
Competence: Who owns competence of the indicator? Who is the responsible in the administration?
Update interval: How often is the update available?
Links to indicators: Describe relationship to other indicators in Climate Strategy
Template records: In which date and who is the responsible for the template records?

**Table 46: Data management of indicators. Adapted from CHAMP – Tool BR05**

<table>
<thead>
<tr>
<th>INDICATOR CHARACTERISTICS</th>
<th>REASON</th>
<th>DATA SITUATION</th>
<th>TEMPLATE RECORDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAME</td>
<td>RESOURCE</td>
<td>DEFINITION</td>
<td>UNIT</td>
</tr>
<tr>
<td>Indicator 1: Public green areas availability</td>
<td>Integrated Management for Local Climate Change Response</td>
<td>m² public green areas/total surface</td>
<td>m²/km²</td>
</tr>
</tbody>
</table>

**READ MORE**

- **RAMSES - D2.1**: Synthesis review on resilient architecture and infrastructure indicators.
- **RAMSES D2.3**: Climate resilience in architecture, infrastructure and urban environment. Analysis of RAMSES case study cities.

**FURTHER MATERIALS**

- ICLEI Canada – Changing Climate, Changing Communities Guide and Workbook for Municipal Climate Adaptation
- ICLEI ACCCRN Process – Building urban climate change resilience: A toolkit for local governments
- CHAMP Project – Integrated Management for Local Climate Change Response – Capacity Development Package

**RAMSES AUDIO-VISUAL GUIDANCE**

- [http://on-urban-resilience.eu/#Climate_resilient_infrastructures_in_cities](http://on-urban-resilience.eu/#Climate_resilient_infrastructures_in_cities)
- [http://on-urban-resilience.eu/#Adaptation_tracking](http://on-urban-resilience.eu/#Adaptation_tracking)
4.3.9 Worksheet no. 7: Communicating the urgency of adaptation and local accomplishments

**INTRODUCTION**

Climate change adaptation is a cross-cutting issue. Not only does the development of a local adaptation strategy need the knowledge and contribution of several municipal departments and selected stakeholders, but the decisions that are made (or not made) on climate adaptation today will also have an impact on a city as a whole in the future.

For this reason, it is crucial to clearly communicate the urgency of climate action to different target groups, as well as the steps that a city has undertaken to adapt to climate change and how the resulting measures will contribute to the general improvement of quality of life for citizens and to making the city more attractive for businesses and economic investments.

In fact, if challenges, strategies and actions are not communicated appropriately and in due time, stakeholders and citizens could express negative reactions to climate change adaptation, and not recognise its level of priority and the efforts made by their city administration.

There is a variety of communication options that cities can choose from to make sure that risks and successes are communicated appropriately and in due time. This worksheet presents a tool that cities can make use of to implement an effective communication strategy.

**KEY MESSAGES**

- Climate change adaptation is in many cases a new topic for non-technical stakeholders. In order to foster buy-in and guarantee that it will be granted the warranted level of importance politically and in the public opinion, an effective communication strategy should be developed.
- Communicating appropriately to citizens and vulnerable groups will not only raise their awareness on the issue of climate adaptation, but also generate behavioural changes that can in their turn support adaptation building (e.g., awareness about how to behave in the case of heat waves).
- Effective communication revolves around 2 key factors. On the one hand, it is crucial to identify the different target groups for communication and to find the most appropriate form to reach them and raise their interest. On the other, it is crucial to select the right moment to carry out a communication campaign. For example, communicating too soon about accomplishments which are not yet consolidated could generate unreasonable expectations and consequent disappointment and rejection.

**GETTING TO WORK**

There are different methods you can use to communicate your accomplishments effectively. Each of them has pros and cons. Table 47 presents different communication methods. Please take time to consult these before deciding on a line of action.

**INSTRUCTIONS**

The first step to carry out in order to communicate effectively is to develop a communication strategy that identifies different communication target groups and the different items to be communicated.

**Step 1**

In order to develop a communication strategy, start by answering the key questions below.

- What elements of your adaptation work would you like to make known and why?
- What groups of individuals and stakeholders would be interested in this information (use the results of Worksheet 1 to answer this question)?
- What are the interests of these groups? What elements of the adaptation plan would they be most interested in?
- Considering Table 47 above, what are the most suitable communication tools that you would like to use to reach that audience?

Please remember to also ask relevant stakeholders to answer the questions in order to gather a complete assessment of your communication needs. Record the answers and draw conclusions from them.

**Step 2**

Use the answers provided to identify key elements to be communicated to respective types of stakeholders and develop the communication plan. Use the table below to summarise and track your communication efforts.

**Table 47: Pros and cons of different communication methods.**

<table>
<thead>
<tr>
<th>COMMUNICATION METHOD</th>
<th>PROS</th>
<th>CONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication Event</td>
<td>- More likely to get participation</td>
<td>- Costly</td>
</tr>
<tr>
<td></td>
<td>- Provides an opportunity for community involvement</td>
<td>- May only reach a small number of people</td>
</tr>
<tr>
<td></td>
<td>- High profile</td>
<td></td>
</tr>
<tr>
<td>Press Release</td>
<td>- Minimal costs</td>
<td>- Difficult to ensure that it is read</td>
</tr>
<tr>
<td></td>
<td>- Reaches a wide audience (e.g. entire community)</td>
<td>- Low profile – not celebratory</td>
</tr>
<tr>
<td>Issue Brief</td>
<td>- Minimal costs</td>
<td>- Only reaches a small internal audience</td>
</tr>
<tr>
<td></td>
<td>- Reaches all arms of the corporate structure</td>
<td>- May not appropriately represent the scale of the adaptation effort</td>
</tr>
<tr>
<td></td>
<td>- Could create internal awareness of adaptation issues and spur</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Interdepartmental memo on the accomplishments of the adaptation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>plan</td>
<td></td>
</tr>
<tr>
<td>Newsletter</td>
<td>- Minimal costs</td>
<td>- Difficult to ensure that it is read</td>
</tr>
<tr>
<td></td>
<td>- Reaches a vast public and keeps it engaged</td>
<td>- Not tailored to a specific stakeholder group</td>
</tr>
<tr>
<td></td>
<td>- Can grow the public interested in adaptation quickly</td>
<td></td>
</tr>
<tr>
<td>Reporting</td>
<td>- Documents progress in a formal way</td>
<td>- Only reaches a small, mostly internal audience</td>
</tr>
<tr>
<td></td>
<td>- Minimal costs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Reaches community website update or feature</td>
<td></td>
</tr>
</tbody>
</table>

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49 Adapted from ICLEI Canada

Adapted from ACCRN, p.48

Image: RAMSES Project

www.ramses-cities.eu
Table 48: Keeping track of communication endeavours. Adapted from ACCRN

<table>
<thead>
<tr>
<th>TARGET AUDIENCE</th>
<th>OBJECTIVE, MESSAGE</th>
<th>ACTIVITY</th>
<th>COMMUNICATION MEDIUM</th>
<th>TIMING</th>
<th>ACHIEVED</th>
</tr>
</thead>
<tbody>
<tr>
<td>E.g. City Departments</td>
<td>Inform all city departments that the city government is participating in RAMSES project</td>
<td>Internal Launch Event</td>
<td>Newsletter, staff meetings</td>
<td>October</td>
<td>YES/NO</td>
</tr>
<tr>
<td>E.g. Residents, Local Business</td>
<td>Inform citizens that the City is participating in RAMSES project</td>
<td>External Launch event</td>
<td>Press release</td>
<td>October</td>
<td>YES/NO</td>
</tr>
</tbody>
</table>

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European Environment Agency 2016; Urban Adaptation to Climate Change in Europe Report


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RESIN D6.1 - Actor Analyses for Urban Climate Adaptation, Methods and Tools in support of Stakeholder Analyzes and Involvement


The Natural Step, www.thenaturalstep.org/sustainability/backcasting


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www.ramses-cities.eu
Disclaimer

The work leading to these results has received funding from the European Community’s Seventh Framework Programme under Grant Agreement No. 308497 (Project RAMSES).
The handbook and training package are based on a systemic step-by-step methodology to support cities in the definition of their plans for urban transitions to successful adaptation action. They have a strong link with the “web-based audio-visual guidance” available at: www.on-urban-resilience.eu