



# RAMSES

Science for cities in transition



Transition  
Handbook

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Training  
Package



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[www.ramses-cities.eu](http://www.ramses-cities.eu)



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# RAMSES

Science for cities in transition

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 causes for health and how different adaptation measures can reduce climate impacts on public health;
- > Conducting high-level vulnerability assessments in order to identify the climatic trends in European macro-regions and consequently the main risks to which cities in these regions are exposed;
- > 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<sup>1</sup> 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 offers worksheets and exercises that cities can use to progress towards their adaptation goals. 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/toolbox](http://www.ramses-cities.eu/toolbox)), which summarises the most policy-relevant project findings to support cities in raising awareness on climate adaptation.

<sup>1</sup> [www.covenantofmayors.eu/index\\_en.html](http://www.covenantofmayors.eu/index_en.html)



Videos from the RAMSES audio-visual guidance tool [www.on-urban-resilience.eu](http://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.

The Transition Handbook and Training Package are not intended 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.



## Chapter 2

# Introduction to the Transition Handbook

This handbook is an educational tool, targeted towards 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 the Covenant of Mayors for Climate and Energy.

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:

- > The [Integrated Management System](#)<sup>2</sup> developed within the framework of the CHAMP project (2009-2011) and consisting of five major steps repeated in annual cycles.
- > The [Urban Adaptation Support Tool](#)<sup>3</sup>, 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).

<sup>2</sup> [www.localmanagement.eu/index.php/cdp:introduction\\_to\\_ims](http://www.localmanagement.eu/index.php/cdp:introduction_to_ims)

<sup>3</sup> <http://mayors-adapt.eu/materials/technical-support>



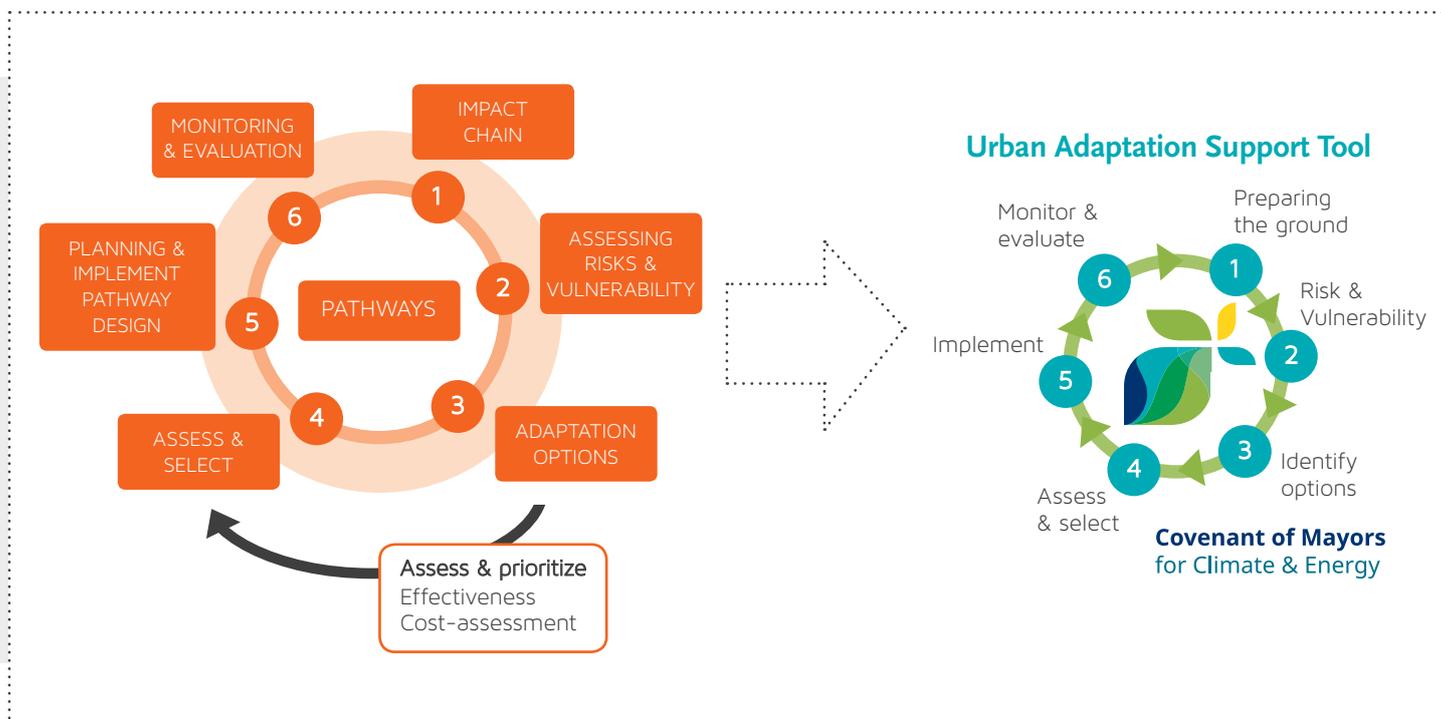
Table 1:

## Adaptation cycle approach in different initiatives

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

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)<sup>4</sup> is developed to support planning: identify adaptation options, assess the performance in order to prioritise (Van de Ven, F.H.M. et al., 2016).
- > Spanish guideline to develop Local Adaptation Plan to climate change<sup>5</sup> (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.).

## 2.2 HOW 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:



## Handbook navigation

By clicking on this icon, you will be redirected to the handbook's table of contents.



This icon is located closely to each of the tables of the handbook. Each of the tables elaborates on a step described in the handbook. By clicking on this icon, you will be redirected to the step that the table refers to.



<sup>4</sup> [www.deltares.nl/en/software/adaptation-support-tool-ast](http://www.deltares.nl/en/software/adaptation-support-tool-ast)

<sup>5</sup> [www.magrama.gob.es/es/cambio-climatico/publicaciones/publicaciones/guia\\_local\\_para\\_adaptacion\\_cambio\\_climatico\\_en\\_municipios\\_espanoles\\_vol\\_2\\_tcm7-430401.pdf](http://www.magrama.gob.es/es/cambio-climatico/publicaciones/publicaciones/guia_local_para_adaptacion_cambio_climatico_en_municipios_espanoles_vol_2_tcm7-430401.pdf)



## Chapter 3

# The process for adaptive management

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

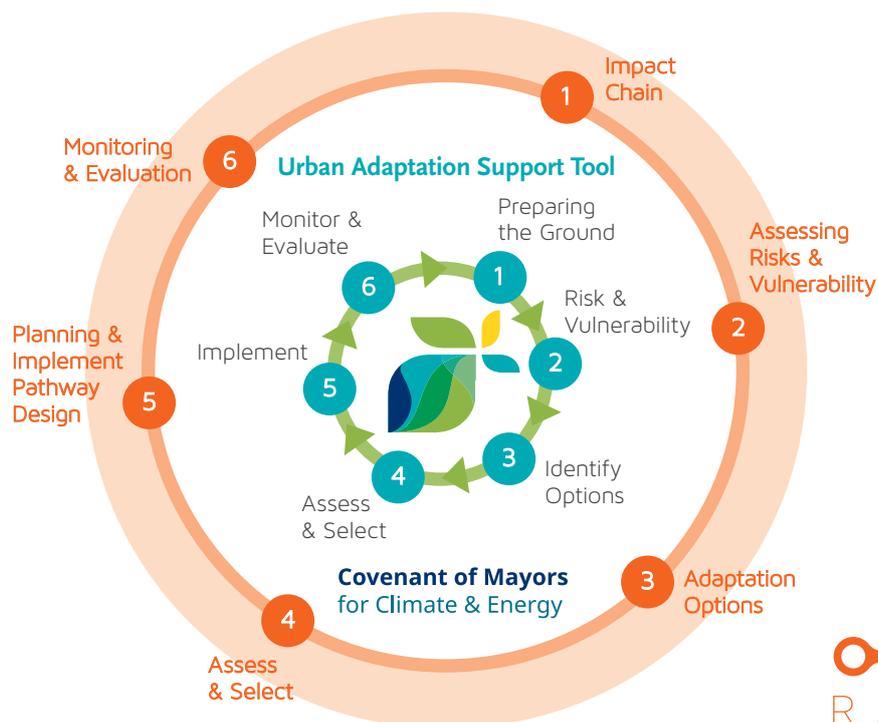
**Phase V** Planning and implementing pathway design

**Phase VI** Monitoring and evaluation

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

Figure 2:

## RAMSES Urban Support Tool vs Urban Adaptation Support Tool



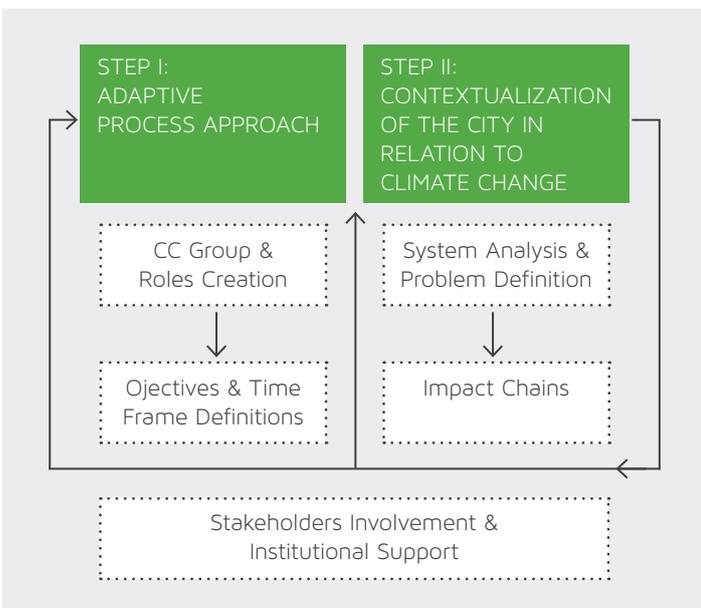
3.1 PHASE I: PREPARING THE GROUND

Phase description and key objectives

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 ensure 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

Figure 3: Phase I: Preparing the ground

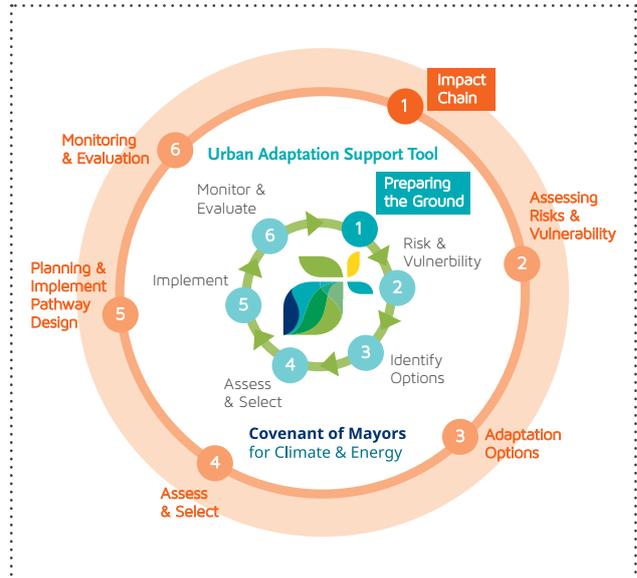


Step I Adaptive process approach

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.

Therefore 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 for 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 to detect the climatic and non-climatic drivers that affect the system you are analyzing and define the impact 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 identified 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 summarising the causal structure of vulnerability and risk within each impact chain.

## Example Boxes

In the RAMSES project we have realized 5 impact chains (Figure 4).

Figure 4:  
Impact chains studied in RAMSES

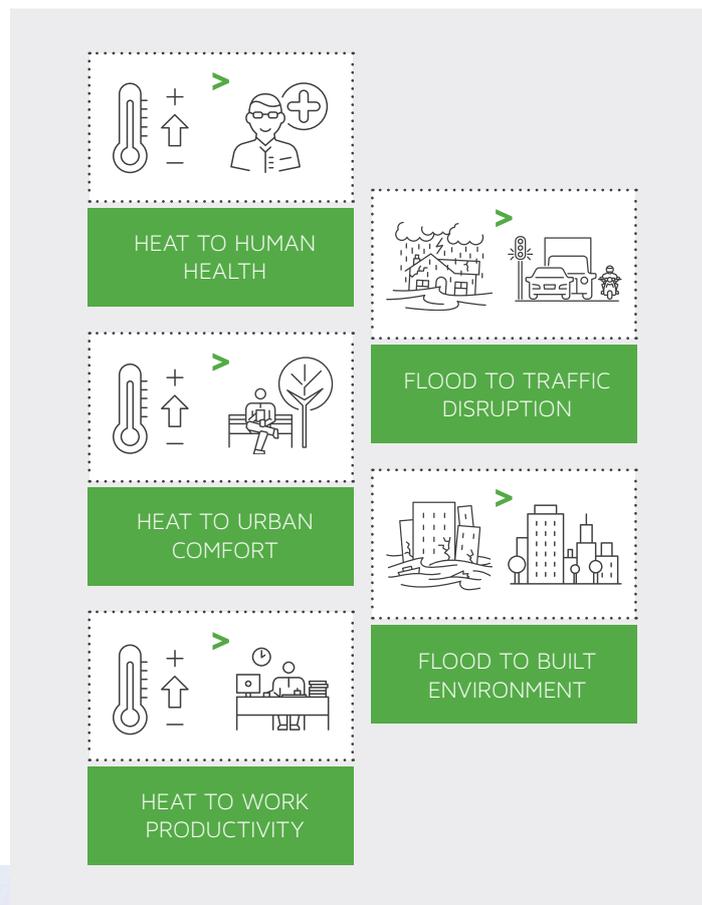
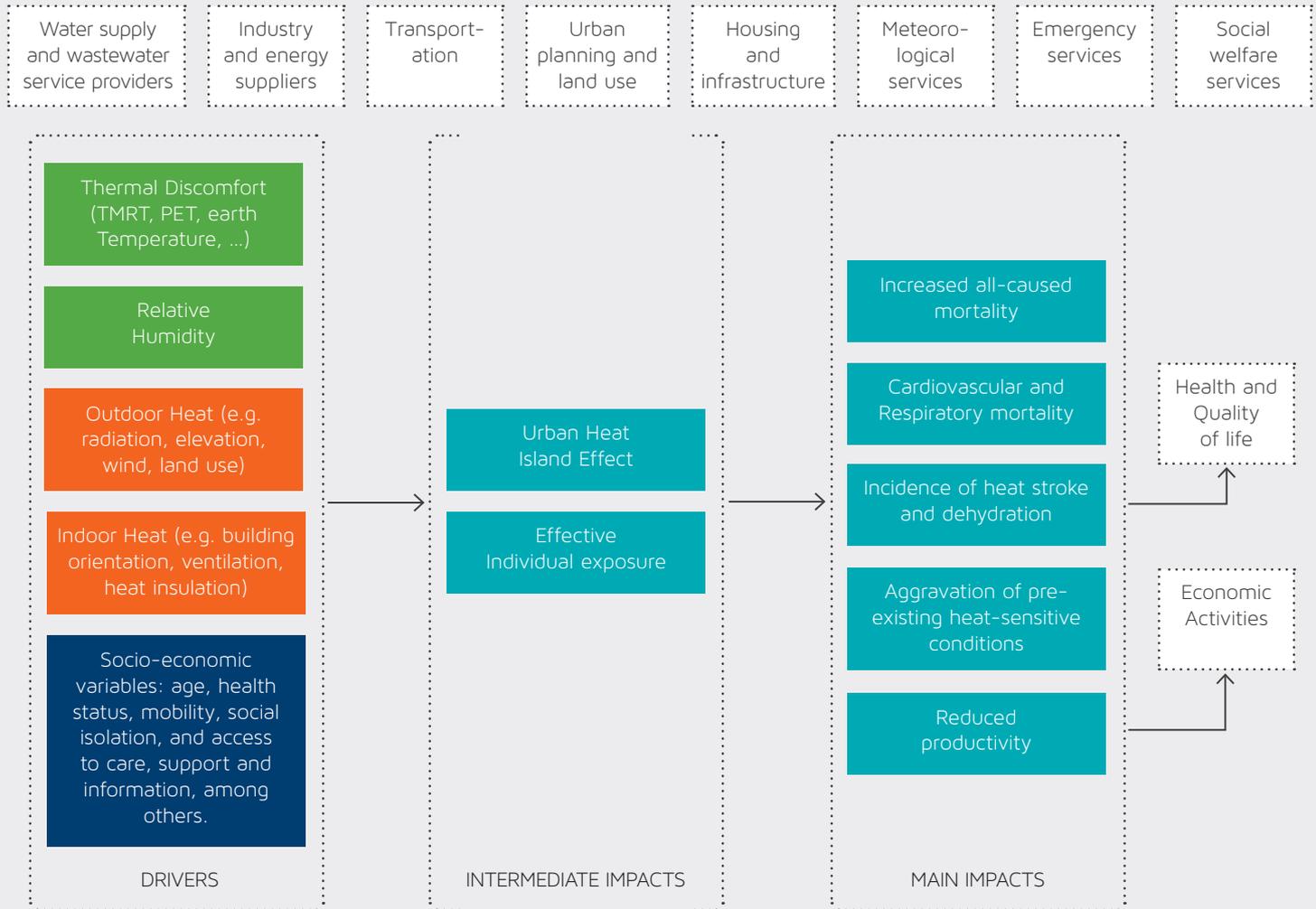


Image: RAMSES Project



Example Box 1:

# Heat to human health impact chain

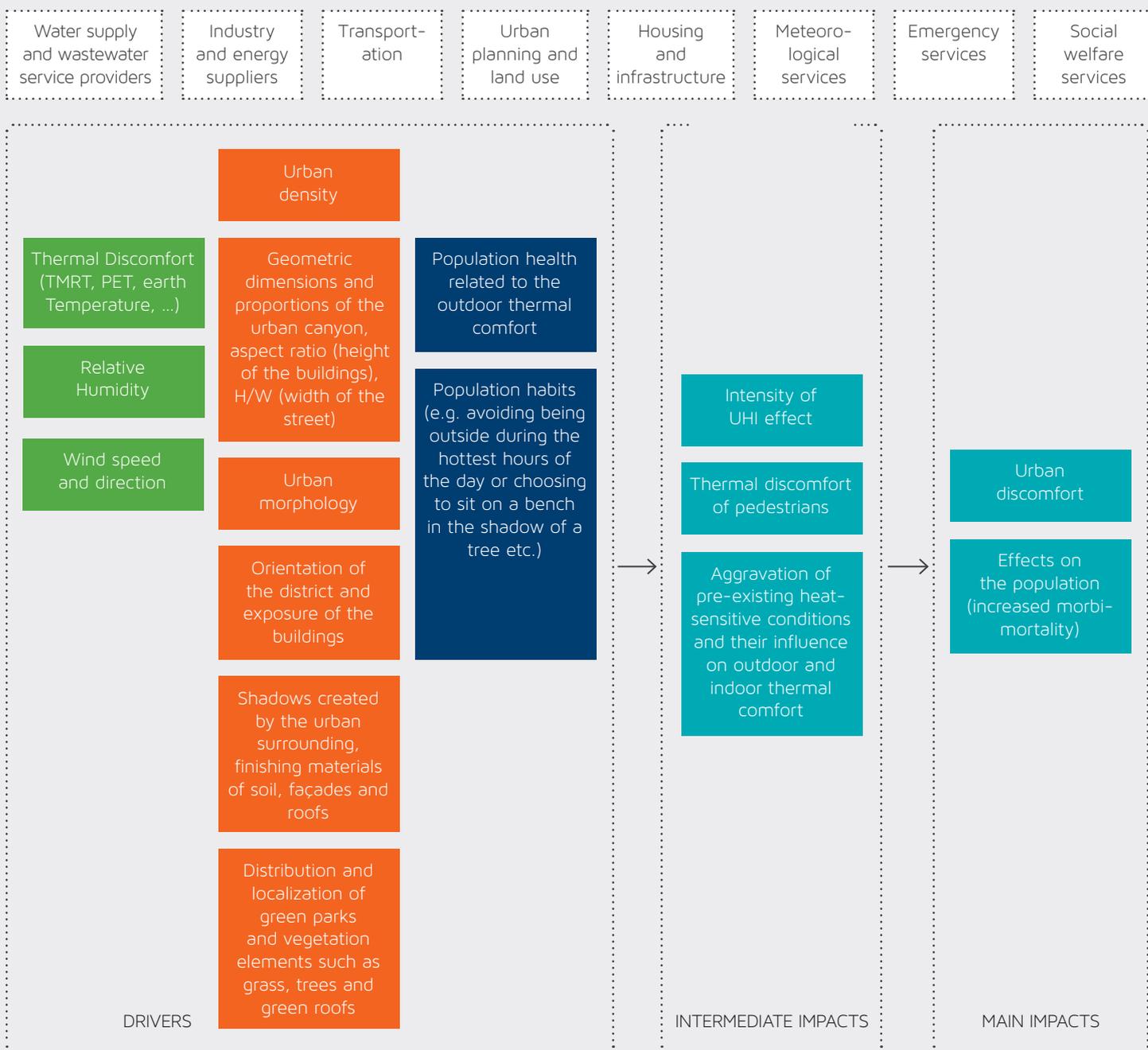


Thermal risk is not necessarily proportional to outdoor environment temperatures, but rather determined by several influencing factors, some environmental and some individual. A conceptual model is presented in the figure, in which exposure to heat is determined by outdoor heat and indoor heat, the latter 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.

[→ Back to Step II](#)

Example Box 2:

# Heat to urban comfort impact chain

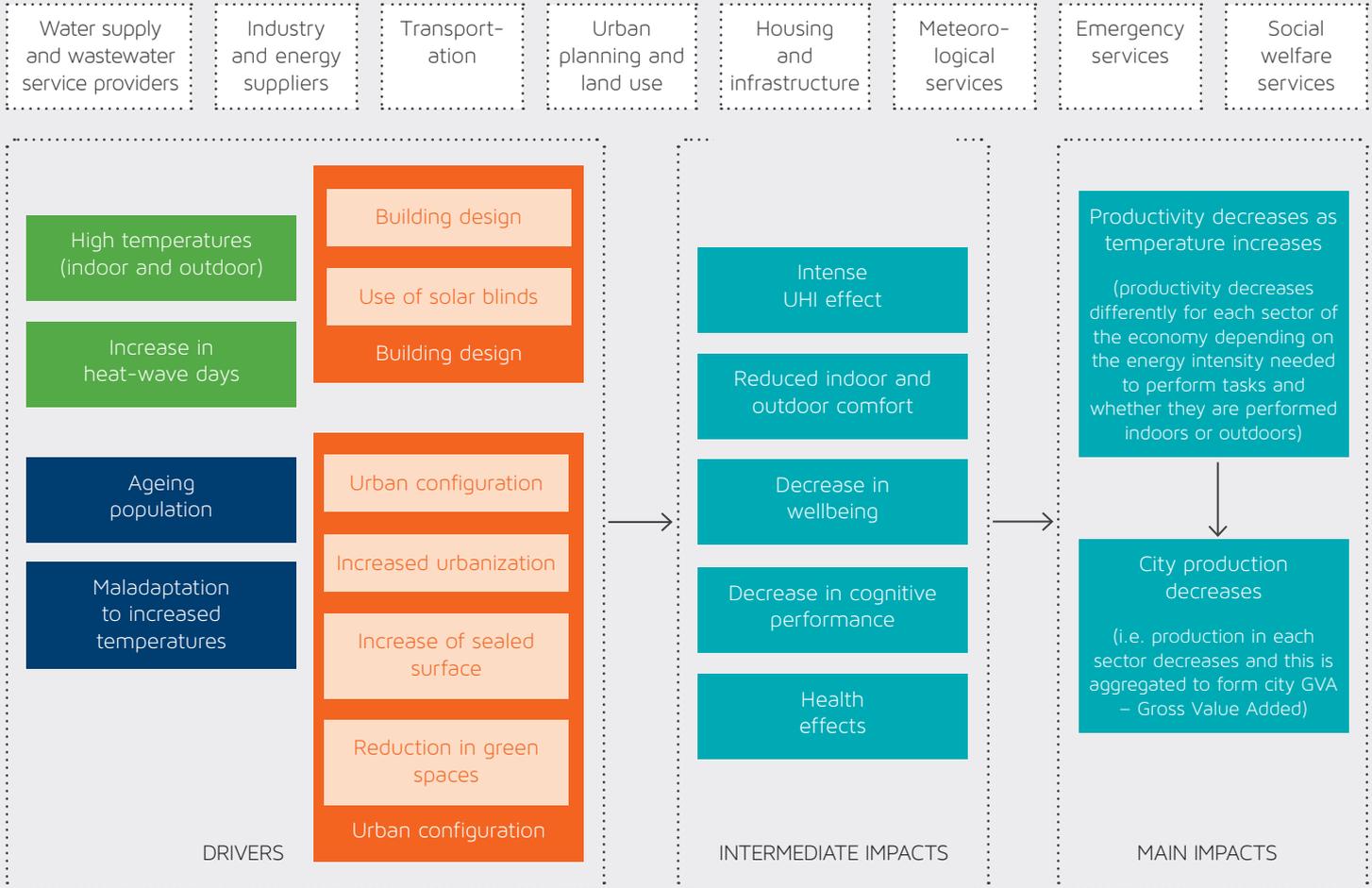
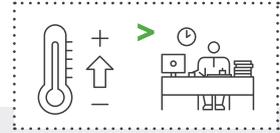


The high temperature in urban built environments is one of the most relevant climate hazards affecting the population. In order to mitigate this climate risk, a combination of climatic drivers, such as mean radiant temperature, relative humidity, wind speed etc. together with non-climatic drivers that influence outdoor heat (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 aforementioned effects cause an increase in thermal discomfort at pedestrian level, aggravate pre-existing heat-sensitive conditions and reduce work productivity among others. Some adaptation options are to control the urban density, convert vehicular streets into green pedestrian promenades, and influence urban planning regulations (i.e. orientation of the district, ratio aspect H/W of urban canyon etc.) and urban decision-making (e.g. close some streets to vehicular traffic and create pedestrian promenades etc.).

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Example Box 3:

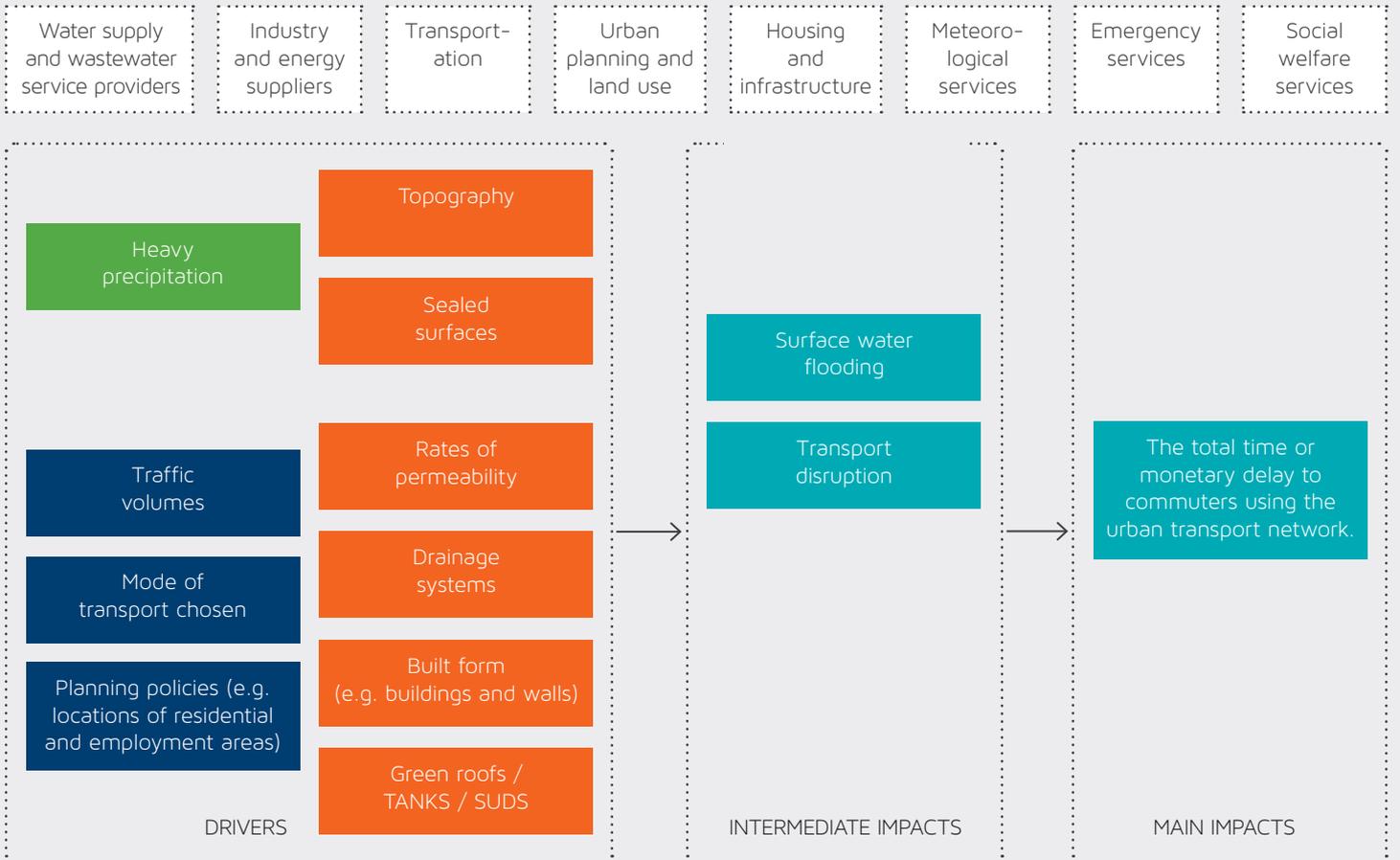
# Heat to work productivity impact chain



The main drivers for heat stress in 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 and high percentage natural surfaces replaced by built surfaces, as well as the lack of green spaces that provide shade, make temperatures higher than in surrounding areas. In the future, these temperatures are likely to increase even more. High temperatures reduce indoor and outdoor comfort for workers and hinder their cognitive performance and ability to carry out tasks, resulting in productivity loss. Productivity decreases are different for each economic sector, depending on the physical energy needed to perform each task and whether tasks are performed indoors or outdoors. Productivity decreases result in lower production in the form of a lower city GVA (Gross Value Added).

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Example Box 4:  
 Pluvial flood to traffic disruption impact chain

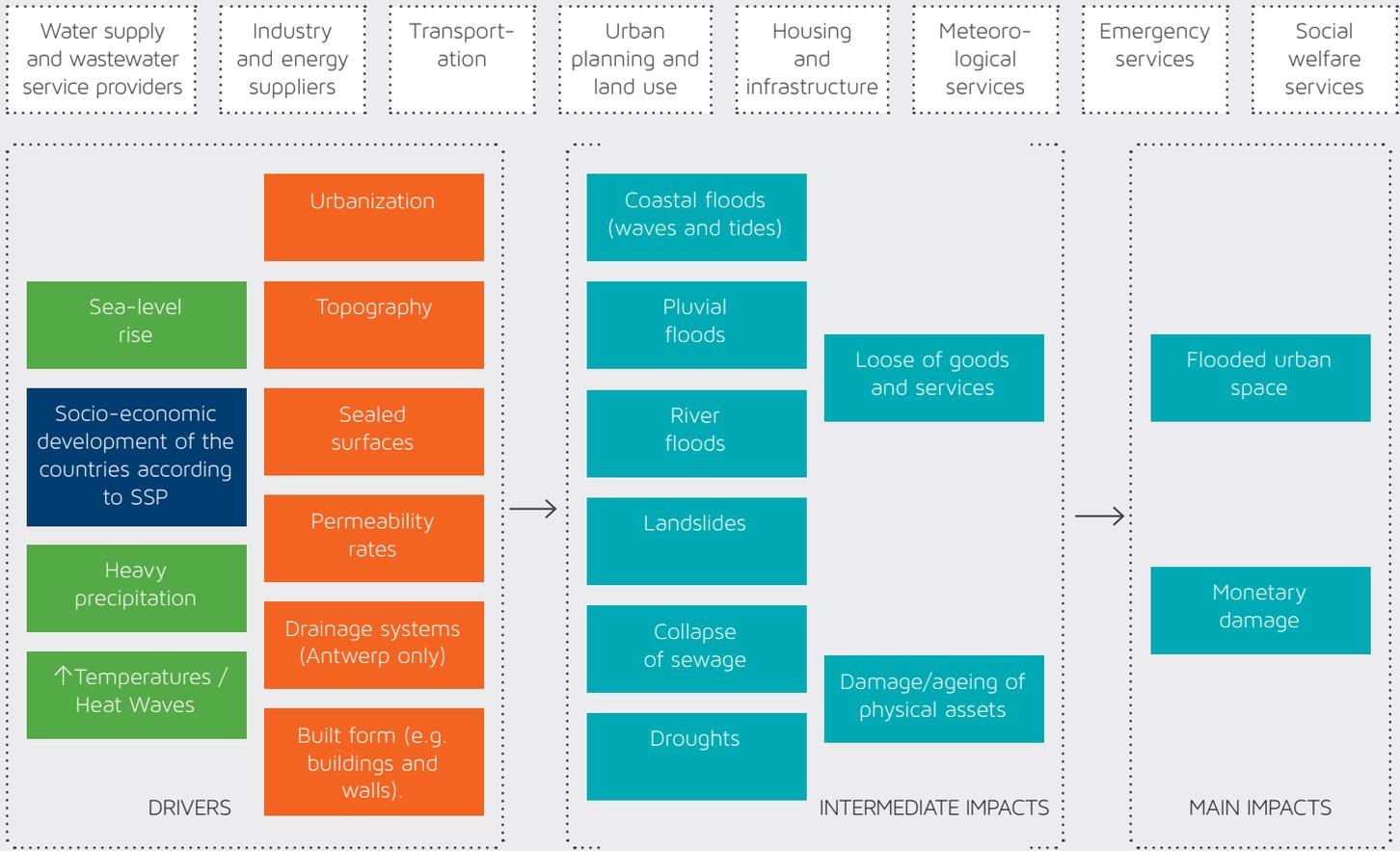


Extreme rainfall events, caused by convective storms, are likely to become more frequent and intense as the climate warms. This will lead to greater disruption in the future. Cities are particularly vulnerable to these events due to the number of sealed surfaces in urban areas, and the concentration 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 (Sustainable Urban Drainage Systems). 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.

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Example Box 5:

# Flood to built environment impact chain



Global climate change is expected to have an intensifying effect on natural hazards. One example would be an increasing risk of coastal flooding due to the joint effect of sea level rise and altered cyclone activity. These climatic drivers, together with other non-climatic drivers like the socio-economic development of the countries (according to the SSP - Shared Socio-Economic Pathways), the topography, drainage systems, permeability, built form etc. increase the probability of damages and losses due to floods. From the different exposure measures available (e.g. potential land-area flooded or number of people affected), potential economic losses from flooding have gained particular importance in literature due to the large concentrations of capital-intensive infrastructure in low-lying areas.

[➔ Back to Step II](#)

“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

 Worksheet 2 of the RAMSES Training Package provides guidance on how to assess the future effects of climate change on your city [follow this link to know more]

3.2 PHASE II: ASSESSING RISKS AND VULNERABILITY

Phase description and key objectives

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 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 follows the risk and vulnerability framework defined by the IPCC in the 5AR (IPCC, 2014).

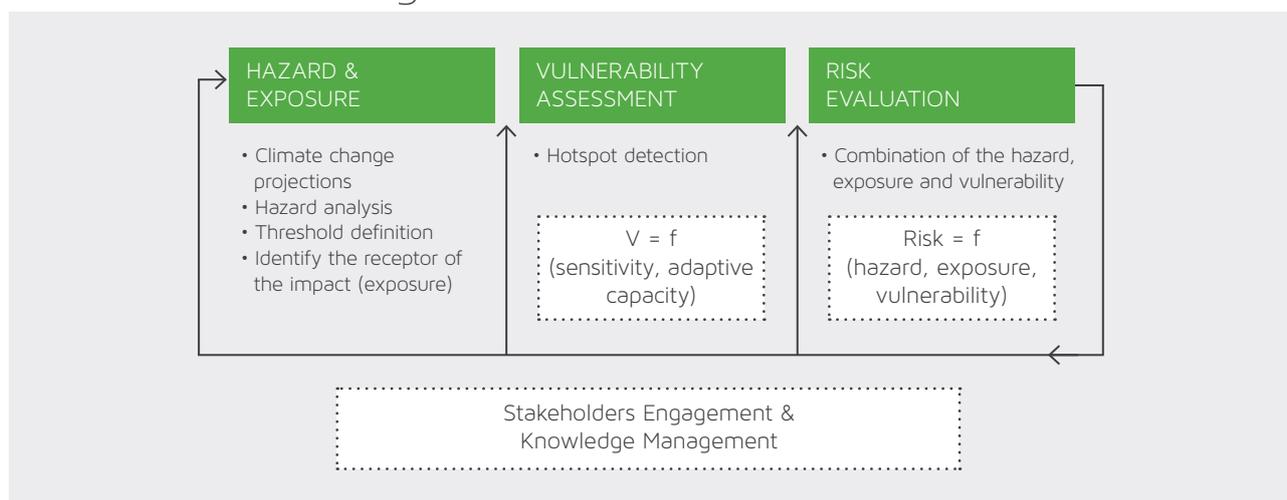
In this phase of the process the idea is addressing the following questions:

- > 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



Step I Hazards and exposure

This first step is devoted to the identification of the key hazards that our city must face and the degree of its exposure to those hazards. The existence of a threat does not necessarily mean being exposed, and therefore being affected. The exposure refers to the presence of people, livelihoods, species or ecosystems, environmental services, resources, infrastructure,

or economic assets, social, or cultural sites that could be affected or adversely impacted by an event.

The following activities will be needed:

- > Climate change projections at the local level
- > Impacts modelling and local studies (hazard analysis)
- > Threshold definition
- > Identify/localise the receptor of the impact (exposure)

PHASE I  
PHASE II  
PHASE III  
PHASE IV  
PHASE V  
PHASE VI



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 571 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, allowing them to compare their future risks with the current day, and to network with other cities facing similar future threats.

Table 2:

Methods and tools for the high level hazard analysis

HAZARD	METHOD/TOOL
Heat	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)
Pluvial flood	CityCat (hydrodynamic surface water flood model and the 25m resolution DEM, forced with future hourly rainfall for a 10 year return period)
Fluvial flood	10 year return levels of annual maximum daily discharge
Drought	Drought Severity Index (it is based on cumulative monthly precipitation anomalies and is calculated for a 12-month timescale)

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 GCMs (Global Climate Models) are used to develop future climate projections (for the end of the century, 2081-2100) and drive impact models. For all GCMs, 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 for temperature and precipitation. The refined climate projection has been developed for 9 cities: Antwerp, Bilbao, London, Rio de Janeiro, Hyderabad, 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 3:  
Flood and heat models/methods

HAZARD	PLUVIAL FLOOD	COASTAL FLOOD	HEAT	HEAT	HEAT
Name of the model/method	CityCAT	EUROSURGE	UrbClim	UrbClim High Res	ENVI-met
Type	Hydrodynamic surface water flood model with linked hydraulic subsurface simulation.	The model combines extreme value statistics of sea-levels with flood damage functions. It is a transferable top-down approach.	Urban climate model	High resolution modelling of human comfort	ENVI-met is an urban climate simulation program, specifically developed to study the urban microclimate.
Short description	Simulates surface water flow from extreme rainfall.	Core to the model are the flood damage functions for cities, which base on the urban extent and simple bathtub-flood modelling.	UrbClim downscales large scale weather data to agglomeration-scale, and calculates the effect of urban development on the most important weather parameters.	Combination of UrbClim meteorological output with high resolution incoming solar radiation, taking into account shading effects of buildings and vegetation.	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.
Output	Flood water depth and velocity in the domain at multiple time steps.	Expected damage	Temperature maps and maps of the number of heat-wave days in urban agglomerations for current and future climate	Maps of human exposure indices (WBGT, Tmrt, PET) at very high resolution (few meters)	ENVI-met is a 3D microclimate modelling software, used to calculate numerous meteorological factors (surface temperature, mean radiant temperature, relative humidity, air temperature) as well as thermal comfort quality (PET/PMV) within an urban area.
Time resolution	One rainfall event – can be from 30 minutes to 6 hours, depending on spatial resolution and rainfall data	Annual	Periods of 20 years	1 hot moment during a summer (noon of the warmest day of the summer)	Typical/extreme summer/winter day/s.
Coverage / resolution	City-scale, 1-5m resolution.	European coasts, 140 coastal cities, CORINE resolution.	250m or 100m resolution, for a domain of approx. 50km x 50km. Within RAMSES, maps of 102 European cities have been made	5m resolution for a domain of approximately 50km by 50km. Within RAMSES, a map of Antwerp has been composed	It has a high spatial resolution (about 0.5 x 0.5 m). Used for simulating the surface-plant-air interactions

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PHASE I

PHASE II

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continuation previous page

Table 3:  
Flood and heat models/methods

HAZARD	PLUVIAL FLOOD	COASTAL FLOOD	HEAT	HEAT	HEAT
Name of the model/method	CityCAT	EUROSURGE	UrbClim	UrbClim High Res	ENVI-met
Benefits	High speed, high resolution, considers urban characteristics.	A top-down approach allows studying the impact to cities in a systematic way, which allows the consideration of many cities (in contrast to case studies). The advantage is comparability and transferability.	High resolution maps of urban climate; fast model, hence time periods of 20 years can be considered; both current and future climate; easy to assess the influence of large green spaces in the city (parks...)	Very high resolution maps of human exposure and discomfort during extreme heat episodes; assessment of shading effect of individual buildings and trees	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.
Type	Computationally- and data-intensive (runs on Cloud).	Compared to case studies, lower level of detail.	Not suited for very high resolution (individual trees, small ponds...)	Only a short time frame can be dealt with (hour with maximal heat stress in a summer)	Time consuming in the simulation and the elaboration of the data through other software (i.e. Leonardo)

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The required input data for the hazard analysis is summarized in Table 4, which presents 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 ...).



Image: woodmonkey photography

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Table 4:

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

HAZARD	PLUVIAL FLOOD	COASTAL FLOOD	HEAT	HEAT	HEAT
Name of the model/method	CityCAT	EUROSURGE	UrbClim	High Resolution module of UrbClim ("UrbClim High Res")	ENVI-met
Climate input	<p>Time series for rainfall event during duration of flood simulation in mm/hr. This can also vary spatially across the model domain.</p> <p>These intensity rates are adjusted for future climate, either through downscaling (e.g. using a stochastic weather generator) or through uplifting factors.</p> <p>For London, downscaled climate parameters are available, but care must be taken over extremes, which are not well captured due to reliance on past observations.</p> <p>Uplifting factors are currently being tested (see Kendon et al, 2012) to scale current return period intensities to future climate projections.</p>	<p>Extreme value parameters of sea level records at sites close to the considered cities.</p>	<p>3-hourly meteorological input.</p> <p>Current climate: reanalysis datasets of ECMWF (European Centre for Medium-Range Weather Forecasts)</p> <p>Future climate: output of global climate models (GSMs)</p> <p>Meteorological parameters: temperature, wind speed, solar radiation, heat fluxes, humidity, precipitation, soil temperatures and moisture</p>	<p>Same as UrbClim</p>	<p>Location Longitude Latitude</p> <p>Meteorological parameters: temperature, wind speed, solar radiation, heat fluxes, humidity, precipitation, soil temperatures</p>
Model input	<p>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).</p>	<p>Land-cover and -use data, elevation model.</p>	<p>DEM, land use, soil sealing, vegetation. All of these can be taken from open source datasets.</p>	<p>3D building information, location of trees</p>	<p>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.</p>

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## 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, Trmrt, UTCI). Each comes with their own advantages and disadvantages. For general understanding, it is best to convert these technical indices to a simple 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).

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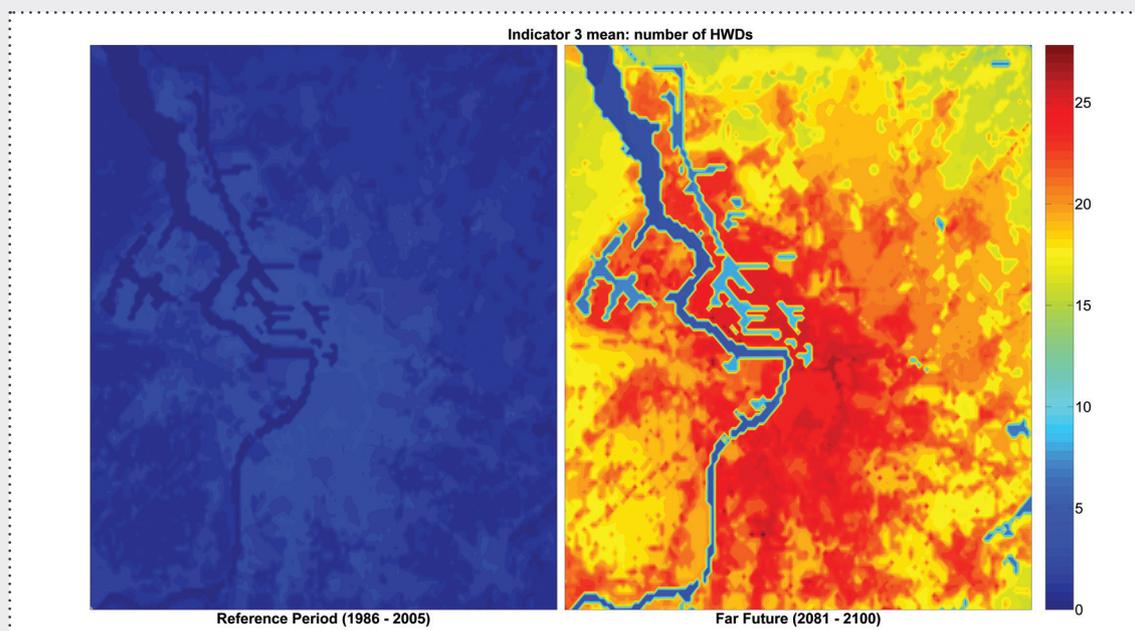
## Example boxes

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 on 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.



A simulation video developed by VITO shows the Mean Radiant Temperature (heat comfort indicator) for a very hot day in the city of Brussels, Belgium. Green locations have lower heat stress, while red locations report the highest heat stress. Two general considerations can be made. First, the more we move towards a high-density built environment, the more the values for MRT increase. This implies that MRT tends to show higher values within the central urban area, while these gradually decrease towards peripheral areas and the countryside. Second, within the central urban area, MRT tends to have lower values in green spaces such as parks.

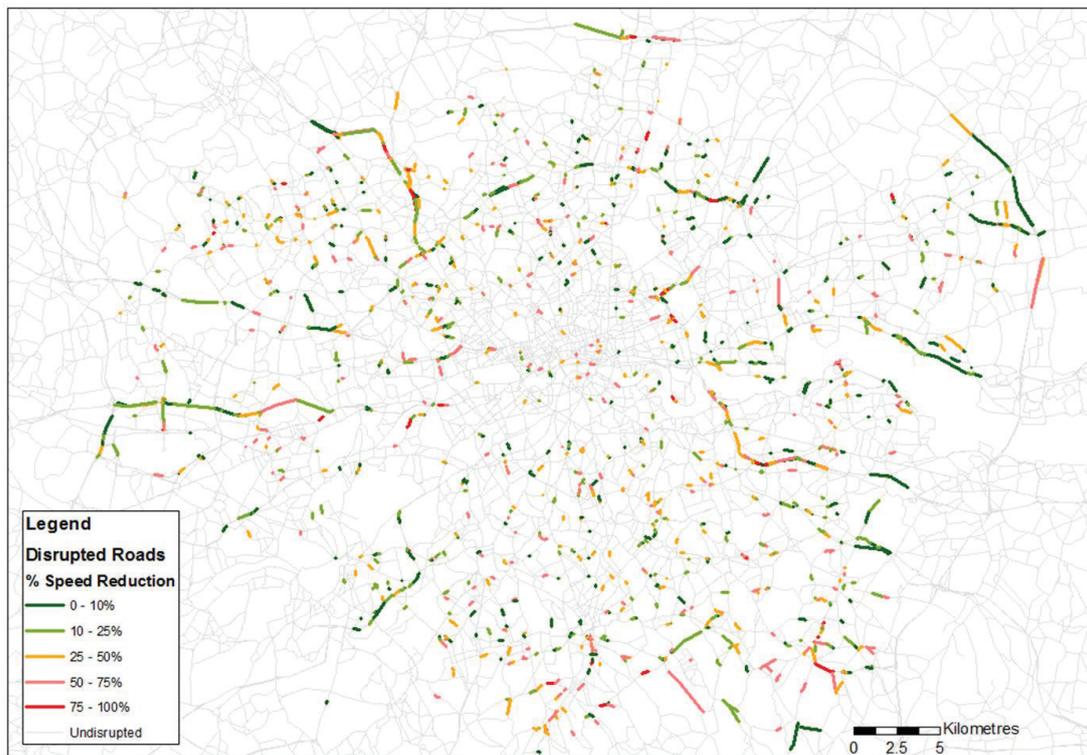
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Example Box 7:

## 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, and the concentration of people and assets in urban areas. 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.

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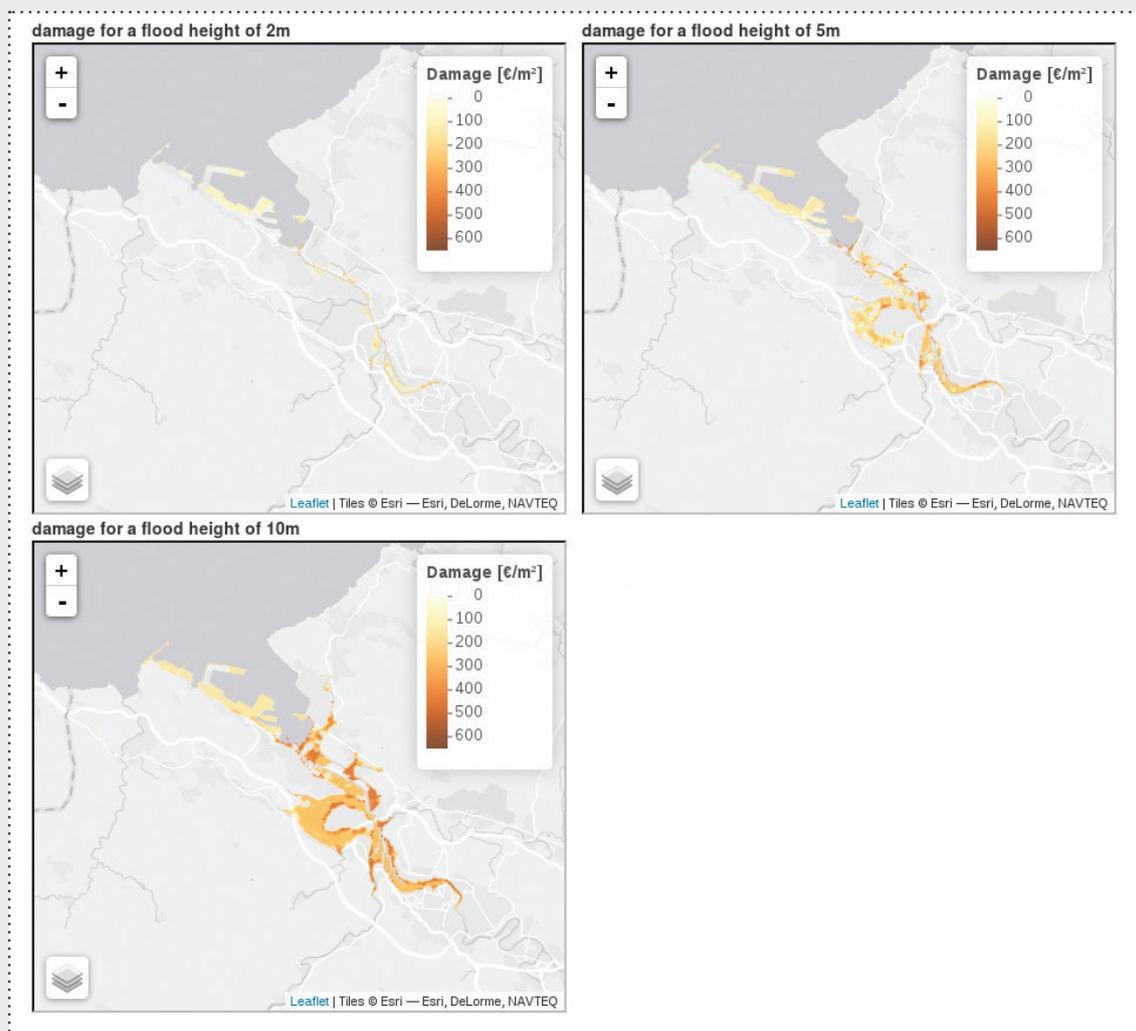


Example Box 8:

## 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.



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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 time 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 hot spell duration. In 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 (WI) 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.

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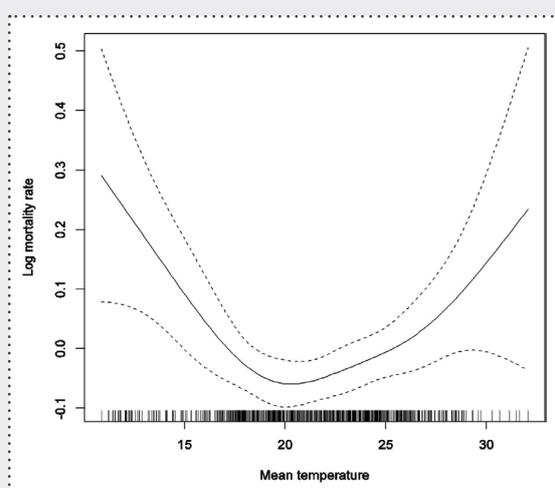


Example Box 10:

## Heat and health threshold: The relationship between $T^{\circ}$ and mortality

This example shows 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.



Adjusted relationship between lag 0-3 mean temperature and mortality for the period 2007-2011 during the warm season (1 May-30 September). Cubic regression spline (pointwise 95% confidence bands) describing the relationship on a logarithmic scale.

Mean (95th percentile) of the warm season (1 May-30 September) daily mean temperatures in degrees Celsius by time period and climate model.

Time period	Median	Minimal	Maximal
1986-2005	20.7 (27.4)		
2026-2045	22.9 (30.0)	21.6 (28.9)	22.9 (30.2)
2081-2100	26.1 (35.1)	24.6 (32.4)	28.5 (37.7)

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“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

To understand this step, firstly it is important to clarify one of the key concepts in climate change adaptation; the vulnerability concept<sup>6</sup>. It refers to the propensity or predisposition of a given system to be affected by a threat. The **vulnerability** of a territory depends on the sensitivity or susceptibility to damage and the ability of such territory to cope and adapt.

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

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 whatever other organism 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



Worksheet 3 of the RAMSES Training Package provide guidance on how assess vulnerabilities in your city [follow this link to know more]

## 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.

RAMSES assessed urban vulnerabilities for the following impact chains: (i) heatwaves on human health; (ii) flooding (pluvial, fluvial and coastal) on the socio-economic tissue and the urban fabric, and; (iii) drought on water planning. 61 sensitivity and adaptive capacity indicators have been collected and then combined with a simple utility function to benchmark the sampled cities against each other. Results shed light on the key challenges that specific groups of cities face in order to better deal with the expected impacts at a European level. This knowledge is a necessary step towards the development of effective EU policies for urban adaptation.

### 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 project case study cities. The hotspot detection aims to detect the most vulnerable assets 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 assessments, which address context-specific situations with more detailed data (detailed analysis), and the kinds of analyses possible for global VA (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.

<sup>6</sup> Vulnerability assessment is a complex process that could be approach from many different perspectives and methodologies. In this handbook we are refereeing to IPCC 2014.



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 derive in an Urban Climate Analysis Map (UC-AnMap) where the urban area is classified in zones with similar impacts 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 UC-AnMap. 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 (e.g. the construction sector has low elasticity – difficult to exchange labour for capital – and high labour shares – more labour relative to capital). The three 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 metrics 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 Pregolato, M. et al., 2016, for full details: <http://rsos.royalsocietypublishing.org/content/3/5/160023>)

### 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.

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### 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 modeling, and on the other from the analysis of exposure and vulnerability.

$$\text{Risk} = \text{probability (threat)} \times \text{consequence f (exposure, vulnerability)}$$

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 their description. It involves identifying threats, potentially impacted areas and their possible causes and consequences. All this information is obtained 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 analysis, 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 summarize, compare and prioritize risks, the results of a risk analysis are often classified according to an ordinal scale, for example a value from 1- 5; or low, medium, high. Having analyzed the risks and estimated their 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 WGII AR5 (IPCC, 2014).

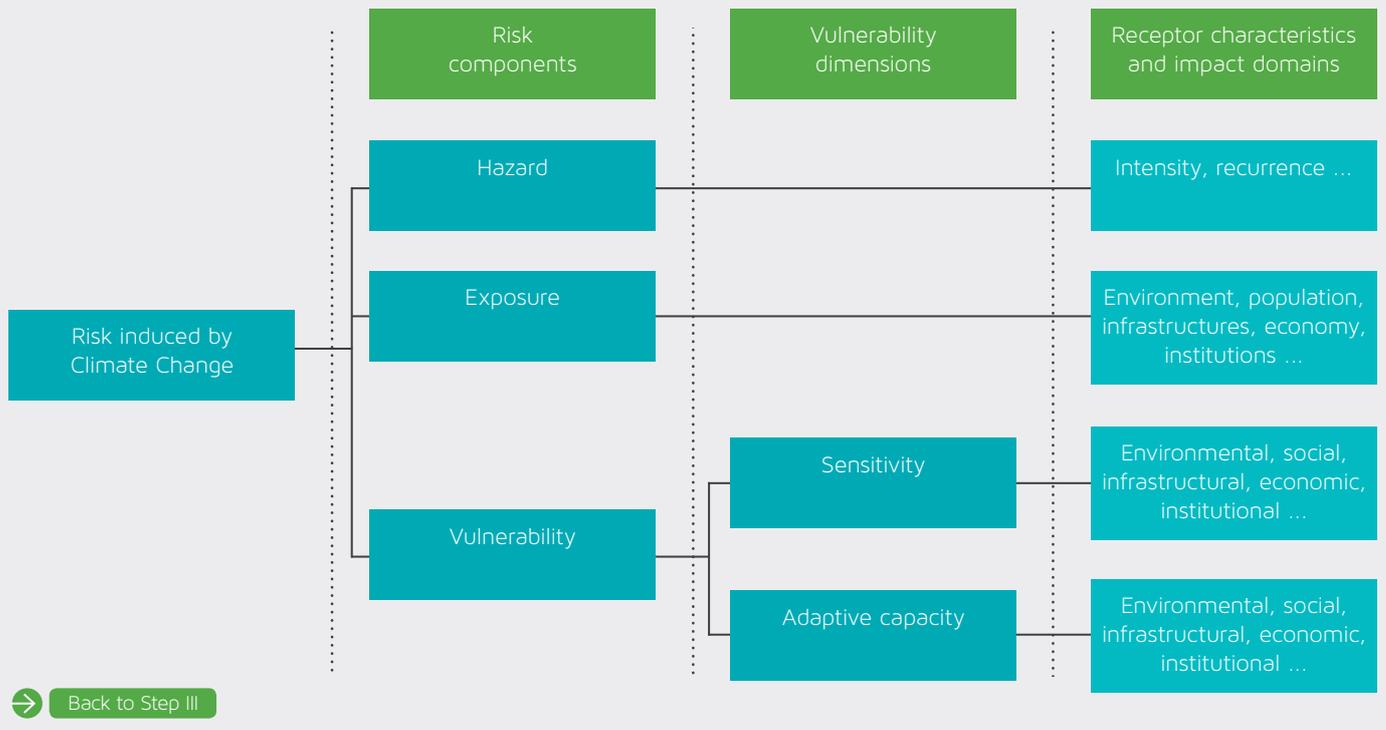
The hazard, exposure and vulnerability indicators have been combined to inform on the relative level of risk faced by each city under each impact chain (Figure 6). A risk score,  $R_{ct}$ , for each city,  $c$ , and climate change threat,  $t$ , is calculated as:

$$R_{ct} = \sqrt[3]{H'_{ct} \times V'_{ct} \times E'_{ct}}$$

where the standardised hazard score  $H'_{ct}$ , standardised exposure score  $E'_{ct}$  and standardised vulnerability score  $V'_{ct}$  are aggregated as a risk score  $R_{ct}$ .  $R_{ct}$  is standardised and re-scaled for visualisation as  $R'_{ct}$ .

Thus, the risk indices have been generated as the intersection of hazard, exposure and vulnerability scores.

Figure 6:  
The operational framework developed within the high level vulnerability and risk analysis for European cities



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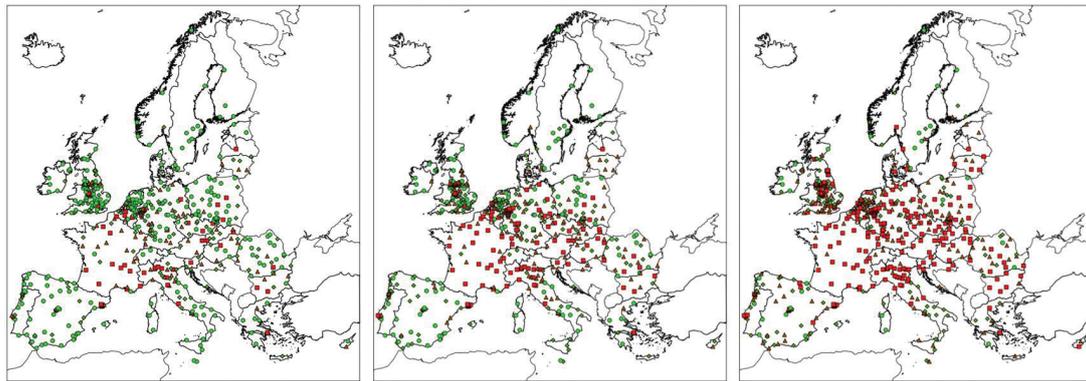




Example Box 12:

## 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 those 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.

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“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



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]



3.3 PHASE III: IDENTIFYING ADAPTATION OPTIONS

Phase description and key objectives

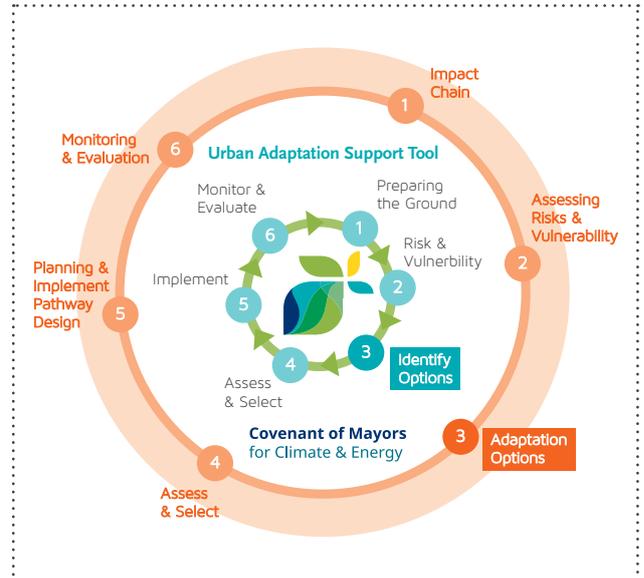
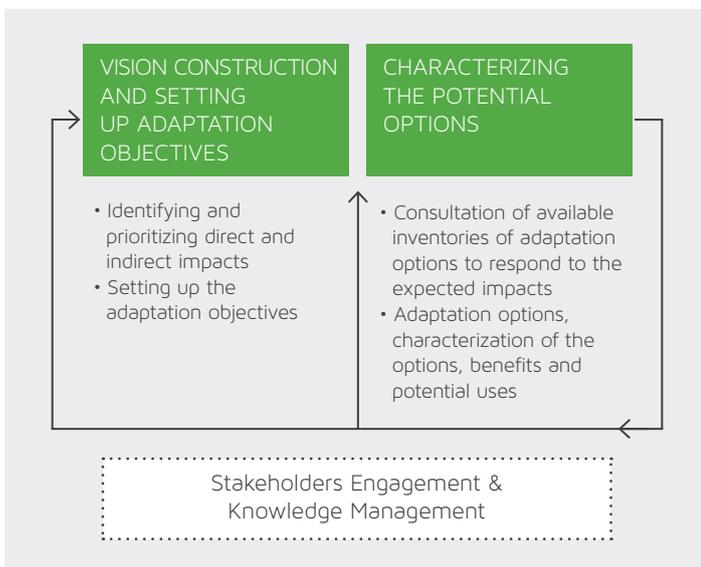
This phase of the RAMSES framework aims to identify a wide range of adaptation options to address the previously identified concerns, in order to bring negative impacts to an acceptable level, or to take advantage of any positive opportunities that arise from climate change.

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

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

Steps to follow

Figure 7:  
Phase III: Identifying adaptation options



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

## Methods and tools applied in RAMSES case studies

Figure 8:

### The methodology and steps followed in the exercises

After vulnerabilities have been identified for a particular city, the next step consists of converting the previous hotspots/challenges of the impact chain into positive statements (combining elements inspired by 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 the vision of the city for the future

#### 3. Vision:

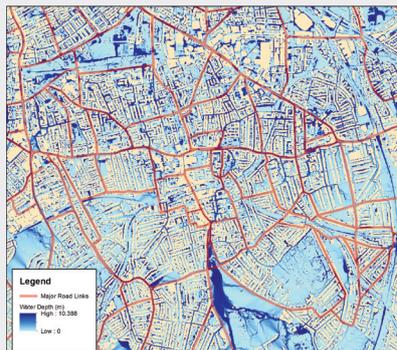
Framework of generic visions and elements combined in order to convert previous hotspots into positive statements about the future resilient city

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Example Box 13:

### Flood models support cities in assessing the 'hotspots' where flood hazard coincides with high exposure

Work Package 3 of RAMSES has been developing ways to assess the impacts of extreme weather events on cities using a modelling framework developed at Newcastle University. Deliverable 3.4 demonstrates the use of models of surface water flooding, driven by simulations of future extreme rainfall events, to assess the potential areas of highest risk in cities. We demonstrate how such modelling can help city decision-makers assess the



'hotspots' in the city where flood hazard coincides with high exposure (important infrastructure and assets) and high vulnerability (determined from damage functions relating to the performance of the infrastructure under flooded conditions). By the use of such detailed modelling of flooding that takes into account urban topography, land-use, and buildings, adaptation options have been tested and their effectiveness measured. This allows the comparison of different adaptation measures and assists with understanding the effectiveness of traditional hard engineering approaches with green or soft adaptation.

D3.4 can be retrieved from: <http://ramses-cities.eu>

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## Example boxes

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

Table 5:  
Objectives and evaluation criteria defined in  
RAMSES for each impact chain

IMPACT CHAIN	MAIN ADAPTATION OBJECTIVES DEFINED IN RAMSES	EVALUATION CRITERIA
Human health to heat	<ul style="list-style-type: none"> <li>Avoid all heat-related mortality and morbidity; however, this seems unfeasible in light of the existing evidence e.g. (Toloo et al., 2013).</li> <li>Maximizing human comfort</li> </ul>	<ul style="list-style-type: none"> <li>Reduction in heat-related mortality</li> <li>Reduction in heat-related hospital admissions</li> <li>Reduction in selected heat-related morbidity outcomes (depending on the information available)</li> <li>Human comfort indices (WBGT, PET...)</li> </ul>
Urban comfort to heat	<ul style="list-style-type: none"> <li>Maximal decrease in the nightly temperature difference between city and rural surroundings</li> <li>To reduce the thermal stress in the urban environment about 1 or 2 two PET thermophysiological assessment classes during the daily maximum values</li> </ul>	<ul style="list-style-type: none"> <li>Temperature reduction in the city centre</li> <li>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)</li> <li>Benefits in reducing the Mean Radiant Temperature and Surface temperature level in the urban environment.</li> </ul>
Work productivity to heat	<ul style="list-style-type: none"> <li>Decrease or avoid productivity reductions because of high temperatures</li> <li>Lower cooling demands in office buildings</li> </ul>	<ul style="list-style-type: none"> <li>Reduction in production (through reduction in productivity losses) because of each adaptation measure</li> <li>Cooling costs in office buildings</li> </ul>
Traffic disruption to flood	<ul style="list-style-type: none"> <li>Reduction in overall traffic delay</li> </ul>	<ul style="list-style-type: none"> <li>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.</li> </ul>
Built environment to flood	<ul style="list-style-type: none"> <li>Reduce damages from coastal floods.</li> </ul>	<ul style="list-style-type: none"> <li>Given a planning horizon, investment (and maintenance) costs can be compared with upcoming damage</li> </ul>

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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

### Step II Characterization of potential adaptation options

Adaptation measures are very diverse and can range from those aimed at strengthening resilience (e.g. sharing information, building institutional support etc.) to concrete adaptation measures and technical solutions, to 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

### Methods and tools applied in RAMSES case studies

In the following table, additional adaptation measures assessed (effectiveness or cost-assessment) in RAMSES are presented.

Image: Terenzi / RAMSES





Table 6:

## Grey adaptation options for heat waves

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

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

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Image: Peleikis / RAMSES



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Table 7:

## Green and soft adaptation options to heat waves

TITLE OF THE ADAPTATION OPTION	GENERAL DESCRIPTION	CLIMATE THREAT	TYPE (IPCC CLASSIFICATION)	GEOGRAPHY	STUDY LOCATION	SCALE	TYPE OF ASSET (TARGET)	SECTOR	TYPE OF URBAN CONFIGURATION	PERFORMANCE ANALYSIS
Greening (neighbourhood)	Greening at the scale of neighbourhoods within the city	Heat waves	Ecosystem based: green - blue	Northern - western Europe	Antwerp	District/ neighbourhood	Residential	Health	Other	Effectiveness
Greening (park)	Impact of parks on the surface (i.e. radiative) temperature	Heat waves	Ecosystem based: green - blue	Northern - western Europe	Antwerp (Stads-park)	District/ neighbourhood	Recreation, leisure, sport	Health	Compact mid-rise (highly sealed)	Effectiveness
Greening (park)	Impact of parks on air temperature	Heat waves	Ecosystem based: green - blue	Northern - western Europe	Antwerp (Stads-park)	District/ neighbourhood	Recreation, leisure, sport	Health	Compact mid-rise (highly sealed)	Effectiveness
Greening by trees on a square	Impact of trees on human thermal comfort (which is expressed using the Predicted Mean Vote (PMV))	Heat waves	Ecosystem based: green - blue	Northern - western Europe	Antwerp (Groen-plaats)	Street	Square	Health	Compact mid-rise (highly sealed)	Effectiveness
Greening scenarios	Comparative analysis of green actions to improve outdoor thermal comfort inside typical urban street canyons	Heat waves	Ecosystem based: green - blue	Southern - central Europe	Bilbao (Basque Country)	Street	Pedestrian street	No specific sector	Compact low rise	Effectiveness
Greening scenarios	Comparative analysis of green actions to improve outdoor thermal comfort inside typical urban street canyons	Heat waves	Ecosystem based: green - blue	Southern - central Europe	Bilbao (Basque Country)	Street	Vehicular street / pedestrian street	No specific sector	Compact mid-rise	Effectiveness
Greening scenarios	Comparative analysis of green actions to improve outdoor thermal comfort inside typical urban street canyons	Heat waves	Ecosystem based: green - blue	Southern - central Europe	Bilbao (Basque Country)	Street	Vehicular street / pedestrian street	No specific sector	Open set high rise	Effectiveness
Changing working hours (Behavioral adaptation)	Changing working hours: from baseline (9h-13h; 14h-17h) to (7h-11h; 17h-20h)	Heat waves	Behavioral	Northern - western Europe	London, Antwerp, Bilbao	City/ village	Population	No specific sector	Other	Benefit

More information can be found in Lobaccaro, G. et al. (2015), Lobaccaro and Acero (2015), Lauwaet, D. et al. (2013) (green options) and in Costa, H. and Floater, G. (2015) (awareness option).

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Table 8:

## Grey, green and technological adaptation options to flood (pluvial, sea level rise)

TITLE OF THE ADAPTATION OPTION	GENERAL DESCRIPTION	CLIMATE THREAT	TYPE (IPCC CLASSIFICATION)	GEOGRAPHY	STUDY LOCATION	SCALE	TYPE OF ASSET (TARGET)	SECTOR	TYPE OF URBAN CONFIGURATION	PERFORMANCE ANALYSIS
Green roofs, road re-engineering	Implement 100% of green roofs in a city vs protection of a single key road junction from flooding	Pluvial flooding	Eco-system based: green - blue	Northern Europe	Newcastle	City / village	Vehicular street	Critical infrastructure	Open midrise	Effectiveness
Full permeability	Increasing city permeability from fully impermeable to fully permeable	Pluvial flooding	Structural / Physical (Grey)	Northern - western Europe	London	City / village	Pavement, land cover	No specific sector	Other	Benefit
Airbrick cover, manual	With a height protection of 0.6m above the threshold of the property (current industrial standard)	Pluvial flooding	Structural / Physical (Grey)	Northern - western Europe	England	Building block	Building	Construction	na	Benefit
Demountable doors guards, manual	Manual activation with height protection of 0.6 m above the threshold of the property (current industrial standard)	Pluvial flooding	Technological	Northern - western Europe	England	Building block	Building	Construction	na	Benefit
Beach nourishment	Kardamaina is a sandy beach. The length of the examined area is 615m. It was assumed a replenishment flow of 154 m <sup>3</sup> /m and 3.3 replenishments until 2100. 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 to the indigenous sediment.	Sea level rise and storm surge	Structural / Physical (Grey)	Mediterranean region	Greece	City / village	Construction	Construction	na	Benefit

More information can be found in Costa, H. and Floater, G., 2015; Haskoning UK LTD., 2012; Pregonato, M. et al. (2016) (pluvial flood) and in Kontogianni et al. (2014) (sea level rise).

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Worksheet 5 of the RAMSES Training Package provides guidance on how to identify and select adaptation options for your city [follow this link to know more]

**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**

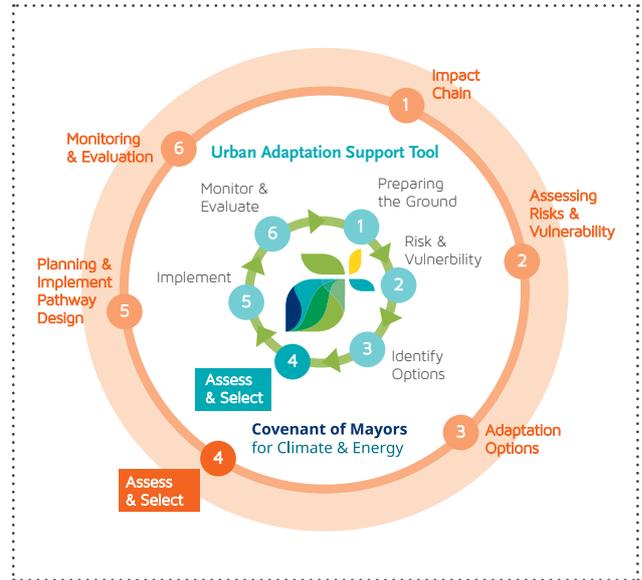
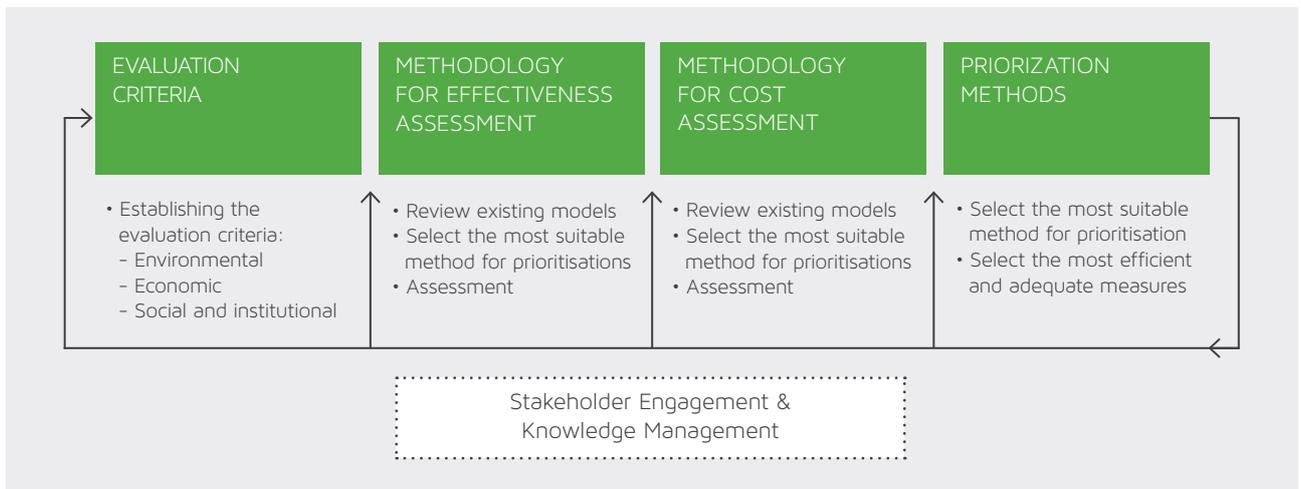


Figure 9: Phase IV: Assessing and selecting adaptation options



**Step I Establishing the evaluation criteria**

The aim of this 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 effectiveness assessment

**Environmental criteria:** the main indicators of environmental criteria are effectiveness and flexibility. **Effectiveness** expresses whether or not adaptation measures reduce the impact of and/or enhance opportunities that may arise from climate change. Flexibility expresses the ability of the adaptation option to reduce risks or enhance opportunities under a range of different climatic conditions (Wijaya, 2015).

The effectiveness analysis identified in the literature are: empirical studies based on field measurements (Armson et al., 2012) and simulation through modelling software (Liu, 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).

## Methods and tools applied in RAMSES case studies

The RAMSES effectiveness methodology, simulation through modelling, will be briefly explained and the information set out in the following tables.



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Table 9:

## Adaptation measures effectiveness in heat health and urban comfort

EFFECTIVENESS	HEAT - HEALTH AND URBAN COMFORT
Characteristics of the study	<p>For local measures: 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 needs to be set at least about 44 hours given that the first 20 hours are used to initialize the model and only the last 24 hours can be taken into 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.</p> <p>For city scale measures: it is best to focus on a period 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 these increase in the future), it is good practice to run simulations for longer time-frames (the literature typically recommends at least 20 years: see e.g. the latest IPCC reports) to correctly assess the urban climate.</p>
Main components to take into account	<ul style="list-style-type: none"> <li>• Details of the case study city (location, climatic zone, urban configuration, location of green and blue in and around the city)</li> <li>• 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 (RCP8.5...)</li> </ul>
Scenario description	Comparison of situation with and without adaptation measure: adding an extra park or water body in the city, planting extra trees in a street
Expected outcomes or results	<ul style="list-style-type: none"> <li>• 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, WBGT, 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.</li> <li>• For the city scales we focus on thermal differences within the city and thermal differences between the city centre and the rural surroundings. Again, the outcomes are differences between the reference situation and the adapted case.</li> </ul>
Problems we can have	<ul style="list-style-type: none"> <li>• Effects on different scales require different models, and different adaptation measures have an effect on different scales.</li> <li>• 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).</li> <li>• 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.</li> <li>• Estimation of the effectiveness of the measures comes with large uncertainties, because of             <ul style="list-style-type: none"> <li>• The large uncertainties related to future climate (different scenarios, different models)</li> <li>• It is difficult to quantify the effectiveness in monetary values</li> </ul> </li> </ul>
Model recommendation	<p>Analysis on a city scale, for large measures: meso-scale models (e.g. UrbClim)</p> <p>For very high resolution analysis 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).</p>


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Table 10:

## Adaptation measures effectiveness in heat work productivity

EFFECTIVENESS	HEAT - WORK PRODUCTIVITY
Characteristics of the study	Calculation of indoor productivity loss by combining climate change studies with building energy models.
Main components to take into account	All details regarding the office building (number of floors, height, surroundings, ventilation devices, internal load and much, much more) Meteorological input (current climate and climatic change)
Scenario description	Adaptations concerning the building design (solar blinds, increased natural ventilation...) and behavioral change (relocation office workers in the building, adapted working hours)
Expected outcomes or results	Number of lost working hours inside office buildings: comparison between base case and scenario
Problems we can have	<ul style="list-style-type: none"> <li>• 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).</li> <li>• 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.</li> <li>• 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</li> <li>• Estimation of the effectiveness of the measures comes with large uncertainties, because of               <ul style="list-style-type: none"> <li>• The large uncertainties related to future climate (different scenarios, different models)</li> <li>• Difficulty to quantify the effectiveness in monetary values</li> </ul> </li> </ul>
Model recommendation	Combination of building energy models (e.g. Energy Plus) and meso-scale weather models / weather data

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Image: Peleikis / RAMSES



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Table 11:

## Adaptation measures effectiveness in flood traffic disruption

EFFECTIVENESS	PLUVIAL FLOOD - TRAFFIC DISRUPTION
Characteristics of the study	It is important to first understand the baseline of the system which we are 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.
Main components to take into account	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/size of the adaptation. The adaptation is simulated over a single event, but a number of events under different conditions (different rainfall returns 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.
Scenario description	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.
Expected outcomes or results	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.
Problems we can have	<ul style="list-style-type: none"> <li>• The location of adaptation options is difficult to assess (this is part of what we are doing).</li> <li>• The simulations of traffic disruption are very data intensive and take a long time to run.</li> <li>• There are many possible rainfall scenarios, depending on return period and climate simulation used.</li> </ul>
Model recommendation	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.

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Worksheet 5 of the RAMSES Training Package provides guidance on how to identify and select adaptation options for your city [follow this link to know more]



## Example Box 14:

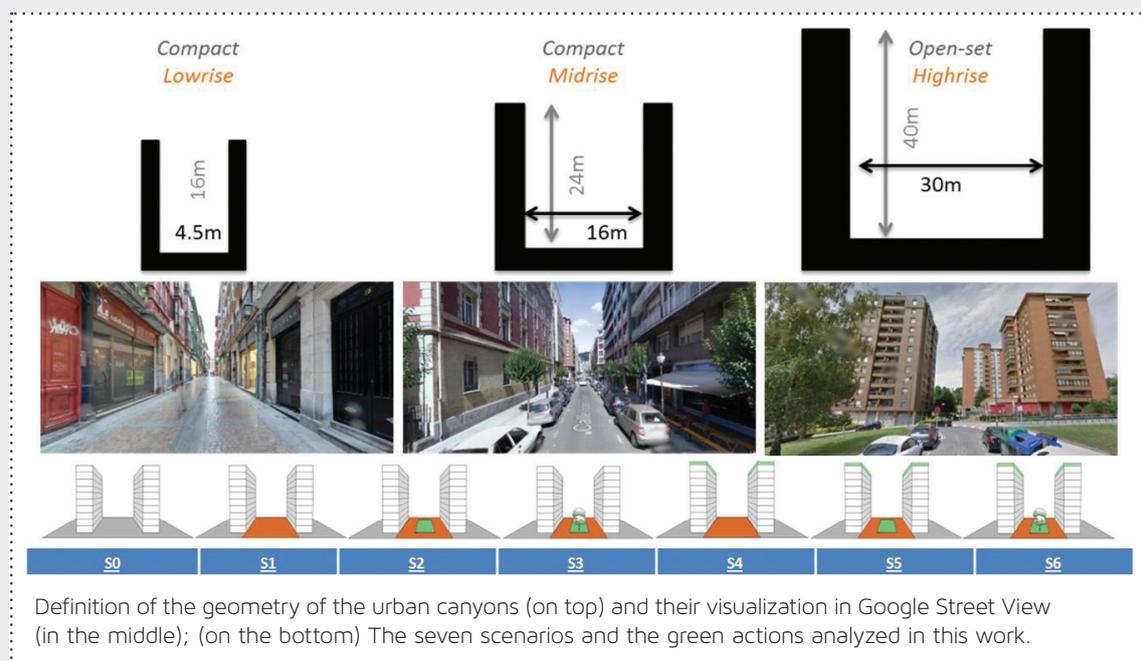
## Effectiveness of adaptation to UHI in Bilbao

The study conducted in Bilbao (Spain), implies a comparative analysis of green adaptation actions to improve outdoor thermal comfort in the hotspot areas of the city. The evaluation was performed in three typical urban street canyons characterized by urban density, which is 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. 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:  $L_2 \{B/T > 0.60 \wedge H/W > 1.5\}$ ; compact mid-rise:  $M_2 \{0.40 < B/T \leq 0.60 \wedge 1.3 < H/W \leq 1.5\}$ ; and open-set high-rise:  $H_2 \{B/T \leq 0.40 \wedge H/W \leq 1.3\}$ .

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/Indautxu (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 mitigating 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:  $H_{tree}/H_{canyon}$  and  $W_{tree}/W_{canyon}$ ) 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 risk of heat waves.



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 + 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.



“We can look at hard engineering, like building walls or a 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 Berrang-Ford, 2013).

### Methods and tools applied in RAMSES case studies

#### EFFICIENCY ANALYSIS

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

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Image: Victoriano Moreno



Table 12:

# Adaptation measures cost-assessment in the heat-health impact chain

## COST-ASSESSMENT : HEAT- HEALTH ADAPTATION

Cost analysis: elements considered	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
Benefit: elements considered	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
Scenario comparison	Different scenarios stem from sensitivity analyses regarding the 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; Unavailable information regarding costing of treatment scenarios Insufficient information on resource unit costs for health adaptation interventions
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.

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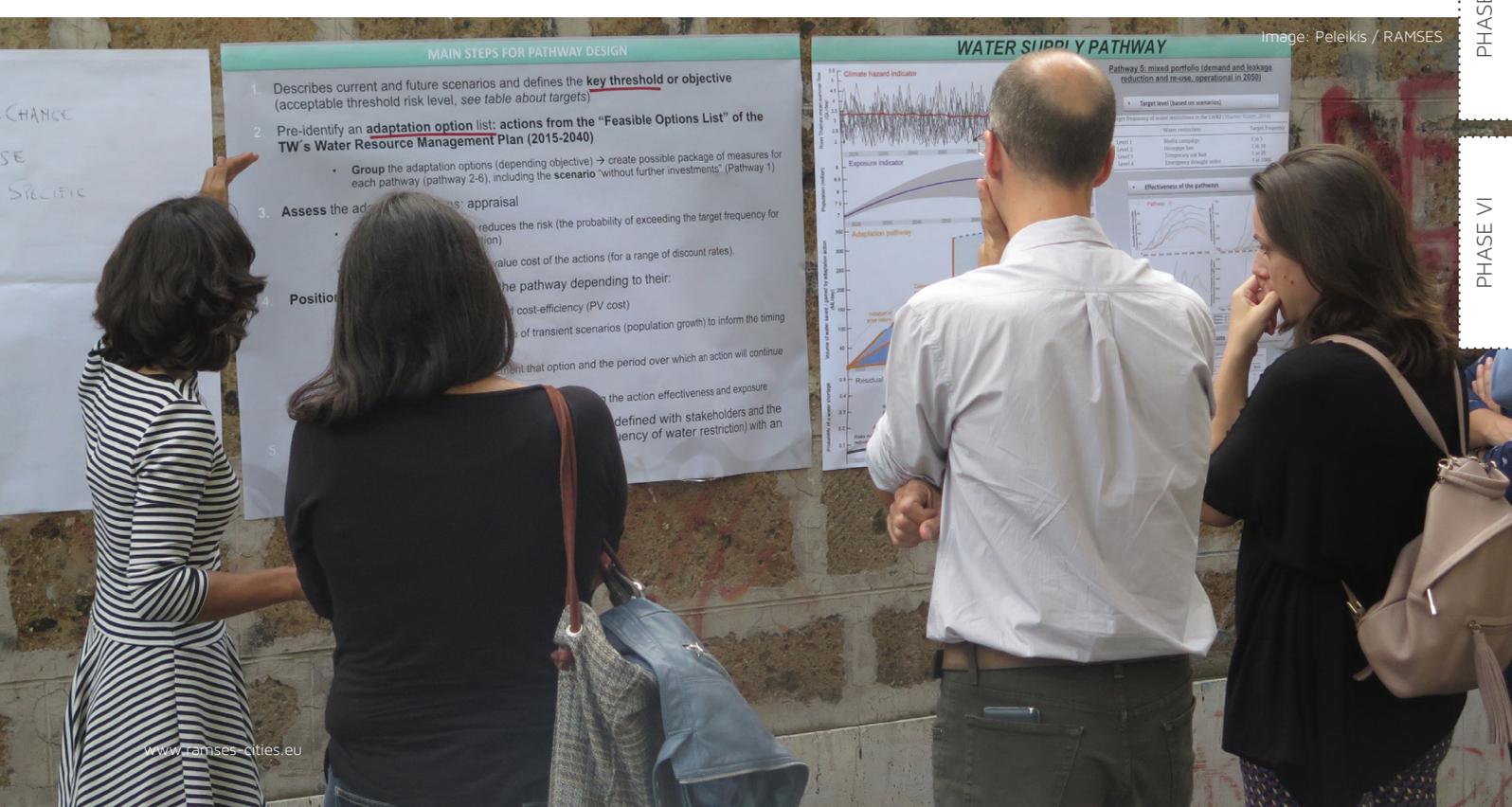


Image: Peleikis / RAMSES



Table 13:

## Adaptation measures cost-assessment in the 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.
Scenario comparison	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)

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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 comparison	Dike 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	<ul style="list-style-type: none"> <li>• Diva model: HinkelJ_PNAS_2014 (dike segments, not explicit for cities, adaptation is dimensioned from some kind of Production Function)</li> <li>• FankhauserS_EnvPlanA_1995: economics of protection vs. retreat.</li> <li>• A more general "macroeconomic" approach could be used for the costs of adaptation</li> </ul>

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Example Box 15:

## Losses in London, Antwerp and Bilbao

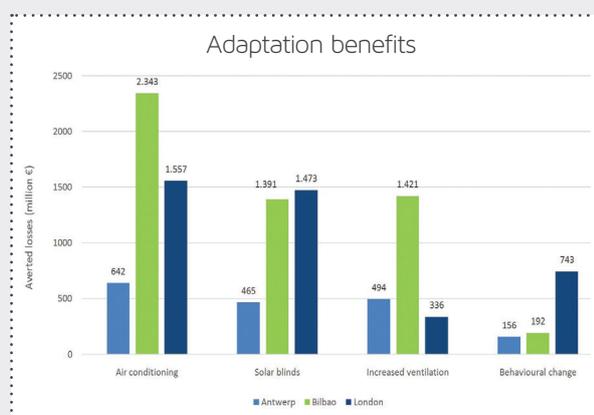
RAMSES has developed a cost methodology that integrates urban climate modelling with labour productivity and economic production. The methodology has been validated in three case study cities: Antwerp, Bilbao and London.

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 of 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.

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: behavioural 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 as 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.

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



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

It is key to first select the most suitable method to perform the prioritization.

- > The most commonly used methods in the context of strictly economic assessments are: Cost-Benefit Analysis (CBA) and Cost-Effectiveness Analysis (CEA). When the decision rationale exceeds 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 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.

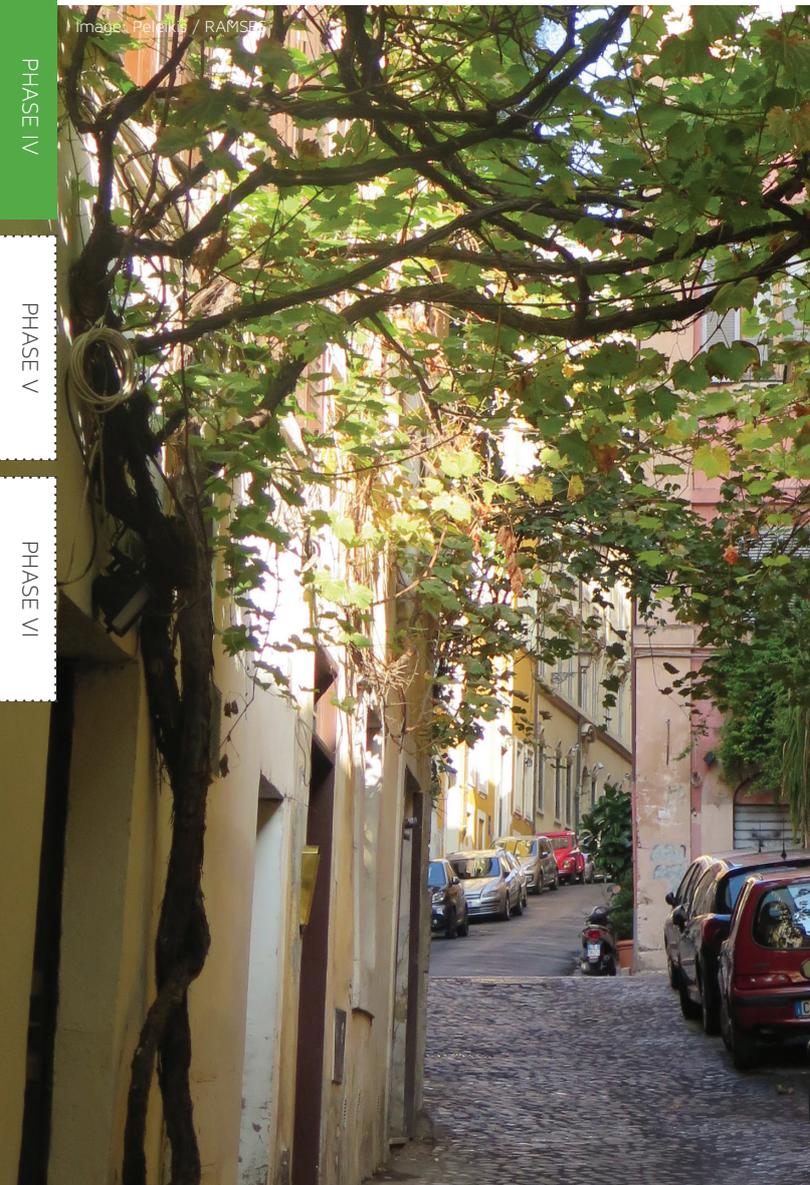
The cost-benefit assessment (CBA) has been used in the coastal flood-built environment impact chain. The reason for using this approach in RAMSES is that CBA is the simplest quantitative approach, also to be presented to stakeholders. Nevertheless, non-monetary (intangible) aspects should not be neglected.

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).

Image: Peleki6 / RAMSES





Example Box 16:

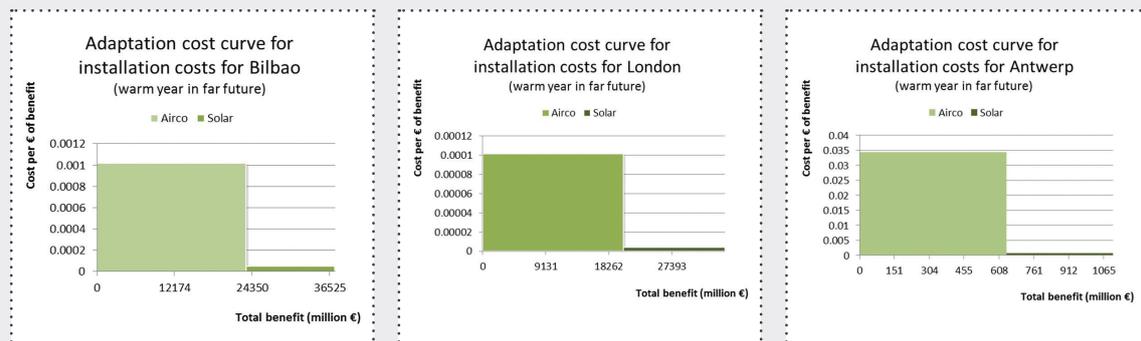
## Adaptation cost curves

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 produced 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 millions of euros. 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.



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Image: Lopez / RAMSES



3.5 PHASE V: IMPLEMENTING

Phase description and key objectives

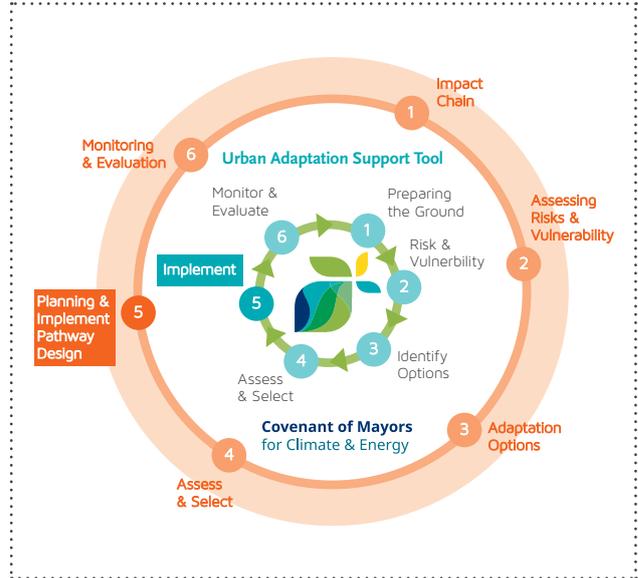
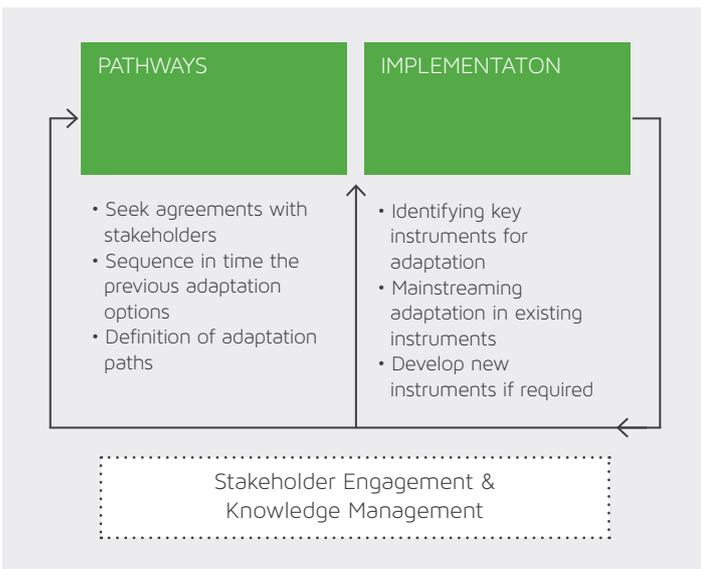
It is important to conceive adaptation as a systemic perspective which does not conclude with a set of actions or measures. In fact, it is necessary to consistently integrate them as part of the national/regional adaptation strategy plans taking into account the existing policies and instruments.

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 I 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 if it 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 pathway.

The following activities will be needed:

**Seek agreements with stakeholders:** To ensure implementation of the strategic framework on adaptation, close collaboration and agreements will be needed with all affected stakeholders during the whole phase. So this activity aims to elaborate a map of key stakeholders appointing roles and responsibilities.

**Identify and make use of entry points for adaptation:** Adaptation should not be performed in isolation from existing policies, management structures or processes. Thus, to allow synergies, instruments in place with relevance to adaptation should be reviewed and key elements selected to cope with strategic objectives.

**Group and sequence the previous adaptation options over time:** Each of the previously identified measures (adaptation options identified in Phase III) need to be grouped depending on the objectives (creating possible adaptation packages or pathways) and sequenced over time (e.g., from now to 2100). To do so, a complementary analysis of temporality is necessary. This includes: (1) When adaptation takes place; (2) the timeframe over which they are relevant (the effective life-time or sell-by date: time span during which the adaptation practice keeps on being effective, after having been implemented); (3) and the lead time.



**Definition of a flexible plan.** One important aspect for adaptation planning is the flexibility. It means that adaptation planning needs to consider measures to be implemented in near-term, while leaving the option open to scale up action in the future. Different tools exist, which cope in a different way with the uncertainty and have 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 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, involves more experts and goes deeper into the pathway design.

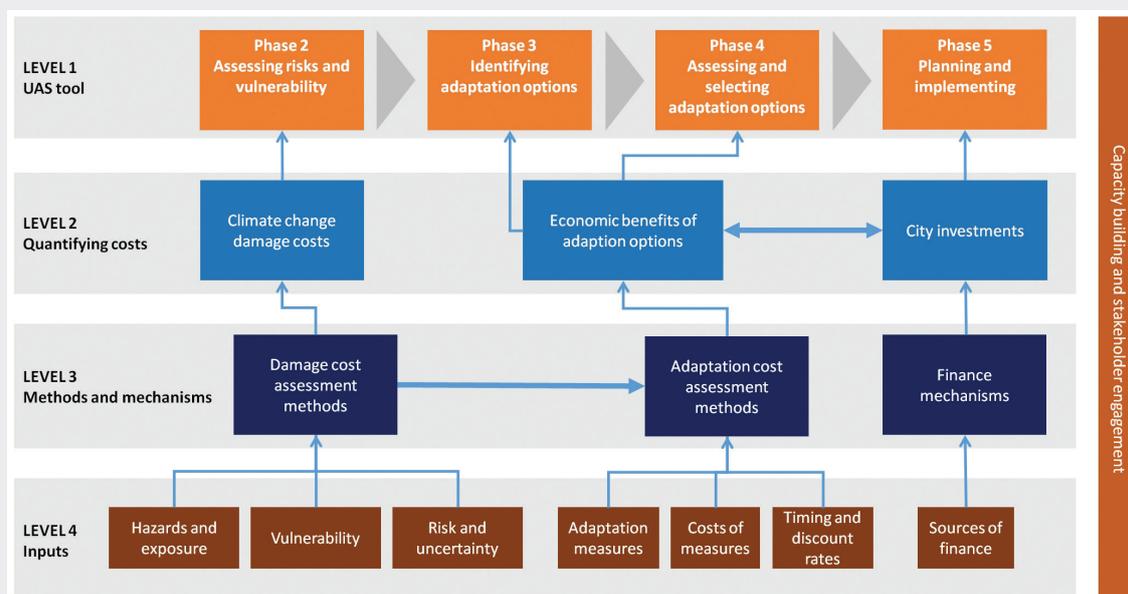
Example Box 17:

## Cost assessment framework for adaptation in cities

In order to utilise limited public finance resources and mobilise private finance effectively, city governments will need appropriate processes and resources for sound investment planning and execution. Despite this, most cities lack the tools for performing economic assessments of damages, adaptation, and financing options.

To help policy makers take adaptation decisions more effectively and efficiently, RAMSES has developed a cost assessment framework that follows a hierarchical approach for prioritising and financing adaptation (Fig. 1). The cost framework is designed to provide much of the economic and financial assessment of risks and vulnerabilities, as well as to give valuable input to plan for adaptation measures.

The cost assessment framework is divided into three key iterative phases that follow a hierarchical process across four levels: describing the Urban Adaptation Support Tool phases 2 to 5 (level 1), quantifying costs (level 2), cost assessment methods and financing mechanisms (level 3) and a range of inputs (level 4). The three phases define a procedure for [1] assessing risks and vulnerability based on damage costs, [2] identifying and assessing adaptation options based on their economic net benefits, and [3] planning and implementing city investments. For more details, see RAMSES Deliverable 5.4 at <http://ramses-cities.eu/results>.



Cost assessment framework for adaptation in cities

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Methods and tools applied in RAMSES case studies

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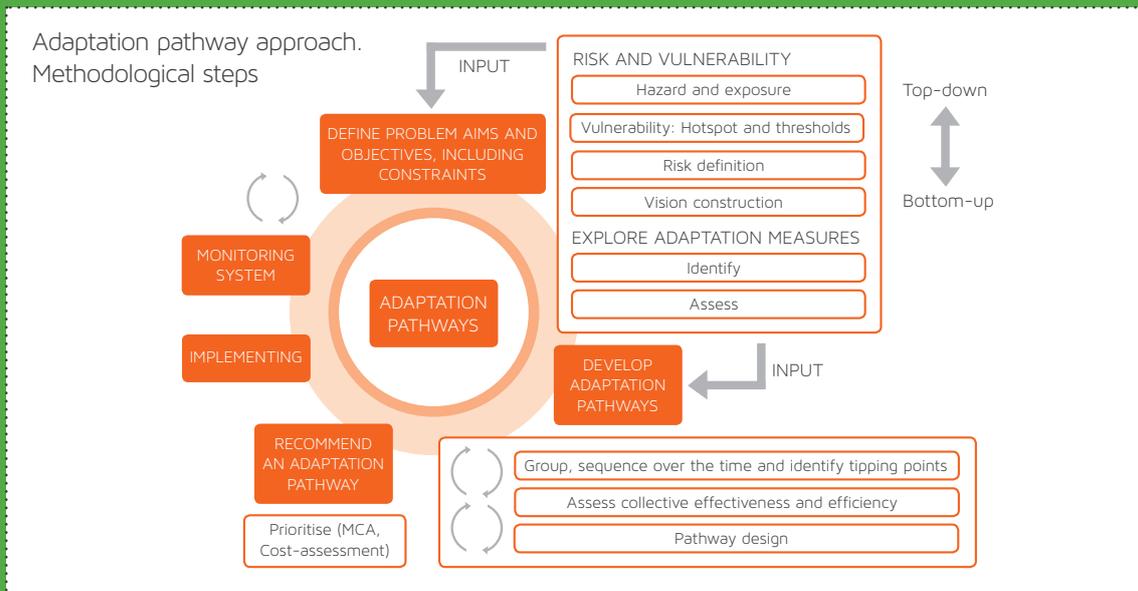
The **Adaptation Pathway approach** has been selected in RAMSES for the planning phase, as it is a suitable approach to developing a flexible adaptation plan under uncertainty.

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 the pathway design are:

- The authorship and the owner of the pathway need to first be identified. Different stakeholders and experts need to be involved. A high level approach can be taken 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 time, several adaptation pathways are developed. The performance of each adaptation pathway can be assessed (to what extent do the different pathways reduce risk, 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, 2011; 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 an open **Stakeholder Dialogue** (held on 4th October 2016, in Rome) and the other contacted participats with **direct invitations** (workshop held on 21th 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.

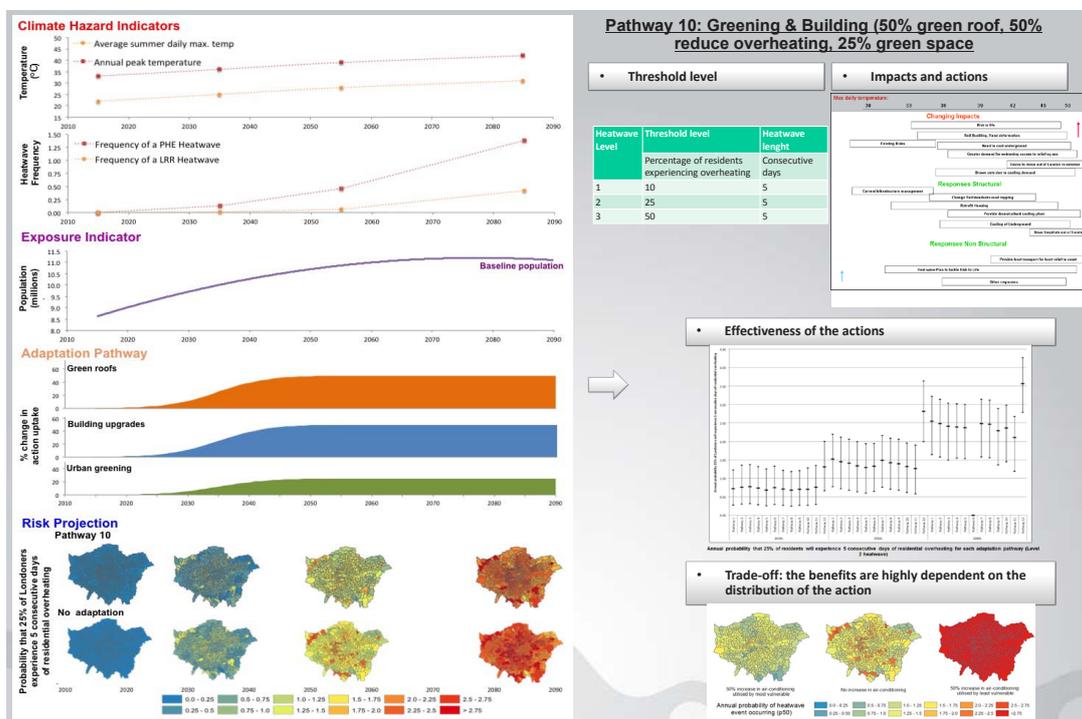


Example Box 18:

# 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, adaptation portfolios proportionate to the projected future levels of risk must be identified. Adaptation pathways have demonstrated potential to contribute to developing a long-term plan for heat-risk in London.

## Heat Pathway



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 (Reeder, 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. Furthermore, the parameter and the metrics in which the thresholds are defined and presented need to be harmonized.

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## Step II Implementing political framework

Adaptation cannot succeed without empowerment of citizens and the consideration of social, institutional and political settings, as well as the nature of urbanization trends.

Thus, this step requires stakeholders to perform the following activities:

- > Implementing the recommended adaptation pathway. Analysing the governance and the tools available for policy-making.
- > Mainstreaming adaptation into existing instruments and institutional structures to make synergies possible.

Instruments in place that are relevant to the previous adaptation pathways should be adapted to cope with current and future impacts of climate.

- > Developing new instruments if required: this should only be considered if the current instruments are not sufficient to cope with the defined strategic objectives. To develop these new instruments, a close collaboration will be needed with all the agents involved (from other departments or other entities). Finally, the deadlines, resources and financing needed to carry out the implementation must be estimated and funding sources sought.

## Methods and tools applied in RAMSES case studies<sup>7</sup>

### 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-creational 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 infrastructure and human capital risk losing effectiveness and credibility. At the same time, new opportunities are opening up for investors, businesses, and local authorities to cope with climate change risks.

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<sup>7</sup> This section is based on the RAMSES deliverables 7.1 (Kari De Pryck et al. 2014), 7.2. (Nicole de Paula Domingos et al. 2015), 7.3. (Nicole de Paula Domingos et al. 2016)



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### *Cities are advancing on climate action*

The work that has been done as part of RAMSES has shown that cities are, independently of the national context, advancing climate aspects in their urban planning, particularly after having been affected by 'triggering' events. Institutions remain incipient but evolving. Several aspects could enable more effective climate action, including: reframing of climate change as a development issue; increasing funding for adaptation actions; improving clarity of jurisdictional areas; and ensuring political support to networks and partnerships (Lee and Meene, 2012).

Overall, four aspects deserved to be highlighted. First, there is a constant need to consider city-wide planning. Second, there is often a need for partnerships between different organizations, and across geographic boundaries. Third, there is a need for clear communications and engagement to achieve success and civil participation.

Finally, thinking about climate change needs to be included in all long-term decision making (LCCP, 2006).

### TOOLS AVAILABLE TO POLICY-MAKERS

Adaptation is a place- and context-oriented matter. A large range of tools is available to policy-makers, and there is no unique method or set of tools that could be pre-defined as an "one-size-fits-all" solution. Ready-made tool-kits for adaptation might be useful to orient cities in their first steps, but they could be counterproductive if not tailored to the local context.

#### *"Grey", "green" and "soft" tools for adaptation*

"Grey" infrastructure approaches correspond to physical interventions with the support of engineering solutions to make cities more resilient to external events.

"Green" infrastructure approaches are the ones that can make the city more resilient through the use of, for example, networks of greenways, open spaces, greenbelts, urban greening, cultural landscapes, urban open spaces, ecological networks, agricultural land, and natural systems aiming at provisioning services (food, water, timber, and fibre), regulating services (regulation of climate, flood, disease, waste and water), cultural services (recreational, aesthetic, and spiritual benefits) and supporting services (soil formation, photosynthesis, and nutrient cycling) (Abunnasr, 2013). The goal of green infrastructure is to achieve sustainability through the maintenance of "nature" that can, at the same time, improve wellbeing and the environmental conditions of urban areas.

"Soft" approaches 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.

In any case, "grey", "green" and "soft" tools for adaptation should be context-oriented, meaning that societal priorities, economic interests, governance structures, policy style and cultural aspects must be taken into account.

#### *Urban recommendations for new and existing urban areas*

The case study of Bilbao demonstrated that the tree-lined streets provided a cooling effect within the urban canyon both in terms of PET reduction and local spatial extent. The strongest reductions of 10°C in air temperature were found inside and specifically under the tree crowns.

The effect of the green roofs on PET in the street canyon was also noticeable but relatively small compared to the presence of grass and trees (< 1°C). However, tree-lined streets are preferable to green roofs because their overall cooling effect is much greater due to their larger vegetation volume and foliage density. In particular, tree-lined streets composed of tree species with tall and broad crowns appear very promising due to the large vegetation volume and leaf biomass inside the canyon. The study clearly showed that the cooling effect was in general locally restricted to within close vicinity of the trees. The combination of all vegetative measures (trees, grass and green roofs) showed the largest impact on the PET level.

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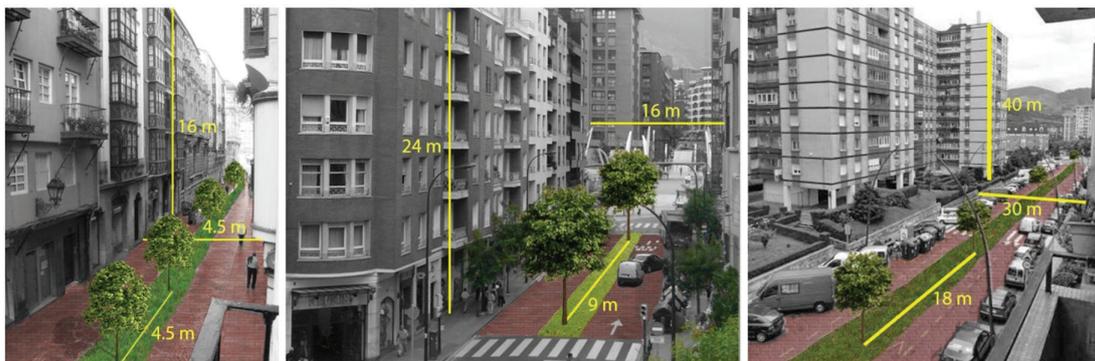
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From the analyses conducted, it is also evident that urban parameters such as orientation and aspect ratio (H/W) of the urban canyons have a considerable influence on thermal comfort at the pedestrian level. They consistently influence the intensity of the PET level, its duration throughout the day and the period of thermal discomfort (PET > 23°C) at the pedestrian level. In all urban areas, for NE–SW orientation the solar radiation has the highest impact on thermal discomfort. This aspect should be taken into consideration for example during the urban design phase for new urban areas.

Another relevant recommendation relates to the thermal effect created by the installation of different finishing materials for the ground: the different finishing materials could increase the PET level by 2 °C.



Visualization of the green mitigation actions in compact low-rise, compact mid-rise and open-set high-rise urban areas (From left).

#### *Phenomena at urban scale.*

Many existing energy and planning models and tools neglect the importance of complex phenomena at the urban scale. Science that effectively includes qualitative and quantitative data calls for timely information that is relevant for both municipal decision makers and users. Models should be useful and should 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, however, this has not yet been elaborated by a published study.

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

There is not 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, recognition both of local and scientific knowledge, accountability, and stakeholder engagement. The Heat Health Plans are one example for which participation of several sectors is required for effective health adaptation (e.g. water supply

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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 discrete 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, we can build on existing civil society mobilization potential and widen its scope.

Overall, the development of adaptation plans is only one indicator of some cities' willingness to take action 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 from academia, business and civil society as possible, through expert panels, public meetings/consultations and working groups, within the policy elaboration process. However, 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 insists on the benefits of co-production: "With urban climate adaptation, co-production indicates that government 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 recognize 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 (Berkes, 2009).

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### *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 co-production, 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 and recreational, while 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 approaches promote the emergence of partnerships and stimulate 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

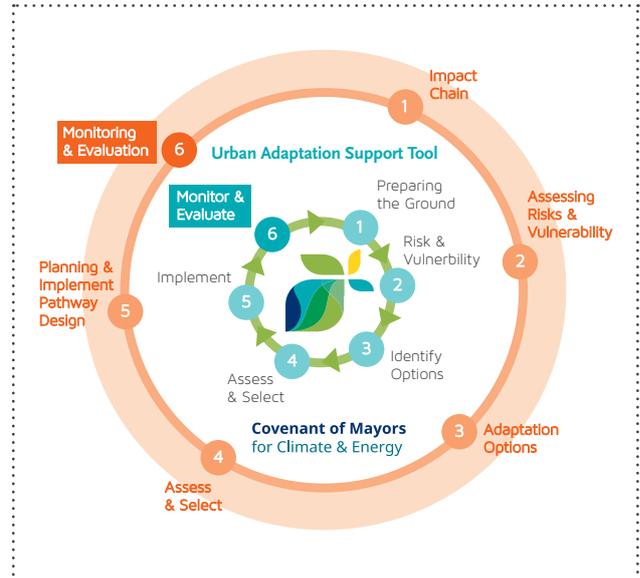




3.6 PHASE VI: MONITORING AND EVALUATION

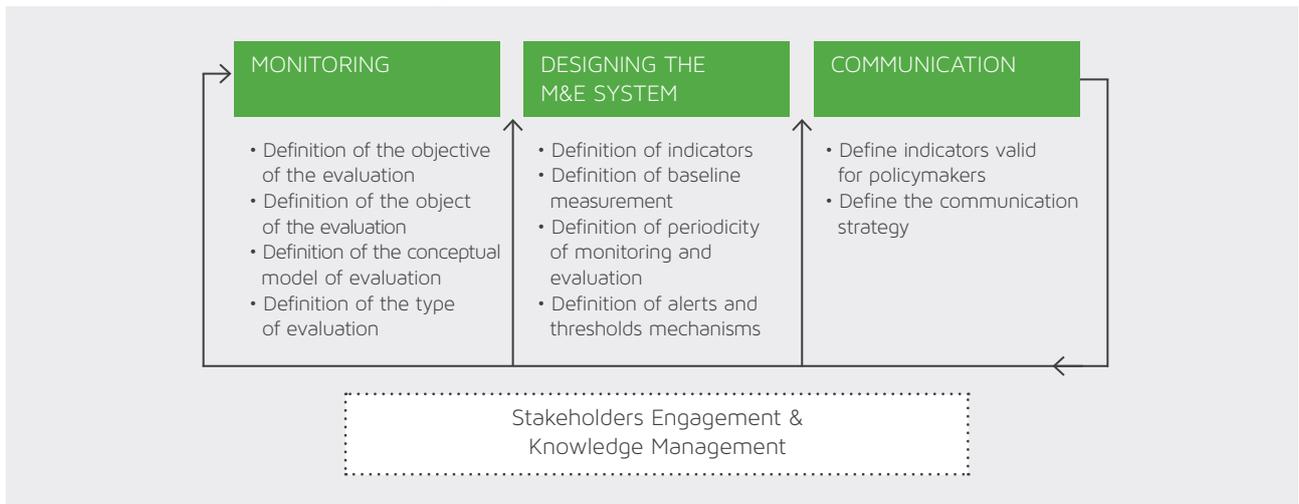
Phase description and key objectives

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 practice. It therefore plays a critical role in 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 many adaptation actions have so far been reactive and have derived from the need to compensate for damage caused by natural disasters. It might be difficult to assess an adaptation measure before an extreme event takes 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: limitations, opportunities and assumptions
- > Definition of the type of evaluation: quantitative, qualitative, or combined?



## Methods and tools applied in RAMSES case studies

**Measuring** successful adaptation planning: RAMSES proposes using effectiveness indicators as part of monitoring. Nevertheless, the effectiveness indicators will differ from case to case as they depend, among other factors, on the 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 removed 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).



## 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]

## 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 measured** 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]

## Chapter 3

# Introducing the Training Package

The Training Package complements the slidedeck 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*<sup>8</sup> (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

Figure 12:

## The Urban Adaptation Support tool



<sup>8</sup> <http://mayors-adapt.eu/materials/technical-support>



topic linked to the RAMSES Project findings, 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

TOOL	REFERENCE
ICLEI Canada – Changing Climate, Changing Communities – Guide and Workbook for Municipal Climate Adaptation	<a href="http://icleicanada.org/resources/item/2-adaptation-tool">http://icleicanada.org/resources/item/2-adaptation-tool</a>
ICLEI ACCCRN Process – Building urban climate change resilience: A toolkit for local governments	<a href="http://resilient-cities.iclei.org/fileadmin/sites/resilient-cities/files/Images_and_logos/Resilience_Resource_Point/ICLEI_ACCCRN_Process_WORKBOOK.pdf">http://resilient-cities.iclei.org/fileadmin/sites/resilient-cities/files/Images_and_logos/Resilience_Resource_Point/ICLEI_ACCCRN_Process_WORKBOOK.pdf</a>
CHAMP Project – Integrated Management for Local Climate Change Response – Capacity Development Package	<a href="http://www.localmanagement.eu">www.localmanagement.eu</a>

#### 4.1 THE RAMSES SLIDEDECK

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 slidedeck 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 slidedeck is available in PPT® format so that it can be downloaded and tailored to practitioners' needs. For example, the slidedeck 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 slidedeck can be consulted and downloaded from the RAMSES website at [www.ramses-cities.eu/toolbox](http://www.ramses-cities.eu/toolbox)

#### 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 developing adaptation action have been added, such as stakeholder involvement and communication, aiming to guide cities through these complex processes. Some of the worksheets are linked to each other. Whenever findings from one worksheet are necessary to progress on another one, they will be cross-referenced accordingly. The following overview presents the general structure of the worksheets.

## Structure of the training package worksheets



### INTRODUCTION

This section introduces briefly the topic of the worksheet.

### KEY MESSAGES

These are policy-relevant pointers that provide useful insights into the topic proposed.

### GETTING TO WORK

In this section tools and exercises are explained and presented. These exercises support a crucial part of the adaptation building process and should be used by municipal staff to progress on their adaptation journey.

### INSTRUCTIONS

In this section, instructions and step-by-step guidance are given to carry out the proposed exercises.

### READ MORE

In this section relevant findings of the RAMSES Project linked to the content of the worksheet will be presented so that the research produced by the project is easily available to the training package users.

### FURTHER MATERIALS

This section presents relevant materials including additional tools that cities can use to progress on their adaptation journey.

### RAMSES AUDIO-VISUAL GUIDANCE

In this last section of each worksheet, links to the videos on from the audio-visual guidance that are inherent to the topic of the worksheet are shared.



## 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 and how different stakeholder groups should participate is essential to a successful engagement.

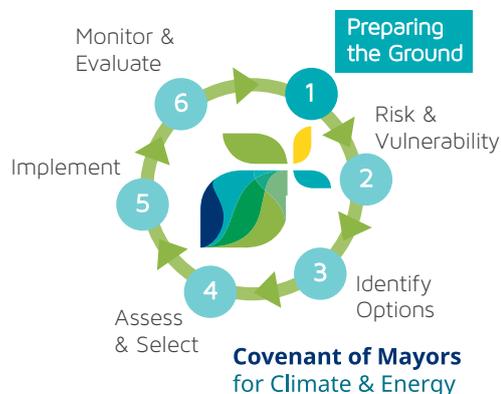
Therefore, throughout the local climate adaptation building process, stakeholders should be first mapped and categorised, and finally engaged.<sup>9</sup>

The identification of stakeholders can be structured according to different criteria. Those stakeholders should be identified who that 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.)<sup>10</sup> should be mapped. This worksheet presents an approach<sup>11</sup> 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 focuses. 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;<sup>12</sup>
- > 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

#### Urban Adaptation Support Tool



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.

- > 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 be always followed up on to create a sense of purpose and keep engagement high.

#### GETTING TO WORK

The exercise proposed serves the identification and categorisation of relevant stakeholders for the adaptation planning process through an "Interest Matrix". The exercise should first be performed by the adaptation team in the municipality. It can be repeated at different times involving different stakeholders to gather different perspectives on different issues (e.g. topics such as water management, or different infrastructures, such as energy or transport infrastructure).

The table on the next page provides a non-exhaustive list of possible stakeholders to engage in the adaptation building process.

<sup>9</sup> RESIN D6.1: [www.resin-cities.eu/resources/actor-analysis](http://www.resin-cities.eu/resources/actor-analysis)

<sup>10</sup> RESIN D6.1: [www.resin-cities.eu/resources/actor-analysis](http://www.resin-cities.eu/resources/actor-analysis)

<sup>11</sup> Adapted from ICLEI Canada – Changing Climate, Changing Communities – Guide and Workbook for Municipal Climate Adaptation

<sup>12</sup> A service area refers to the areas in which a government or community delivers, manages, plans, or makes policy. Source, ICLEI Canada

Table 16:

## Examples of stakeholder groups (adapted from ICLEI Canada)

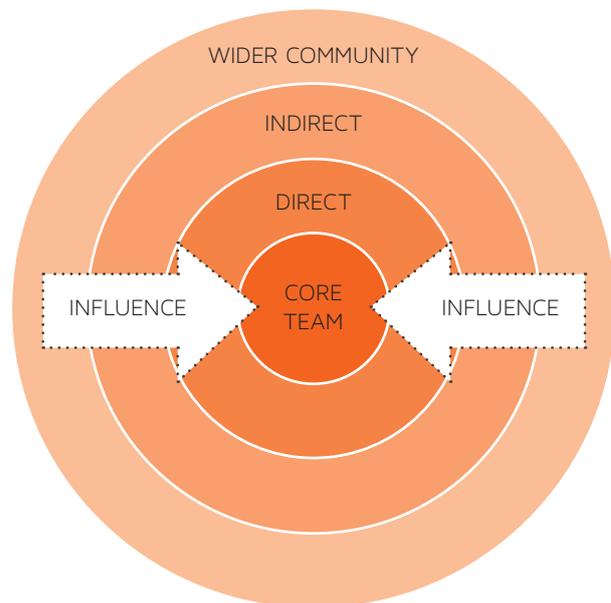
Other municipal departments, staff and department heads (urban planning, social affairs, public health, emergency response, etc.)	Community groups, local neighbourhood associations
Mayor and Council	Media
Utilities	Other levels of government (national, regional)
Local universities and other knowledge providers	Local businesses and the private sector
Hospitals	Different transport authorities (local transport, airports, etc.)

### 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.

Figure 13:

## Influence matrix. Adapted from ICLEI Canada



When the exercise is used to identify stakeholders in specific sectors, the “core team” can be interpreted as the group of people holding knowledge, responsibility or accountability over a certain sector and that should for this reason be active part in the process (e.g., through the creation of a steering group).



After you have completed the exercise, report the results in the table below, noting down the details requested about the stakeholders identified. In order to understand how to best involve these stakeholders, try to find out if relationships between them and the municipality already exist and what would incentivize them to collaborate with the adaptation development process.<sup>13</sup>

 To know more about the importance of stakeholder engagement for climate adaptation in cities please watch:

[http://on-urban-resilience.eu/#Stakeholder\\_involvement](http://on-urban-resilience.eu/#Stakeholder_involvement)  
[http://on-urban-resilience.eu/#Stakeholder\\_involvement\\_for\\_successful\\_adaptation\\_in\\_cities](http://on-urban-resilience.eu/#Stakeholder_involvement_for_successful_adaptation_in_cities)  
[http://on-urban-resilience.eu/#Collaboration\\_as\\_a\\_key\\_factor\\_for\\_adaptation](http://on-urban-resilience.eu/#Collaboration_as_a_key_factor_for_adaptation)  
[http://on-urban-resilience.eu/#Adaptation\\_strategy\\_for\\_a\\_city\\_-\\_how\\_to\\_start](http://on-urban-resilience.eu/#Adaptation_strategy_for_a_city_-_how_to_start)

Table 17:

## Stakeholder table

SECTOR (E.G., PUBLIC ADMINISTRATION, PRIVATE SECTOR, ACADEMIA, ETC.)	ORGANISATION	TITLE	NAME, SUR-NAME	EXISTING RELATIONSHIP WITH THE MUNICIPALITY	EMAIL	PHONE	INFORMATION NEEDED FROM STAKEHOLDER	INFLUENCE (TEAM MEMBER, DIRECT, INDIRECT, WIDER COMMUNITY)	WHAT WOULD INCENTIVISE THE STAKEHOLDER TO PARTICIPATE?

### 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 UrbClim simulation model. The results of the simulations can be found in D4.3.<sup>14</sup> 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 modelling<sup>15</sup>, 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.<sup>16</sup>

Unfortunately, in many European cities, such accurate information is still lacking. Nevertheless, the absence of accurate down-scaled data and simulations should not



<sup>13</sup> Adapted from ICLEI Canada – Changing Climate, Changing Communities – Guide and Workbook for Municipal Climate Adaptation

<sup>14</sup> RAMSES D4.3

<sup>15</sup> For further information about climate modeling: RAMSES D4.3 – Urban adaptation effects on urban climate

<sup>16</sup> RAMSES D4.3



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<sup>17</sup> 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 neighbourhood scale.
- › Further to physical damage, cities should also map local socio-economic vulnerabilities to understand if climate change impacts will exacerbate them.<sup>18</sup>

### 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 annual 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.

Table 18:

### List of relevant data sources

ORGANIZATION	WEBSITE
E.g. Deutscher Wetterdienst	www.dwd.de

#### NOTE

It is important to source information appropriately; in the final column include all of the relevant bibliographic information for each resource.



<sup>17</sup> 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

<sup>18</sup> RAMSES 2nd Policy Brief



Table 19:

## Recording of climatic changes

CHANGE OF CLIMATIC CONDITION	GEOGRAPHIC AREA	RANGE OF EXPECTED CHANGE BY A SPECIFIC DATE	COMPARING RATE OF CHANGE TO PAST AND CURRENT CONDITIONS	SOURCE(S)

#### 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 "someone" 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 change 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)

#### MAKE IT CLEAR!

Once your team has refined its impacts, apply a common sense test to check whether the impact statement will be understood by everyone who reads it.



#### 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:

- > Agricultural Services
- > Biodiversity
- > Coastal Zone Management
- > Community Development
- > Corporate Services
- > Culture and Tourism
- > Economic Development
- > Emergency Management
- > Emergency Response
- > 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
- > Stormwater Management
- > Transportation
- > Water
- > Waste Management
- > Forestry and Forest Services



Identify the service areas that are relevant for your city and include these 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").

Table 20:

### Direct and indirect impacts on service areas

CLIMATIC CHANGE:	IDENTIFIED SERVICE AREAS														
	Agricultural Services	Biodiversity	Coastal Zone Management	Corporate Services	Culture and Tourism	Engineering	Environment	Fire Service	Housing	Parks and Recreation	Planning and Zoning	Port and Harbour Management	Public Health	Water	Waste Management
<b>DECREASED PRECIPITATION IN SUMMER</b>															
Increased demand on water supply due to summer drought	D	I	I	D	I	D	D	D	I	D	I	I	D	D	I
Increased irrigation needs due to decreased water supply	D		D				D				D		D	D	
<b>INCREASED TEMPERATURES IN SUMMER</b>															
Increased demand on energy due to increased cooling needs in summer			D	I	I	D	D				D	I	D	I	
May experience longer growing seasons which increases potential to double crop	D	D	D	I	I				D	D		D		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).

#### 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
- > Blake, R., A. Grimm, T. Ichinose, R. Horton, S. Gaffin, S. Jiong, D. Bader, L. D. Cecil, 2011: Urban climate: Processes, trends, and projections. Climate Change and Cities: First Assessment Report of the Urban Climate Change Research Network, C. Rosenzweig, W. D. Solecki, S. A. Hammer, S. Mehrotra, Eds., Cambridge University Press, Cambridge, UK, 43–81.
- > [STORM EU project](#) 2016 - Safeguarding Cultural Heritage through Technical and Organizational Resources Management

#### RAMSES AUDIO-VISUAL GUIDANCE

To find out more about climate projections and climate impacts, please watch:

[http://on-urban-resilience.eu/#Local\\_climate\\_change\\_models](http://on-urban-resilience.eu/#Local_climate_change_models)

[http://on-urban-resilience.eu/#What\\_is\\_a\\_model](http://on-urban-resilience.eu/#What_is_a_model)



LINK TO HANDBOOK

Phase II: Assessing risk and vulnerability

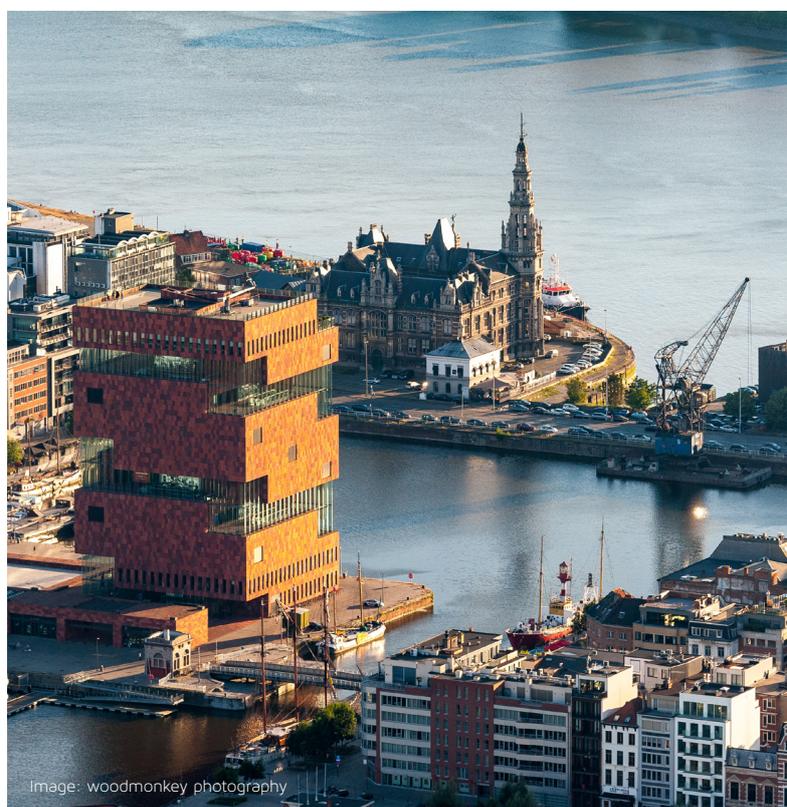


Image: woodmonkey photography



### 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.

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

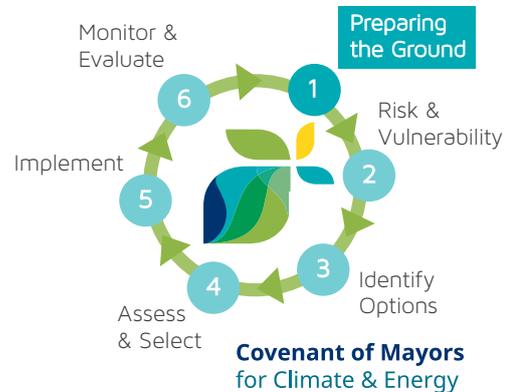
The assessment of different vulnerabilities in a city, region or community is crucial in order to understand how economic or socio-ecological systems at city level could be affected by certain hazards, and therefore to establish and enact the adequate mechanisms and effective policies to respond and adapt to them.<sup>19</sup>

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 specifications and characterization of vulnerabilities for 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.<sup>20</sup>

#### Urban Adaptation Support Tool



#### 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:

- > **Climate and biophysical science:** Focuses on climate change manifestations and impacts.
- > **Technical domain:** Focuses on the functionality and vulnerability of 'hard' systems.
- > **Socio-economic domain:** Focuses on 'soft' systems, particularly the governance and management system as well as socio-economic systems.<sup>21</sup>

#### 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<sup>22</sup>

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.

<sup>19</sup> RESIN project D1.1

<sup>20</sup> RAMSES 2<sup>nd</sup> Policy Brief

<sup>21</sup> CHAMP Project - Integrated Management for Local Climate Change Response – Capacity Development Package

<sup>22</sup> Methodology adapted from the ICLEI Canada, Changing Climate, Changing Communities workbook



Table 21:

## Example impact and directly affected service areas

IMPACT	SERVICE AREAS
Increased demand on water supply due to summer drought	<ul style="list-style-type: none"> <li>• Environment</li> <li>• Corporate Services</li> <li>• Public Health</li> <li>• Water</li> </ul>
Contamination of streams and/or lakes due to sewer overflow	<ul style="list-style-type: none"> <li>• Waste Management</li> <li>• Coastal Zone Management</li> <li>• Parks and Recreation</li> <li>• Engineering</li> <li>• Water</li> </ul>
Impact 3	

### 3. Sensitivity Assessment

Once the list of impacts and their related service areas is completed, your Adaptation Team should look at each identified impact and assess, to the extent possible, if changing climate conditions will significantly affect the functionality of a given service area (e.g. if your electricity grid is already at maximum capacity and increased summer temperatures are likely to drive homeowners to increase air conditioning - thereby increasing their demand on the grid - then the service area of energy services is sensitive to changes in temperature).

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

S1	S2	S3	S4	S5
Functionality will stay the same	Functionality will likely stay the same	Functionality is likely to get worse	Functionality will get worse	Functionality will become unmanageable



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 (ice 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 climatic 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?

Table 23:

## Sensitivity assessment example. Adapted from ICLEI Canada

IMPACT	Functionality will likely stay the same	Functionality is likely to get worse	Functionality will get worse
SERVICE AREA	Water Supply	Environment	Energy Services
Which climatic changes affect the functioning of this service area?	<ol style="list-style-type: none"> <li>1. Temperature (warmer temperatures expected across all seasons under all climate change scenarios, especially during summer months)</li> <li>2. Precipitation (less rain in summer and snow in winter)</li> </ol>	<ol style="list-style-type: none"> <li>1. Precipitation (more rain in summer and snow in winter)</li> </ol>	<ol style="list-style-type: none"> <li>1. Temperature (warmer temperatures expected across all seasons under all climate change scenarios, especially during summer months)</li> </ol>
How would the service area be affected by these changes today?	<ol style="list-style-type: none"> <li>1. Warm winter and spring temperatures lead to lower snowpack and earlier snowmelt, increasing summer drought</li> <li>2. Warmer summer temperatures increase evaporation rates and demand on water</li> <li>3. Lower winter precipitation lowers winter snowpack, reducing water supply</li> </ol>	<ol style="list-style-type: none"> <li>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</li> <li>2. Large flow variations between wet and dry weather can cause contamination issues</li> </ol>	<ol style="list-style-type: none"> <li>1. Increased number of hot days in summer months leading to increased demand for cooling centres</li> <li>2. Increased temperatures leading to increased household use of air-conditioning</li> </ol>
Is the service area subject to any existing stress?	Water shortages have occurred in the past during particularly hot summers	Decreasing marine ecosystem habitat due to urban development	Electricity grid is already at maximum capacity
If the impact occurs, will it affect the functionality of the service area?	<p>Yes: Increased summer drought will increase the frequency of water shortages during the summer months</p> <p><b>Yes: Functionality will become unmanageable (S5)</b></p>	<p>If the already limited water area is contaminated by domestic waste, plant and animal species will be subject to increased pressure which may affect their longevity. (S3)</p> <p><b>Yes: Functionality will get worse (S4)</b></p>	<p>Increased summer temperatures are likely to drive homeowners to increase air cooling – thereby increasing pressure on energy supplies. (S4)</p> <p><b>Yes: Functionality will get worse (S4)</b></p>



#### 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 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 a system's vulnerability.

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 24:

#### Adaptive capacity scale. Adapted from ICLEI Canada

AC1	AC2	AC3	AC4	AC5
No, will require substantial costs and staff intervention	No, will require significant costs and staff intervention	Maybe, will require some costs and staff interventions	Yes, but will require some slight costs and staff intervention	Yes, no to little costs and staff intervention are necessary

Table 25:

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

IMPACT	Increased demand on water supply due to summer drought	Contamination of streams and/or lakes due to sewer overflow	Increased demand on energy due to increased cooling needs in summer
SERVICE AREA	Water Supply	Environment	Energy Services
Can the service area adjust to the projected impact with minimal cost and disruptions?	No: Will require substantial costs (\$\$\$\$) and staff intervention (AC1)	No: Will require significant costs (\$\$\$) and staff intervention (AC2)	No: Will require significant costs (\$\$\$\$) and staff intervention (AC4)
Explain Response	Unable to "adapt" snowpack to warmer temperatures; limited options for expanding water supply and summer demand is already greater than supply	Unable to adapt with minimum 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.

- > **V1** = Low Vulnerability
- > **V2** = Medium-Low Vulnerability
- > **V3** = Medium Vulnerability
- > **V4** = Medium-High Vulnerability
- > **V5** = High Vulnerability

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 26:

Sensitivity and adaptation capacity matrix

ADAPTATION CAPACITY		SENSITIVITY SCORE				
	AC1	S1	S2	S3	S4	S5
AC1		V2	V2	V4	V5	V5
AC1		V2	V2	V3	V4	V5
AC1		V2	V2	V3	V4	V4
AC1		V1	V2	V2	V3	V3
AC1		V1	V1	V2	V3	V3

- > 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 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 - AC3 OR S2 - AC2) = V2		LOW VULNERABILITY (S1 - AC5) = V1	
Impact	Service Area	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	...	...	...	...



## READ MORE

- > [RAMSES D3.1](#) - High level quantified assessment of key vulnerabilities and priority risks for urban areas in the EU



LINK TO HANDBOOK

Phase II: Assessing risk and vulnerability

## FURTHER MATERIALS

- > RESIN project [D1.1](#) – State of the art report (4) – Vulnerability Assessment, Definitions, Indicators and Existing Assessment Methods
- > 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
- > World Bank 2011 – Guide to climate change adaptation in cities [report](#)

## RAMSES AUDIO-VISUAL GUIDANCE

To find out more about vulnerability assessments in cities, please watch:

[http://on-urban-resilience.eu/#Adaptation\\_strategy\\_for\\_a\\_city\\_-\\_how\\_to\\_start](http://on-urban-resilience.eu/#Adaptation_strategy_for_a_city_-_how_to_start)

[http://on-urban-resilience.eu/#The\\_concepts\\_resilience\\_and\\_vulnerability](http://on-urban-resilience.eu/#The_concepts_resilience_and_vulnerability)

Image: Giovanna Silva / RAMSES



### 4.3.4 Worksheet no. 4: Determining key climate risks for cities

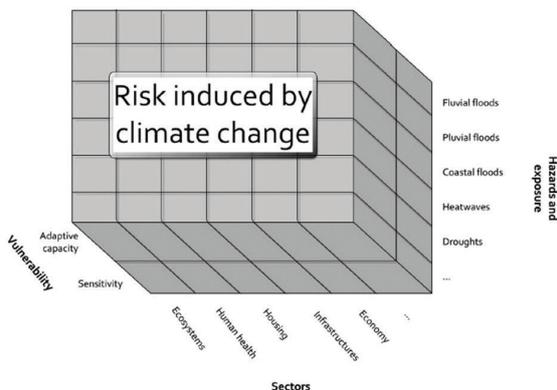
#### INTRODUCTION

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.<sup>23</sup> 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 crucial city sectors. 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 interface, putting cities at danger.<sup>24</sup>

Figure 14:  
Risk induced by climate change.  
Retrieved from RAMSES D3.1



#### Urban Adaptation Support Tool



High level vulnerability assessments can support cities in identifying macro-regional risks deriving from climate change and understand 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<sup>25</sup> 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.<sup>26</sup>

<sup>23</sup> RAMSES D3.1

<sup>24</sup> RAMSES D3.1

<sup>25</sup> Adapted from: ICLEI Canada, Changing Climate and Changing Communities workbook for Municipal Climate Adaptation and ICLEI ACCCRN publication: Building Urban Climate Change Resilience: A Toolkit for Local Governments.

<sup>26</sup> RAMSES 2<sup>nd</sup> Policy Brief



Table 28:

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

	DECISIONS TO INFORM	DATA AND METHODS SOURCES	METHODS	
↑ INCREASING SCALES OF ANALYSIS	<p><b>Benchmarking</b></p> <ul style="list-style-type: none"> <li>Nationwide assessment of sustainability in cities</li> <li>Identification of national priorities</li> <li>Planning policy and national directives</li> </ul> <p><b>Regional and urban planning</b></p> <ul style="list-style-type: none"> <li>Spatial development strategies</li> <li>Strategic assessments</li> </ul> <p><b>Detailed design</b></p> <ul style="list-style-type: none"> <li>Neighbourhood planning</li> <li>Infrastructure design</li> <li>Building and orientation</li> </ul>	<ul style="list-style-type: none"> <li>Satellite observations</li> <li>Energy generation</li> <li>Rainfall, temperature monitoring</li> <li>Traffic and local air quality monitoring</li> <li>Airborne lidar and photogrammetry</li> <li>Property location, land use and land cover</li> <li>Population and demographic information</li> <li>Travel, energy, consumption and waste surveys</li> <li>Smart sensors and building air quality, energy and water monitoring</li> <li>Terrestrial and mobile laser scan</li> <li>Individual and mobile phone sensors</li> </ul>	<ul style="list-style-type: none"> <li>Indicator and checklists</li> <li>GIS overlays</li> <li>Global and regional climate model outputs</li> <li>Accounting tools</li> <li>Quantified modelling of risks and sustainability</li> <li>Integrated assessment models</li> <li>Urban metabolism</li> <li>Land use and demand modelling</li> <li>Weather generators</li> <li>High resolution simulation and process models of selected urban functions</li> <li>Industrial ecology and life cycle analysis</li> <li>Engagement with individuals, community groups and other stakeholders</li> </ul>	↓ INCREASING RESOLUTION OF MONITORING AND MODELLING

### GETTING TO WORK

Natural hazards, and in particular climate change impacts tend to occur either simultaneously or consecutively. As flooding can result from melting snow, the major impacts on infrastructure may not necessarily be due to the natural event itself but to its secondary consequences. Reciprocally a damaging impact can result from different natural events. For example, flash floods can result from a storm event or a rapid melting of snow. Table 29 lists the links between different natural hazards and impacts identified by the UK National Risk Register (Cabinet Office, 2012b).<sup>27</sup>

<sup>27</sup> Adapted from: D2.1 – pag.27, ICLEI ACCCRN – Tool 2.3 Risk Assessment, CHAMP – Worksheet 8

Table 29:

## Linkages of natural hazards and climate change impacts (Cabinet Office 2011)

SOURCE	INITIAL CONSEQUENCES	KNOCK-ON CONSEQUENCES
Storm and gales	Strong winds Tidal surge Snow Lightning Heavy rainfall Tornadoes Hail	River and coastal flooding Surface water flooding Land instability Wildfire
Prolonged period of hot weather	Heat	Thunderstorms Drought Dust/smog/haze Land instability Wildfire
Prolonged period of dry weather	Reduced rainfall	Dust/smog/haze/fog Reduced ground water flow Water quality Land instability Drought Wildfire
Excessive cold with snow	Cold Snow	Ice Wind chill Fog Surface water and river flooding (snow melt)

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

$$\text{RISK} = \text{LIKELIHOOD} \times \text{CONSEQUENCE}$$

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.



## INSTRUCTIONS

### 1. Engage the right stakeholders

First, it is essential to identify and bring together relevant stakeholders with competence for example in infrastructure, public works, health, civil protection, environment, etc. (see Worksheet 1 on stakeholder mapping).

### 2. Risk Prioritization

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

Table 30:

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

CLIMATE RISK PRIORITIZATION	LIKELIHOOD	CONSEQUENCE	RISK SCORE (LIKELIHOOD X CONSEQUENCE)	RISK STATUS
E.g., Increased precipitation cause water to freeze in the pipelines				
Risk 2				
Risk 3	...	...	...	...

### 3. Assess the likelihood of each risk occurring

Assess the likelihood of each risk occurring by assigning a score from 1 to 5 to them considering whether the impact is recurring or a single event. Please base your scoring on the rating presented in the table below.

Table 31:

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

LIKELIHOOD RATING	DESCRIPTION	SCORE
Almost certain	Is highly likely to occur, could occur several times per year. Likelihood probably greater than 50%	5
Likely	Reasonable likelihood may arise once per year. Likelihood 50/50 chance	4
Possible	May occur, perhaps once in 10 years Likelihood less than 50% but still quite high	3
Unlikely	Unlikely but should still be considered, may arise once in 10 or 25 years	2
Rare	Likelihood probability significantly greater than zero. Unlikely in foreseeable future – negligible probability	1



#### 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 32:

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

CONSEQUENCE RATING	IMPACT ON SYSTEM	IMPACT ON POOR AND VULNERABLE	SCORE
Catastrophic	System fails completely and is unable to deliver critical services, may lead to failure of other connected systems	Severe impacts on poor and vulnerable groups in the city leading to situations of extreme destitution	5
Major	Serious impact on the system's ability to deliver critical services, however not complete system failure	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	4
Moderate	System experiences significant problems, but is still able to deliver some degree of service	Moderate impacts on the lives and livelihoods of the poor and vulnerable groups in the city	3
Minor	Some minor problems experienced, reducing effective service delivery, possibly affecting certain other systems or groups	Minor impacts on the lives and livelihoods of the poor and vulnerable groups in the city	2
Insignificant	Minimal impact on system: may require some review or repair, but still able to function	Minimal impacts on the lives and livelihoods of the poor and vulnerable groups in the city	1



### 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.

$$\text{RISK} = \text{LIKELIHOOD} \times \text{CONSEQUENCE}$$

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

1 - 5 Low risk	5 - 10 Medium risk	10 - 20 High risk	20 - 25 Extreme risk
----------------------	--------------------------	-------------------------	----------------------------

Figure 15:

Risk Spectrum. Adapted from ICLEI Canada, Changing Climate and Changing Communities workbook for Municipal Climate Adaptation

Table 33:

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

LIKELIHOOD	CONSEQUENCES				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost certain	Medium ( RS = 5 )	Medium ( RS = 10 )	High ( RS = 15 )	Extreme ( RS = 20 )	Extreme ( RS = 25 )
Likely	Low ( RS = 4 )	Medium ( RS = 8 )	High ( RS = 12 )	High ( RS = 16 )	Extreme ( RS = 20 )
Possible	Low ( RS = 3 )	Medium ( RS = 6 )	Medium ( RS = 9 )	High ( RS = 12 )	High ( RS = 15 )
Unlikely	Low ( RS = 2 )	Low ( RS = 4 )	Medium ( RS = 6 )	Medium ( RS = 8 )	Medium ( RS = 10 )
Rare	Low ( RS = 1 )	Low ( RS = 2 )	Low ( RS = 3 )	Low ( RS = 4 )	Medium ( RS = 5 )

- > **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.<sup>28</sup>

<sup>28</sup> 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

CLIMATE RISK PRIORITIZATION	LIKELIHOOD	CONSEQUENCE	RISK SCORE (LIKELIHOOD X CONSEQUENCE)	RISK STATUS
Increased precipitation causes water to freeze in the pipes	4	4	16	High
Increased precipitation disrupts/damages water supply infrastructure	3	3	9	Medium
Risk 3	...	...	...	...

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.<sup>29</sup>

### 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

### 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://on-urban-resilience.eu/#Risk\\_analysis\\_explained](http://on-urban-resilience.eu/#Risk_analysis_explained)

<sup>29</sup> Methodology adapted from the ICLEI ACCCRN publication: Building Urban Climate Change Resilience: A Toolkit for Local Governments



### 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.<sup>30</sup> 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 work days 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;



3. **Estimating 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.

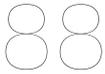
The following example box 19 provides an overview of the cost assessment tool structure.<sup>31</sup>



Image: RAMSES Project

<sup>30</sup> RAMSES D6.1

<sup>31</sup> RAMSES D6.2



Example Box 19:

## 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.<sup>32</sup>

### 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](#).

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.<sup>33</sup>

<sup>32</sup> RAMSES 2<sup>nd</sup> Policy Brief

<sup>33</sup> RAMSES D6.2, pages 14-15



Table 35:

## Main variables for health damage costing

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

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.<sup>34</sup> This should be consulted before completing the Excel sheet.

<sup>34</sup> [www.ramses-cities.eu/resources](http://www.ramses-cities.eu/resources)

## INSTRUCTIONS

### 1. Engage the right stakeholders

First, it is essential to bring together stakeholders that 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.

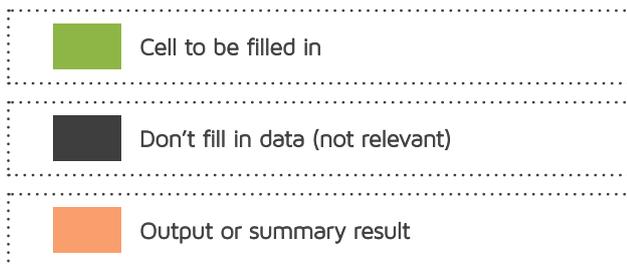
This methodology and the accompanying tool are mainly intended to support local policy-makers in planning and implementing climate change health adaptation policies, however, other stakeholders involved in planning and implementing such policies can also use this material.

### 2. Data input and "Read me" spreadsheet

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



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.



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

- > **Geographical 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.).

- > **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.

### 3. "Health costs" and "Economic values" spreadsheets



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.



Image: ICLEI



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

Table 36:

## Health service parameter needs and possible sources

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

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

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



## 5. "Outputs" 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 (recurrent 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:

$$\text{BRC} = \frac{\text{Benefits from averted damage through adaptation activity } \times}{\text{Cost adaptation activity } \times}$$

$$\text{CER} = \frac{\text{Cost of adaptation activity } \times}{\text{Outcome cases averted by adaptation activity } \times}$$

Where:

- > BCR: Benefit to cost ratio<sup>35</sup>
- > CER: Cost-effectiveness ratio<sup>36</sup>

Moreover, in the "Outputs" 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.

<sup>35</sup> BCR is defined as the comparison of the present value of an investment decision or project with its initial cost. A ratio of greater than one indicates that the project is a viable one. Source: [www.businessdictionary.com/definition/cost-benefit-ratio.html](http://www.businessdictionary.com/definition/cost-benefit-ratio.html)

<sup>36</sup> CER is defined as the difference in costs divided by the difference in health effects. "The numerator is the change in cost due to the application of an intervention and the denominator is the change in health benefit. Average cost-effectiveness ratios were calculated for each intervention by combining the information on the total costs with information on the total health effects". Source: [www.who.int/choice/publications/p\\_2003\\_generalised\\_cea.pdf](http://www.who.int/choice/publications/p_2003_generalised_cea.pdf)

## 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/#Health\\_impacts\\_costing](http://on-urban-resilience.eu/#Health_impacts_costing)

[http://on-urban-resilience.eu/#Health\\_costing\\_tool\\_explained](http://on-urban-resilience.eu/#Health_costing_tool_explained)



**LINK TO HANDBOOK**

Phase I > Step II: Contextualisation 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.<sup>37</sup>

RAMSES estimated the effectiveness of green infrastructure in improving specific climate impacts faced by cities, as for example the Urban Heat Island (UHI) effect. Vegetation has strong potential to reduce the UHI risk both at the very local level and in nearby areas, especially due to its positive effect on the city's microclimate. If you would like to learn more, please consult [RAMSES D4.3](#).



#### Urban Adaptation Support Tool



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.

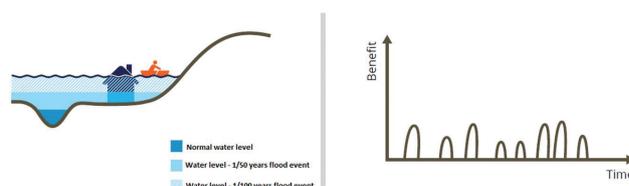


Figure 16:  
Coping adaptation.  
Retrieved from EEA, 2016

<sup>37</sup> RAMSES D7.2

- › **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.

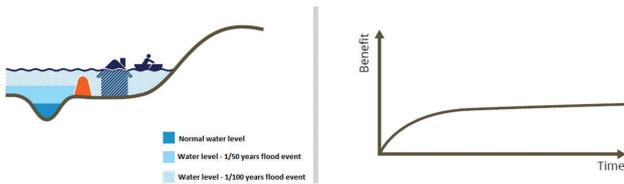


Figure 17:

Incremental adaptation.  
Retrieved from EEA, 2016

- › **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 settling 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.

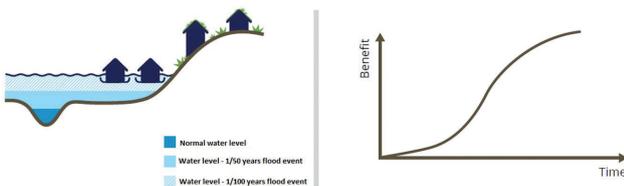


Figure 18:

Transformative adaptation.  
Retrieved from EEA, 2016

When selecting adaptation measures, cities should think of the ideal mix of coping, incremental and transformative adaptation that they would like to implement on their territory and on the costs and benefits linked to the chosen mix (EEA, 2016).

## 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.<sup>39</sup>

## GETTING TO WORK

This worksheet<sup>39</sup> 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).

<sup>38</sup> RAMSES 2<sup>nd</sup> Policy Brief

<sup>39</sup> Readapted from the ICLEI Canada Changing Climate, Changing Communities workbook



It is also important to identify pre-cursors to action which are steps that need to be taken to enable the implementation of an action. Consider a research study for example. It may be necessary to conduct research in cases where there is a lack of information, however, the research itself does not have a positive adaptation effect, although it is necessary to inform your adaptation action and increase your adaptive capacity.

Precursors of actions may include a wide range of strategies and will likely involve a combination of the following:

- > **Establishing partnerships with different stakeholders and government levels.**
- > **Carrying out or commissioning of research studies.**

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).

## INSTRUCTIONS

### 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.  
[www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4\\_syr.pdf](http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf)



Use the table below to record the identified list of possible adaptation options in light of your risks. Reflect on the different adaptation options that you are developing. To do so, please compile the "approach", "classification" and "co-benefits" columns. Are the measures you thought of grey, green or soft? Do they have a long-term transformative potential? Do they provide co-benefits that contribute to improve citizens' quality of life?

Table 38:  
List of adaptation options

RISK	ADAPTATION OPTION	CLASSIFICATION (GREY, GREEN OR SOFT OPTION)	APPROACH (COPING, INCREMENTAL OR TRANSFORMATIVE ADAPTATION)	CO-BENEFITS
e.g. Increased demand on water supply due to summer drought	Diversify water supply sources	Grey - Soft	Transformative	Water Emergency Response Public Health Communication
	Implement conservation measures	Green	Coping	Water Public Health Communications
	Increase drought preparedness	Soft	Incremental	Emergency Response Water Public Health
Risk 2	...	...	...	...

**3. Evaluation of adaptation option**

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.<sup>40</sup>

<sup>40</sup> Adapted from the CHAMP Project



Table 39:

## Checklist to evaluate adaptation options

CRITERION	INDICATORS / SUB-CRITERIA	QUESTIONS TO BE ASKED	YES / NO	COMMENT
Effectiveness of adaptation	Adaptation function	Does the measure provide adaptation in terms of reducing impacts, reducing exposure, enhancing resilience or enhancing opportunities?	Yes <input type="checkbox"/> No <input type="checkbox"/>	
	Robustness to uncertainty	Is the measure effective under different climate scenarios and different socio-economic scenarios?	Yes <input type="checkbox"/> No <input type="checkbox"/>	
	Flexibility	Can adjustments be made later if conditions change again or if changes are different from those expected today?	Yes <input type="checkbox"/> No <input type="checkbox"/>	
Co-benefits	No regret	Does the measure contribute to more sustainable water management and bring benefits in terms of also alleviating already existing problems?	Yes <input type="checkbox"/> No <input type="checkbox"/>	
	Win-win (or win-lose)	Does the measure have side-benefits for other social, environmental or economic objectives? E.g. does it: <ul style="list-style-type: none"> <li>• Contribute to closing the gap between water availability and demand?</li> <li>• Affect the delivery of other WFD objectives (e.g. river flow)?</li> <li>• Create synergies with mitigation (e.g. does it lead to decreased GHG emissions)?</li> </ul>	Yes <input type="checkbox"/> No <input type="checkbox"/>	
	Spill-over effects	Does the measure affect other sectors or agents in terms of their adaptive capacity?  Does the measure cause or exacerbate other environmental pressures?	Yes <input type="checkbox"/> No <input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/>	
Efficiency/ costs and benefits	Low-regret	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.	Yes <input type="checkbox"/> No <input type="checkbox"/>	
Framework conditions for decision-making	Equity and legitimacy	Who wins and who loses from the adaptation measure?		
		Are those affected by the measure consulted and involved in the decision-making procedures and in the design of the measure?	Yes <input type="checkbox"/> No <input type="checkbox"/>	
	Feasibility of implementation	What barriers are there to implementation?		
		• Technical?	Yes <input type="checkbox"/> No <input type="checkbox"/>	
		• Social (number of stakeholders, diversity of values and interests, level of resistance)	Yes <input type="checkbox"/> No <input type="checkbox"/>	
	Alternatives	Are there alternatives to the envisaged adaptation measure that would e.g. be less costly or would have fewer negative side-effects?	Yes <input type="checkbox"/> No <input type="checkbox"/>	
Priority and urgency		How severe are the climate impacts the adaptation measure would address relative to other impacts expected in the area/ country?		
		When are the climate change impacts expected to occur?		
		At what timescales does action need to be taken?		



#### 4. Prioritization 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.<sup>41</sup>

Table 40:

### Prioritised adaptation options

PRIORITISED ADAPTATION OPTIONS	TIME FRAME FOR IMPLEMENTATION
1. Improved drought preparedness	Long Term
2. Heat Health action plan	Short Term
3...	...

#### READ MORE

- > [RAMSES D2.1](#) – Synthesis review on resilient architecture and infrastructure indicators
- > [RAMSES D2.3](#) – 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 D7.2](#) – Typology of the tools available to policy-makers and assessment of their efficiency
- > [RAMSES D8.2](#) – Stimulating European urban strategies for transition

#### FURTHER MATERIALS

- > European Environment Agency 2016; Urban Adaptation to Climate Change in Europe [report](#)
- > 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
- > UK Climate impacts program – Identifying adaptation options [report](#)

#### RAMSES AUDIO-VISUAL GUIDANCE

- [http://on-urban-resilience.eu/#Urban\\_heat\\_islands](http://on-urban-resilience.eu/#Urban_heat_islands)
- [http://on-urban-resilience.eu/#Flexible\\_work\\_supports\\_adaptation](http://on-urban-resilience.eu/#Flexible_work_supports_adaptation)
- [http://on-urban-resilience.eu/#Adaptation\\_options\\_in\\_the\\_transport\\_sector\\_-\\_infrastructure\\_vs\\_vehicles](http://on-urban-resilience.eu/#Adaptation_options_in_the_transport_sector_-_infrastructure_vs_vehicles)

<sup>41</sup> Methodology readapted from the ICLEI Canada – Changing Climate, Changing Communities – Guide and Workbook for Municipal Climate Adaptation



### 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" (Vergragt 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.<sup>42</sup>

#### Urban Adaptation Support Tool



#### GETTING TO WORK

Depending on the a city's requirements or planning approach, different backcasting approaches can be selected.

- > **Target-oriented backcasting**, which focuses on developing and analyzing target-fulfilling images in which the target is usually expressed in a quantitative manner. The development of a future vision is more elaborate than the specific pathways of how to get there;
- > **Pathway-oriented backcasting** in which setting strict goals is considered less important. The focus is on how change can take place and which measures can support the changes like policies, taxes, or behavioural changes;
- > **Action-oriented backcasting** in which the main objective is to develop an action agenda, strategy or action plan. The focus is on who could bring about the changes and realising buy-in and commitment among stakeholders;
- > **Participation-oriented backcasting** in which backcasting is used as a creative workshop tool. Key elements of participatory backcasting are (1) stakeholder involvement and dialogue, (2) participatory generation of desirable future visions, and (3) stakeholder learning through involvement, interaction, vision development and vision assessment.
- > **Combinations** of the above (Quist et al., 2013).

<sup>42</sup> RAMSES 2<sup>nd</sup> 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<sup>43</sup> at city (or neighbourhood) level that strengthen the city's preparedness for climate change.

Table 41:

## List of projects, initiatives and activities

PROJECTS	INITIATIVES	ACTIVITIES

### 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

LONG TERM GOALS 2050
GOAL 1:
GOAL 2:
GOAL 3:

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.

Table 43:

## Characteristics of the 3 scenarios identified

	SCENARIO CHARACTERISTICS
SCENARIO 1	
SCENARIO 2	
SCENARIO 3	

### 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.<sup>44</sup>

<sup>43</sup> Projects can be defined as financed multi-year endeavours to reach a determined resilience objectives. Initiatives should be understood as short-term actions (such as, for example, the "adaptation week", etc.), while activities are bottom-up actions that community groups promote to (explicitly or implicitly) enhance local resilience.

<sup>44</sup> Re-adapted from the methodology available on: [www.thenaturalstep.org/sustainability/backcasting](http://www.thenaturalstep.org/sustainability/backcasting)



Table 44:

## Steps and milestones to achieve a desired scenario

SCENARIO	STEPS	MILESTONES

#### 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.

#### READ MORE

- > [RAMSES- D8.1](#)- Factors of transition and their dynamics

#### FURTHER MATERIALS

- > Scientific Workshop: Pathways, scenarios and Backcasting for low-carbon lifestyles, [Proceedings](#) of SCORAI Europe & InContext Workshop, October 2013, 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/#Incorporating\\_the\\_adaptation\\_perspective](http://on-urban-resilience.eu/#Incorporating_the_adaptation_perspective)

Image: RAMSES Project





### 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 proposed 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.

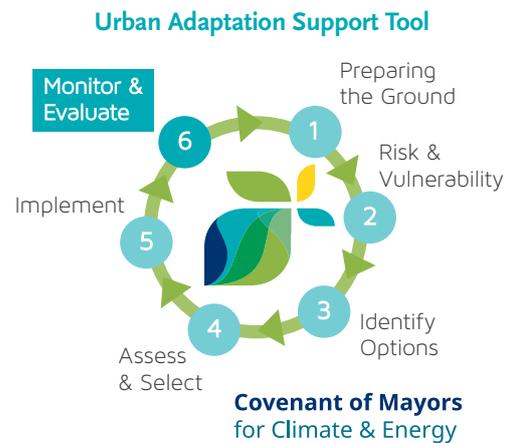
#### KEY MESSAGES

- > 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).<sup>45</sup>

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.<sup>46</sup>

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



Image: bluesky6867 / fotolia

<sup>45</sup> RAMSES D2.1 – p.31

<sup>46</sup> RAMSES D2.1 – p.100



Table 45:

## Core dimensions of resilient systems, characteristics and benefits for

CHARACTERISTIC	DESCRIPTION	GREY INFRASTRUCTURE
Adaptability, flexibility	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)	How robust are infrastructures to last 80 years? How adaptable is the infrastructure in the future?
Connectivity, feedbacks, safe-failure	<p>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:</p> <ul style="list-style-type: none"> <li>• absorb shocks</li> <li>• absorb cumulative effects of slow-onset challenges</li> <li>• avoid catastrophic failure if thresholds are exceeded</li> <li>• fail progressively rather than suddenly</li> <li>• fail without cascading impacts (domino effect)</li> <li>• analyse and implement across spatial scales (city to site)</li> <li>• analyse as human-technology coupled system</li> <li>• identify lock-in effects and potential conflicts with mitigation</li> <li>• identify synergies with other city policies, added value assessment</li> <li>• balance clear distribution of responsibility with concerted action</li> </ul>	Look at the whole system not just parts of it – interrelations
		Decentralised systems  Infrastructure connectivity in case of extreme events
Dependence on local ecosystems	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)	
Spatial Diversity	<ul style="list-style-type: none"> <li>• Spatial diversity - Key assets and functions physically distributed to not all be affected by a given event at any time</li> <li>• Functional diversity - Multiple ways of meeting a given need balance diversity with potential cascading effects</li> </ul>	Location of critical parts of infrastructure
		Location of networks



## urban quality (RAMSES D2.1)

### BENEFITS AND CHARACTERISTICS

GREEN AND BLUE INFRASTRUCTURES	LAND USE, MOBILITY, URBAN-RURAL INTERFACE	ARCHITECTURE, PUBLIC SPACE, URBAN REGENERATION
	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)	Embedding measures in the existing city (design + management) Flexible structures, multiple uses
Safety of water supply from more remote areas (pipelines), desalination plants	Settlement hierarchy	Maximise use of industrial ecology
Integrated green infrastructure mix		
Connecting city green spaces with the surrounding landscape		
Connectivity of green areas; landscape fragmentation, number of unfragmented areas	Connectivity	
Green infrastructure measures implemented at all levels (region/city, city/district, district/sites)		
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)	Ensure connectivity of rural and urban ecosystems for services provided to cities	The compact city in the ecological net (mitigation + adaptation)
Water storage capacity in relation to amount of paved urban area		
Urban agriculture as food security issue	Being able to cycle to green areas in a heatwave	Maximise use of local resources
Restore natural functions of ecosystems to optimise benefits of green infrastructure, ecosystems services	Accessibility of rural products	Integration with nature (bioclimatic)
Maintain and increase the number, accessibility, functionality and distribution of green urban areas, facades and roofs, trees, parks, gardens and other vegetation; multifunctionality	Create street and footpath networks that allow for different choices, with clear and multiple connections (avoid dead ends) and sufficient capacity Design urban form and density to allow for integration of decentralised renewable energy systems, for energy security during excessive weather events	Accessibility of the open spaces and services
Different types of green infrastructure (public, private, trees, grass etc.) can serve different purposes in different ways. E.g., private green is still important for climate, less for recreation	Polycentric development vs. centralised concentration (existing settlements) Number of mixed-use zones	Accessibility index for buildings of various functions
Sewage systems: split grey water and rainfall	Number of functions for land parcel Land use diversity	Fiscal gap indicator Economic diversity

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Table 45:

## Core dimensions of resilient systems, characteristics and benefits for

CHARACTERISTIC	DESCRIPTION	GREY INFRASTRUCTURE	GREEN AND BLUE INFRASTRUCTURES
Learning, memory, foresight	Capacity or ability to: <ul style="list-style-type: none"> <li>• learn from past experiences and failures</li> <li>• use information and experience to create novel adaptations</li> <li>• avoid repeating past mistakes</li> <li>• accumulate, store, and share experience</li> <li>• build on long-term cultural value and history of the city</li> <li>• integrate resilience in long-term development scenarios</li> </ul>	Historical data saving	
Performance	Following a disruptive event, the capacity or ability to: <ul style="list-style-type: none"> <li>• contain losses, including mortality and illness</li> <li>• reorganise</li> <li>• maintain and re-establish function</li> <li>• reinstate structure</li> <li>• restore basic order</li> <li>• avoid future disruption</li> </ul>		
Rapidity, responsiveness	Following a disruptive event, the capacity or ability to: <ul style="list-style-type: none"> <li>• contain losses, including mortality and illness</li> <li>• reorganise</li> <li>• maintain and re-establish function</li> <li>• reinstate structure</li> <li>• restore basic order</li> <li>• avoid future disruption</li> </ul>	Recovery of vital infrastructure Security of energy supply	
Redundancy, modularity	The capacity or ability to: <ul style="list-style-type: none"> <li>• substitute systems, or elements of systems</li> <li>• buffer from external shocks or demand changes</li> <li>• replace components with modular parts</li> <li>• balance redundancy with potential cascading effects</li> </ul>	Ensure diverse and redundant energy supply and distribution, including local, decentralised systems	
Resourcefulness	The capacity, ability, resources and infrastructures to: <ul style="list-style-type: none"> <li>• identify (and anticipate) problems</li> <li>• establish priorities</li> <li>• mobilise resources</li> <li>• visualise, plan, collaborate and act</li> <li>• re-evaluate</li> <li>• integrate resilience in governance and working processes</li> <li>• involve and co-create with citizens (e.g., crowd-sourcing and funding)</li> </ul>	Building code	Indicators for new development
		User-based approaches (the very first)	Knowledge of what you have, state it is in, to ensure resilience
			Green intervention measures for private and public spaces
			Integrate biodiversity in construction standards



# urban quality (RAMSES D2.1)

## BENEFITS AND CHARACTERISTICS

LAND USE, MOBILITY,  
URBAN-RURAL INTERFACE

ARCHITECTURE, PUBLIC SPACE,  
URBAN REGENERATION

Avoid building in risk-prone areas

Vulnerability of electricity units in public space for functioning of rail transport (train, tram...) + restore capacity

Ability to bring food and services into the city

Guarantee accessibility (e.g., work-home)

Design a coherent structure of public spaces, forms and functions with accessibility to all user groups; provide connections and overlaps between different areas, streets and squares, of a human scale; recognisably distinct and with a positive relationship between public and private spaces

Redundancy of infrastructure to cope with extreme events (e.g., transport)

Provide sufficient density for accessible services, but avoid competition for scarce resources among neighbouring functions and sectors (housing, tourism, industry etc.); multiple services – redundancy of uses

Use spatial planning as a tool to stop urban development in current and future risk-prone areas, risk factor per area for flooding

Resource and information flow from rural to urban for new governance system

Rate of provision of housing (having people accommodated quickly)

Capacity of restoring functionality of buildings after flooding in unembanked areas, making damaged buildings usable again and restore to previous level of quality (economic impact)

Capacity of public space (e.g., roads, plazas) to store water incidentally (how are roads, pavements etc. designed?)

Preparedness for extreme events

Building standards for climate extremes

Indicators dealing with uncertainty, thresholds

Indicators for management

Society's demands and expectations

Competitiveness

Upgrade of indicators for urban planning, e.g. using good urban planning/design to reduce the urban heat island effect

Helping politicians deal with it

Insurance ratio – finance

How to measure the resilience of people?

Public acceptance as an indicator of resilience

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Table 45:

## Core dimensions of resilient systems, characteristics and benefits for

CHARACTERISTIC	DESCRIPTION	GREY INFRASTRUCTURE	GREEN AND BLUE INFRASTRUCTURES
Robustness	The capacity or ability to: <ul style="list-style-type: none"> <li>withstand a given level of stress or demand</li> <li>without degradation or loss of function</li> <li>capacities that ensure sufficient margins</li> </ul>	Make infrastructures able to withstand excessive weather conditions using appropriate location, design, materials and detailing, and regular maintenance, e.g., spare storage capacity in sewage system before overflow into surface water; number and capacity of drains; ground permeability	Select vegetation that tolerates variable and sometimes excessive weather conditions, and does not require excessive watering or regular maintenance  Reducing on-site demand by means of efficient equipment, grey water recycling systems, ground water recharge systems, and rain water harvesting systems
		Prioritise vital infrastructures, e.g., railtrack materials (buckling etc.), metro vulnerability to floods, temperature level ICT datacentres can cope with	Design water bodies for natural gravity-flow drainage, improved ground drainage, proportion of city area that is built-up, area per capita
		Reconstruction of vulnerable structures	Ensuring sewage systems can cope with heavier precipitation; separate treatment of rainwater, disconnected from sewage
Co-benefits	<ul style="list-style-type: none"> <li>Added value assessment of resilience</li> <li>No/low regret measures</li> </ul>	Coordination of mitigation and adaptation	Green-blue areas provide an attractive visual environment and valuable ecological habitats; no-regret measures, social and environmental co-benefits, quality of life, health benefits
		Level of ITS (Intelligent Transport Systems)	
		Waste reduction as preventive measure for extreme events; recycling facilities; Pollution and consumption; Reuse and recycle – less dependency	Ensuring good green spaces; green infrastructure well-adjusted to environmental and social conditions of a city (expert and public assessment); distance to green space average for citizens, accessibility of green spaces for inhabitants; green roofs; bicycle lanes
		Annual energy imports, energy consumption and conservation; self-sufficiency; insulation density; renewables	Traditional compact cities increase heat island effect, but a greened compact city should reduce the effect
		Demand side management, smart grids	Ocean acidification, biodiversity loss, invasives, number of species
		Greenhouse gas emissions	



## urban quality (RAMSES D2.1)

### BENEFITS AND CHARACTERISTICS

#### LAND USE, MOBILITY, URBAN-RURAL INTERFACE

#### ARCHITECTURE, PUBLIC SPACE, URBAN REGENERATION

Design mobility systems in a manner that is accessible and attractive for pedestrians and cyclists, reducing dependability on motorised transport; e.g., street and footpath networks adapted to local topography and orientation

Regular maintenance, reconstruction of vulnerable buildings

Reduce on-site energy demand by means of energy-efficient buildings and infrastructures, use energy and resource efficient devices, and promote on-site integration of renewable energy generation to increase self-sufficiency and depend less on external supply

Avoid large building mass with extensive impervious surfaces, as these will act as thermal mass for heat and will prevent water drainage. Use surfaces with high albedo or reflectance where possible.

Provide a sufficient amount and distribution of permeable and green surfaces to avoid contributing to the urban heat island effect and allow for water storage and draining

Design for changes in temperature and relative humidity to avoid pests (fungus, bacteria and insects) that threaten the integrity of built structures and health

Prioritise bioclimatic design of buildings and open space: adaptation to local climate and topography to provide a comfortable microclimate with natural ventilation, solar access and shading, and green surfaces in open space. Design of buildings with sufficient insulation, wind and rain resistance, solar access and shading, natural ventilation, and green roofs and walls rather than relying solely on mechanical systems such as air conditioning.

Resistance of gas or heat networks for amount of water on ground level due to flooding (pressure)

Design public spaces for protection from excessive weather events. Excessive heat, storm, flooding, drought and humidity will reduce the use of public spaces, and thus constrain life.

Appropriate selection of geographical location and topography, taking into account for example soil instability and other exposure

Make buildings flood proof by appropriate design and material use, such as elevated entrances, building on poles, floating houses, temporary water storage, green roofs etc.

Link to identity

Synergies with resilient concepts to other changes (e.g., demographic, financial, crisis...) – use it!

Quality indicators too (e.g., not only km of bike lanes, but actual quality of lanes, safety and awareness of cyclists and pedestrians

Connectivity in the aim of sustainable transport (e.g., bike facilities), daily travel distance, time required for regular trips, to get out of the city

Expanding greenery while reducing urban sprawl

Local economy

Looking for opportunities to reduce urban sprawl and encourage densification without increasing impervious surfaces, with good width-height ratio of streets, reducing loss of forests and semi-natural areas

Bioclimatic design also saves energy and can make cities more visually attractive, protection against air pollution etc., opportunity for a healthier livelier city



**INSTRUCTIONS<sup>47</sup>**

1. First, 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 applicable resource

**Definition:** How do you verbally define the indicator?

**Unit:** What is the unit of measure/physical unit?

**Target direction:** 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?

**Basis 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?

**Measuring method(s):** What measuring method needs to be applied?

**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 –

	INDICATOR CHARACTERISTICS				REASON			BASIS DATA
	NAME	RESOURCE	DEFINITION	UNIT	TARGET	VALUE	AIM	
INDICATOR 1	Public green areas availability	Integrated Management for Local Climate Change Response	m <sup>2</sup> public green areas/ total surface	m <sup>2</sup> /km <sup>2</sup>	Increase relation	Air quality, heat waves action, health, life quality, sustainable land use	Provide data for future urban land use	City's total area and green area extension
INDICATOR 2								
...								

<sup>47</sup> The methodology is re-adapted from the ICLEI Canada, Changing Climate, Changing Communities workbook (worksheet 12) and the CHAMP project tool BR05



### 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)



#### LINK TO HANDBOOK

Phase VI > Step II: Designing the monitoring and evaluation system

## Tool BR05

DATA SITUATION						TEMPLATE RECORDS			
SOURCE	COMPETENCE	UPDATE INTERVAL	MEASURING METHOD(S)	LINKS TO OTHER	REFERENCES	COMPLEITON		REVISION	
						DATE	RESPONSIBLE	DATE	RESPONSIBLE
GIS systems, urban land use plan	Urban planning department	1 year	GIS systems, cartography	e.g. Green areas accessibility	UEE; EGCA, EUROSTAT	-	-	-	-



### 4.3.9 Worksheet no. 7: Communicating the urgency of adaptation and local accomplishments

#### INTRODUCTION

Climate 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 the 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.

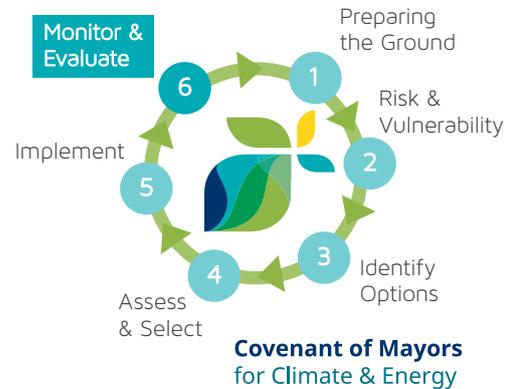
In fact, if challenges, strategies and actions are not communicated appropriately and in due time, stakeholders and citizens could express negative reactions to climate change adaptation, and not recognise its level of priority and the efforts made by their city administration.

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 of 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 choose the most appropriate means to reach and engage them. 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 subsequent disappointment and rejection.

#### Urban Adaptation Support Tool



#### 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.<sup>48</sup> Please take time to consult these before deciding on a line of action.



Image: RAMSES Project

<sup>48</sup> Adapted from ICLEI Canada



Table 47:

## Pros and cons of different communication methods. Adapted from ICLEI Canada

COMMUNICATION METHOD	PROS	CONS
<b>Communication Event</b> e.g. an "Adaptation Week", launch event, or awards ceremony	<ul style="list-style-type: none"> <li>✓ More likely to get participation</li> <li>✓ Provides an opportunity for community involvement</li> <li>✓ High profile</li> </ul>	<ul style="list-style-type: none"> <li>✗ Costly</li> <li>✗ May only reach a small number of people</li> </ul>
<b>Press Release</b> e.g. a public announcement on the accomplishments of the adaptation plan	<ul style="list-style-type: none"> <li>✓ Minimal costs</li> <li>✓ Reaches a wide audience (e.g. entire community)</li> </ul>	<ul style="list-style-type: none"> <li>✗ Difficult to ensure that it is read</li> <li>✗ Low profile – not celebratory</li> </ul>
<b>Issue Brief</b> e.g. interdepartmental memo on the accomplishments of the adaptation plan	<ul style="list-style-type: none"> <li>✓ Minimal costs</li> <li>✓ Reaches all arms of the corporate structure</li> <li>✓ Could create internal awareness of adaptation issues and spur interdepartmental involvement</li> </ul>	<ul style="list-style-type: none"> <li>✗ Only reaches a small internal audience</li> <li>✗ May not appropriately represent the scale of the adaptation effort</li> </ul>
<b>Newsletter</b> e.g. a three-monthly newsletter on your progress on adaptation including relevant public debates and events where the recipients are invited	<ul style="list-style-type: none"> <li>✓ Minimal costs</li> <li>✓ Reaches a vast public and keeps it engaged</li> <li>✓ Can grow the public interested in adaptation quickly</li> </ul>	<ul style="list-style-type: none"> <li>✗ Difficult to ensure that it is read</li> <li>✗ Not tailored to a specific stakeholder group</li> </ul>
<b>Reporting</b> e.g. annual progress report on adaptation plan and implementation efforts or community website update or feature	<ul style="list-style-type: none"> <li>✓ Documents progress in a formal way</li> <li>✓ Minimal costs</li> </ul>	<ul style="list-style-type: none"> <li>✗ Only reaches a small, mostly internal audience</li> <li>✗ Is not accessible to wider audience</li> </ul>

### 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:<sup>49</sup>

- › 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?

- › What is your timeframe?
- › What financial and human resources do you have available to you?

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.<sup>50</sup>

<sup>49</sup> Adapted from ICLEI Canada

<sup>50</sup> Adapted from ACCRN, p.48



Table 48:

Keeping track of communication endeavours.  
Adapted from ACCRN

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

#### FURTHER MATERIALS

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



#### LINK TO HANDBOOK

Phase VI > Step III: Communicating results to inform policy and practice

#### RAMSES AUDIO-VISUAL GUIDANCE

[http://on-urban-resilience.eu/#From\\_understanding\\_to\\_action](http://on-urban-resilience.eu/#From_understanding_to_action)  
[http://on-urban-resilience.eu/#Understanding\\_communication](http://on-urban-resilience.eu/#Understanding_communication)



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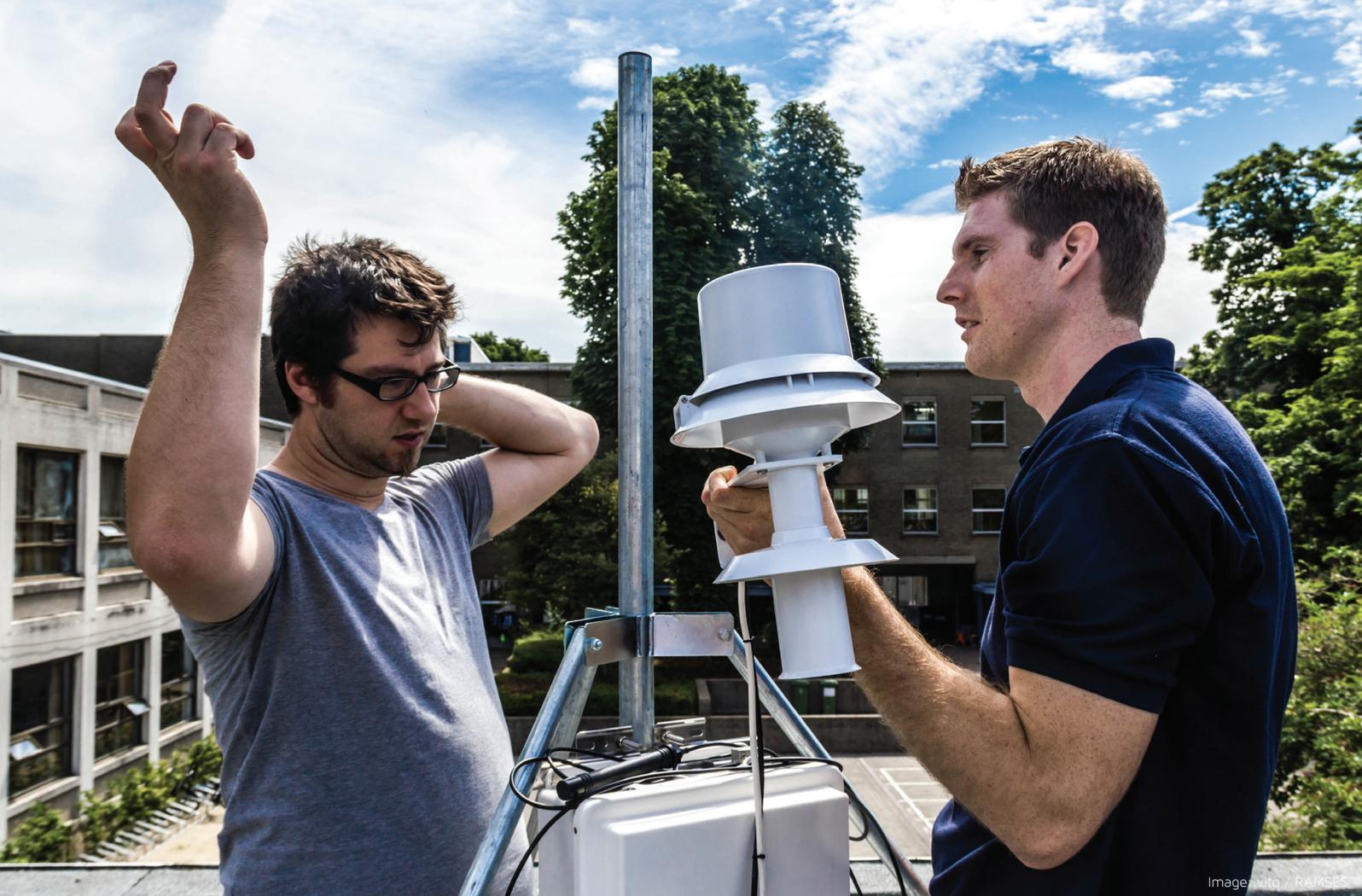


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#### AUTHORS AND CO-AUTHORS

Maddalen Mendizabal, Nieves Peña, Gemma García-Blanco, Efen Feliu [Tecnalia] / Alberto Terenzi, Vasileios Latinos, Julia Peleikis, Borja Anza Porras [ICLEI] / Giuseppe Forino, Katja Firus [T6] / Jürgen Kropp, Diego Rybski [PIK] / Annemie Wyckmans, Gabriele Lobaccaro [NTNU] / Richard Dawson, Alistair Ford, Oliver Heidrich [UNEW] / Koen de Ridder, Hans Hooyberghs [VITO] / Graham Floater, Helia Costa [LSE] / Gerardo Sanchez [WHO] / Charlotte Da Cunha, Dina Salakhova [UVSQ] / Bernd Hezel, Ephraim Broschkowski [CMF]

#### EDITING

Clara Grimes [ICLEI]

#### DESIGN

unger+ kreative strategien GmbH  
[www.ungerplus.de](http://www.ungerplus.de)

#### LAYOUT

Stephan Köhler [ICLEI]

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R A M S E S

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:

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