WP 6: City specific health impacts of climate change, damage and adaptation costs

D6.2:
Assessment tool to estimate the economic costs of health impacts of climate change

Reference code: RAMSES – D6.2

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**Short Description:** This report accompanies a prototype tool that can be used to estimate the economic costs of health impacts of climate change using data for health economic analysis and adaptation activity costs at the local level in the RAMSES cities within the WHO European Region.

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List of Abbreviations

ADB: Asian Development Bank
BCR: Benefit to Cost Ratio
CER: Cost Effectiveness Ratio
COI: Cost Of Illness
DRGs: Diagnosis Related Groups
EBRD: European Bank for Reconstruction and Development
EC: European Commission
EU: European Union
EUROSTAT: European Union Directorate General of Statistics
GDP: Gross Domestic Product
HMDB European Hospital Morbidity Database:
ICD: International Classification of Disease
IMF: International Monetary Fund
IPCC: Intergovernmental Panel on Climate Change
LCU: Local Currency Unit
OECD: Organization for Economic Cooperation and Development
PPP: Purchasing Power Parity
UN: United Nations
UNDESA: United Nations Department of Economic and Statistical Affairs
VOLY: Value Of a statistical Life Year
VSL: Value of a Statistical Life
WB: World Bank
WHO: World Health Organization
WHO-CHOICE: World Health Organization Cost effectiveness and strategic planning
WHO EURO: World Health Organization Regional Office for Europe
WIIW: Vienna Institute for International Economic Studies
Executive Summary

Local authorities play a crucial role in adaptation to climate change in general, and in protecting the health of their communities against climate impacts in particular. Ultimately, local adaptation action is needed to reduce vulnerability to climate change at all levels. This is even more the case for health adaptation, since the underlying health status and vulnerability of populations conform unique profiles that cannot be easily extrapolated. When it comes to concrete adaptation action, the roles and responsibilities of different stakeholders, including public administration, businesses and households, etc. are also best defined at the local level.

However, the engagement of local governments in general and specific adaptation remains on average low, both in countries of the European Union and in a broader European context. A number of barriers help explain this inadequate engagement, including a lack of awareness and political commitment, inappropriate governance structures, scarce data and a lack of specialized knowledge. In this context, it is clear that the involvement of local governments in adaptation should be facilitated.

In particular, generating, using and sharing local scientific and technical evidence are important on the one hand to inform adaptation policy, and on the other hand to provide a basis for inter-institutional dialogue in order to generate the necessary human and financial resources for efficient and effective local climate adaptation. Moreover, the monetization of impacts and adaptation options is an increasingly important basis of this evidence for the fair assessment of priorities in the allocation of resources. Like all adaptation activities, interventions to protect human health from climate change should routinely be evaluated not only in terms of their effectiveness or unintended consequences, but also in terms of the health damage cost of inaction, the cost of health adaptation, and the monetized benefits of different alternatives.

This deliverable (D6.2) consists of: 1) the present document providing background information and guidance for the use of a tool which can be used to estimate the economic costs of health impacts of climate change, and 2) the tool itself, as a simplified model based on Microsoft® Excel™. The tool together with this accompanying document thus aim at contributing to the overall goal of the RAMSES project to facilitate local engagement in adaptation planning, policy and implementation.

This document presents a simplified methodology for the evaluation of the economic consequences of disease and injury resulting from climate-related health outcomes. The methodology is based on a limited number of inputs, which makes it applicable also in settings of low data availability. The results provide estimates for advocacy by local governments and other stakeholders and early adaptation guidance. Despite this simplification, using this methodology requires some effort of data collection and modelling assumptions. While sound locally generated data are always preferable for local adaptation planning, a range of additional sources are offered in the text and annexes where available.

The valuation methods of the tool are based on mainstream bottom-up techniques widely used in the fields of health economics and environmental economics. These methodological choices were informed by the findings of RAMSES deliverable 6.1 A review on the health economics of climate change in Europe, and of the work packages that obtained direct feedback from urban adaptation stakeholders. Given the relatively limited involvement of local governments in health adaptation, an excessive complexity in modelling and the use of non-standard valuation techniques would very likely hinder the uptake and usefulness of the methodology for the relevant stakeholders.

The resulting outputs are cost-effectiveness ratio and partial benefit-to-cost ratios (a full social cost-benefit assessment of health adaptation is virtually unfeasible, for the reasons explained in section 2.4 Estimating the local costs and benefits of health adaptation to climate change).

Ultimately, this methodology is part of the comprehensive RAMSES toolkit for urban adaptation, with the overall goal of facilitating local engagement in adaptation planning, policy and implementation.
1 Introduction

1.1. Health adaptation to climate change in cities

Climate change has already affected human health over the last decades, directly by changing weather patterns (temperature, precipitation, rising sea levels and more frequent extreme events); indirectly by disrupting basic determinants of health like safe drinking-water, clean air and food security and quality; and also by shifting patterns of disease vectors and other effects in disease transmission. The IPCC projects that this trend will continue and most likely worsen to different extents and through various mechanisms in different parts of the world (Smith et al., 2014). In the European region1 (including the European Union) the main categories of observed and projected health-relevant climate exposures are (Baccini et al., 2011; Ciscar et al., 2014; Ciscar, Soria, & Goodess, 2009; Lindgren et al., 2012; WHO, 2008a): 1) Heat and cold; 2) Vector-borne diseases; 3) Floods; 4) Foodborne and water-borne infections; 5) Poor air quality; and 6) Heavily human-mediated impacts such as mental health and occupational health issues.

While climate change is a global phenomenon, its consequences and health impacts are observed and best understood locally, albeit the causal networks are complex. Global climate change affects regional climate patterns; these result in local variations such as increased frequency of hotter days, more episodes of extreme rainfall or drought; and in turn these have impacts on assets, livelihoods and health. This causal link from global phenomena to local impacts and vulnerability is highly influenced by local factors like geography, environmental and social determinants in ways and magnitudes still poorly understood by the scientific community (McMichael, 2013). Moreover, some of the defining characteristics of urban settings influence the relationship between climate-related exposures and health. Higher population density increases, all else being equal, the population at risk from health impacts from extreme weather. A higher degree of soil sealing (e.g. through paved surfaces) may increase the probability of flooding – more information on flood damage functions in urban settings is available in RAMSES deliverable 1.2 (Boettle et al., 2015). Reduced vegetation, heat-conserving urban materials, urban geometry and abundant heat sources all contribute to the “urban heat island” effect. On the other hand, the concentration of resources and human capital may contribute to health protection and greater resilience. The overall effect of the urban landscape and characteristics on the relationship between climate and health is not fully clear (Barata et al., 2011). However, urban populations across the European Union and the broader European region are already experiencing several of the health impacts of climate variability and climate change.

Against this background of risk, there is a relatively wide consensus on the generic categories of actions required to protect health from climate change impacts (European Commission, 2013; Samet, 2009; Smith et al., 2014; WHO, 2008a). These priorities and key interventions have been translated into policy commitments that can serve as frameworks for analysis and action. RAMSES deliverable 6.1 Review on economic assessment of damage or adaptation costs of health effects of climate change (section 1.2) provides more detail about such frameworks, the scope of which is besides the present report.

Beyond the main health adaptation principles, the categories of specific interventions needed to protect health from climate impacts are also well established. Such categories include, for example, general and sector-specific emergency preparedness and response management; strengthening health systems to effectively prevent and treat diseases and health conditions; and preventive measures, such as safer housing, flood protection, vector control, improved surveillance, early warning information systems and community-based disaster risk reduction. These categories are still generic, since specific responses can only be planned and implemented according to the specific climate-related hazards faced by each community. The process of identification of these hazards, population vulnerability and adaptation options can be managed via existing national guidelines on the matter or, in their absence, through the methods laid out in international guidance documents (e.g. EC, 2013; WHO, 2013).

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1 In this report, the “European Region” refers to the 53 countries comprising the World Health Organization European Region. These include all countries of the European Union and European Economic Area. The full list of countries is available at http://www.euro.who.int/en/countries
Even when health adaptation priorities and actions are clear, tackling the challenges and risks posed by climate change will require action at multiple levels of governance (international, national, sub-national and local) and the active engagement of multiple sectors and stakeholders (EU, 2013a; WHO, 2013c). Due to the varying severity and nature of climate impacts between regions in Europe, most adaptation initiatives will need to be taken at the regional or local levels. Like climate adaptation in general, health adaptation can be significantly fostered through an adequate engagement of local authorities. Ultimately, regardless of the geographical jurisdiction of the institutions driving adaptation (in the case of institutional adaptation), vulnerability reduction and health adaptation translate into a portfolio of actions implemented locally. This makes sense, since both vulnerability and adaptive capacity are context specific. It is even more clear for the case of health adaptation, as the underlying health status and vulnerability of populations to climate impacts and climate change combine into specific risk profiles that cannot be easily extrapolated.

While heterogeneous, national-level engagement in adaptation is to a certain extent harmonised in the European region (especially EU countries) due to international and European policy and legislation (Wolf et al., 2014), the engagement of local authorities in adaptation remains “diffuse, uncoordinated and heterogeneous” (EU, 2013b). This general description obviously summarizes a great variability of situations: In the past years, several local authorities throughout the European region have started to address climate adaptation, including health adaptation, explicitly or de facto, and some of them have made considerable progress. In general, larger cities who are proactive in mitigation are also among the frontrunners in climate adaptation. However, many cities are still only at the beginning or have not started their adaptation process yet. This can be explained by a number of barriers local governments face, including (EU, 2013b; WB, 2011): 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, McDowell, & Luber, 2012). This leaves practitioners and planners with little conceptual foundation for health adaptation at the local level, and the only option is to adapt the established concepts of health adaptation to the local reality on a case by case basis.

Two crucial dimensions define climate change as a health threat. The first one is the role of climate change as a stressor to current health dynamics, thus stressing the need for increased investment and program expansion in current climate-sensitive health priorities. The second is based on the risk of climate change jeopardizing critical infrastructure vital for public health, thus representing a distinct health stressor and requiring new strategies, tools and frameworks. Even though these two dimensions are complementary, health adaptation narratives are frequently more polarized towards one than the other leading to potential conflict (Hess et al., 2012) due to:

- Competing funding priorities – in practice, new initiatives usually are funded at the expense of other programming;
- Deficit in essential public health services – which many believe should be addressed before considering climate change impacts;
- Aversion to invest in risks that are yet to materialize, instead preferring to rely on existing infrastructure and all-hazards preparedness; and
- Difficulties in pursuing a long-view, systems-based, management-oriented approach to public health due to existing funding and administrative structures.

Therefore, in the process of planning and deciding health adaptation, a frank discussion is necessary from the inception phase with regard to the approach to be taken: an expansion of existing programs and services, the implementation of new ones, or both.

Regardless of the approach adopted, the best evidence should be used to inform adaptation - including health adaptation - at every level of governance, including the local level. Although there are efforts to develop standardised approaches to climate adaptation, there is up to now no generally accepted framework on the use of evidence for adaptation policy. In a context of limited resources and competing priorities, it is clear that economic evidence should play a role in adaptation planning. Specifically, activities to protect human health from climate change should routinely be evaluated not only in terms of their effectiveness or unintended consequences, but also in terms of the health damage cost of inaction, the cost of health adaptation, and the monetized benefits of different alternatives.
1.2. The economics of health adaptation to climate change

Besides their inherent human cost, ill health and premature mortality represent real and significant economic costs to society. The health impacts of climate change, if not averted, will thus add a component of economic stress and losses. For adequate evidence-based planning of health protection under a changing climate, data need to include economic costs and benefits, and the research community has a responsibility to develop and apply appropriate methods and communicate findings.

In this regard, the basic techniques and methodologies used for the health economics evaluation of climate change impacts and adaptation have a relatively solid basis, since they greatly overlap with those routinely used in environmental health economics. These, in turn, are for the most part adapted from commonly used tools for the economic evaluation of disease and injury, which have been used for several decades with little conceptual change.

The cost of health damage from climate change, and indeed any health economic impact, can be estimated in several ways. A key question to determine what approach to use is whether the economic impact is to be measured on society as a whole or on some parts of it. The latter frequently entails in practice aggregating partial estimates of the cost of increased morbidity and its consequences, and of the cost of increased premature mortality risk. The cost of premature mortality can be estimated through various methods, most of which assume either a loss of welfare to society associated to premature death (measured through willingness to pay), or an opportunity cost of such premature death in terms of foregone income, capital formation or both. The economic valuation of mortality risk is extensively explored elsewhere (OECD, 2010, 2012), but for the purposes of this report it is worth noting that the choice of valuation technique and metric greatly affects the final estimates. This is further discussed in subsection 2.4.3 Valuing mortality risk.

For the estimation of the costs associated to morbidity, a commonly used approach is the “Cost of illness” (COI), which is the technique used by this tool and is further discussed in subsection 2.4.2 Valuing morbidity: methodological choices and rationale. In a so-called “full income” approach, health economics evaluations sometimes pool morbidity and mortality costs. However, given that the conceptual foundations of the measurement of lost welfare associated to premature mortality through willingness to pay are disputed, in principle the best practice would be to separately report market costs such as treatment and lost income, and nonmarket costs such as mortality.

The main current alternative analytical approach to the aforementioned is to assess, for a whole economic system, the aggregate impact of climate-related disease and injury across different economic agents. The diversity and complexity of methods derived from this approach is considerable, but the most common categories found in the literature are (WHO, 2009): 1) Regression-based estimation models, which try to derive empirical relations between health indicators and growth or Gross Domestic Product (GDP); 2) Simulation-based calibration models, which include intermediate factors such as labour supply or savings rates in the relationship between health and economic growth; and 3) Computable general equilibrium models, which attempt to simulate the impact of health “shocks” across all sectors of the market economy.

The implementation of this tool as an integrated assessment model estimating the economy-wide health costs of climate change would not be compatible with the overall costing framework of RAMSES, as laid out in the deliverables of WP5. Therefore, the methodological approach taken in this tool follows “microeconomic” methods and foundations.

The main categories of economic evidence relevant to health adaptation are:

- The cost of inaction, that is, the full cost of the health damage brought about by climate change if nothing is done to avert it;
- The cost of adaptation, meaning the full cost of the actions intended to avert the health damage from climate change (and possibly others with a different intent but clear health protection effects – see discussion in section 2.5.2 Theoretical basis for the Adaptation costs worksheet); and
- The benefits of adaptation, namely the monetized benefits from averting a proportion of the health damage of climate change through adaptation.
In the following chapters, the methodology to calculate these three types of outputs based on available information and local data is described. The provided information serves as guidance to estimate the economic costs of health impacts of climate change and fill the accompanying spreadsheet.

2. A methodology and a tool for the economic evaluation of climate-related health impacts and adaptation at the local level

2.1. Tool description and methodological framework

The tool, illustrating the methodology laid out in this report, is operationalized through a simple model based on a Microsoft® Excel™ spreadsheet. While several display and interface options are now available for the development of a tool illustrating the methodology, a spreadsheet is a format that most users will be familiar with. It also allows to audit interactions between parameters and underlying formulas, thus eliminating the “black box” component of several models.

The spreadsheet features the following individual sheets:

- **Read me:** an explanation of the structure of the tool, its components and the color-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.

These sheets correspond to the steps followed in the present methodology (see Figure 1 below), which can be summarized as follows:

1. Calculate 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 to illness;
2. Calculate the cost of health adaptation, that is, of the interventions planned and necessary to avert or minimize the health impacts considered;
3. Estimate the economic benefits of such interventions, by monetizing the avoided cases of the health impacts considered; and
4. Obtain and report indicators needed for planning and decision-making, such as cost-effectiveness estimates and benefit-to-cost ratios.

Step 1 corresponds to the “Health costs” and “Economic values” sheets; step 2 corresponds to the “Adaptation costs” sheet, and steps 3 and 4 correspond to the “Outputs” sheet.

While these steps may seem conceptually straightforward, their calculation is frequently labour-intensive, and often requires previous supporting analyses. It is important to note upfront that the assessment of the climate change health impacts is beyond the scope of this manual and of the accompanying tool. That implies that the health evaluation is to be conducted before the application of the tool. For various reasons (see subsection 2.3.3 Health outcomes considered) such impact assessment cannot be summarized into a standard methodology, or even a reasonable subset of them. This is, however, only a relative drawback. Firstly, the ascertainment of the additionality of the health impacts due to climate change, as opposed to the health impacts due to a certain climate exposure (e.g. heat) is of limited importance with regard to public health responses and prevention. Secondly, the tool can thus also be used for the economic evaluation of other locally relevant environmental health risks, such as air pollution. Thirdly, the proposed tool is flexible enough to accommodate future health impact assessments. And lastly, the adaptation costing component of the tool specifically accommodate the timeframes and structure of climate change adaptation responses.

Therefore, the proposed methodology was devised to provide monetary evidence on the impacts on climate change on health in order to support local decision-making and advance local climate adaptation. This description is accompanied by a Microsoft® Excel™ - based tool which allows end-users to insert the collected information and obtain a summary of the results. Given the current barriers
for local decision-makers regarding local adaptation (see subsection 1.1), any approach dependent on specialized expertise or large data availability would be of limited use for most local governments. Therefore, this methodology and the accompanying tool are based on a “bottom-up” approach of a microeconomic character, that is, on aggregating partial estimates of the cost of increased morbidity and its consequences, and of the cost of increased premature mortality risk (Martinez, Williams, & Yu 2015).

As mentioned in the first deliverable of RAMSES Work Package 6 (D6.1), the basic techniques and methodologies used for the health economics evaluation of climate change impacts and adaptation greatly overlap with those routinely used in environmental health economics. These, in turn, are for the most part adapted from commonly used tools for the economic evaluation of disease and injury. The World Health Organization recently proposed a methodology (WHO, 2013a) for their application in the context of climate change at the national level. The present methodology draws its overall framework from this methodology, adapting it for the local level and here in particular for adaptation planning in settings with low data availability and low specialized expertise.

All the preparatory work for filling in the inputs and interpreting the outputs of these sheets is explained in the following subsections.

2.2. Using this tool in the context of local health adaptation

The specific use of the tool outputs is obviously highly context dependent, but like other evidence inputs into the decision-making process it can be introduced at various stages. Due to its simplified approach and lacking a formalized uncertainty analysis, the estimates generated by this tool are best suited for early stages of policy development.
Stakeholders gathered in the 2nd RAMSES Stakeholder Dialogue “Drawing pathways towards the resilient city: identifying vulnerabilities, empowering decision-making, fostering change” provided feedback with regard to the context for the best use of evidence in health adaptation planning. It was clear that the evidence base would have great value for the department leading and promoting the health adaptation actions (most commonly the health department) in the engagement of different departments and institutions. In that regard, economic parameters would be crucial to secure the financing needed for the additional component of health adaptation, particularly in smaller urban settings with limited technical and human resources. Moreover, evidence could be used by stakeholders advocating for action on adaptation, including health adaptation. In line with this feedback, this methodology and the accompanying tool are intended to mainly support local policy-makers to plan and implement climate change health adaptation policies. However, also other stakeholders involved in planning and implementing such policies are encouraged to use this material. The calculation of the health costs of climate change can provide overall estimates of the economic magnitude of the problem, and the estimates of adaptation costs can illustrate the relative affordability of mitigating the health impacts of climate change.

The outputs from this toolkit would, however, represent only one of several inputs to be considered in decision-making and policy cycles. Moreover, economic evidence can easily be included in several types of decision-support tools commonly utilized in local governance regarding environmental and adaptation policy. The amount and diversity of those techniques is large and well beyond the objectives of this document, but a good description can be found in (Crabbé & Leroy, 2008). Many of those tools have the ability to include economic data either derived from markets or from evaluations like the ones obtained through the present methodology and tool.

While health impacts cannot be fully represented in economic terms, experience shows that attempts to indicate the costs of climate change related health and adaptation costs are considered an important input to local decision-making. Furthermore, credible estimates of adaptation costs provide a basis for budgeting as well as assessing value for money (WHO, 2013a). By making the economic consequences of the health impacts of climate change explicit, planners, policy-makers and other actors can further strengthen the case for early action in protecting health from the impacts of climate change.

2.3. **Before starting: Scoping the evaluation**

Given the complexity frequently involved in prospective evaluations - especially those related to climate change and climate policy - it is important for the analyst to clearly define the scope and limits of the analysis. To a large extent, this scope will be determined by the intended use of the results. If the intention is only to raise attention to the health costs of climate change, it is sufficient to implement the first of the above outlined steps only, that is, to calculate the health damage costs attributed to climate change. If, however, an estimate of the value for money from health adaptation is needed, all described steps need to be undertaken. Scope limits should ideally be defined early on in the evaluation process as a basis for the data collection and processing by the analysis team. Below are presented some important scoping considerations to be clarified before starting the analysis.

### 2.3.1. **Geographical scope**

Although other levels of application are possible (e.g. provincial, regional, etc.), the main geographic scope of this tool is the local level. At the local level, it is particularly important to determine whether the focus is on the urban agglomerations or administrative boundaries. The latter may include rural areas where factors potentially differ from urban areas. If more than one geographical scope of application is required (for example, at the provincial level and also at a particularly climate-sensitive area within this province), one separate Excel™ file should be filled for each level. In such a case, an additional final worksheet for summarizing damage costs at all levels considered will be required.

### 2.3.2. **Population**

Furthermore, the analyst team needs to decide whether the analysis considers the whole population or only parts of it, and, if relevant, the type of disaggregation (e.g. by age, sex, income or other
variables). The population considered should mainly be determined by the intended purpose of the analysis. However, in some cases the epidemiological profile of some climate sensitive exposures suggests a focus on certain subgroups. For instance, high temperatures tend to affect in particular certain risk groups, such as elderly people, infants and children, people in certain occupations, people taking certain medications, people with disabilities, persons living alone or socially isolated, and chronically ill persons (Bouchama et al., 2007; Kovats & Hajat, 2008).

2.3.3. **Health outcomes considered**

The specific health outcomes selected constitute the basis of the health damage costing in this methodology and the accompanying tool (see section 2.4.1. *Data inputs for health damage costing*).

The ascertainment of the health impacts attributable to climate change is in general a complex process, requiring specialized expertise and with high uncertainty. An estimation of the impacts of climate change or specific climate-related exposures on health is needed for the economic evaluation. However, assessing climate change health impacts is beyond the scope of this manual and of the accompanying tool. WHO provides guidance on quantifying the health impact of climate change at national and local levels (Campbell-Lendrum & Woodruff, 2007) as well as other resources to assist Member States in adaptation (WHO, 2013c). In addition, there is a growing body of national and subnational studies on the effects of climate variables and/or climate change on a wide range of health outcomes. Relevant examples include, among others, the health effects of temperature (Amengual et al., 2014; Baccini et al., 2011; Hajat et al., 2014), tick-borne diseases (Daniel et al., 2010; Lindgren, Ebi, & Johannesson 2010) and flood-related mortality and morbidity (Ciscar et al., 2014; Watkiss et al., 2009). The relevant literature in this field has been summarized elsewhere (Confalonieri et al., 2007; Smith et al., 2014; Woodward et al., 2014). Annex 1 lists online resources that can serve as guide in the health impact assessment stage.

Acknowledging the uncertainty related to the strict attribution of health impacts to climate change, and the fact that many local authorities may not have the resources or expertise to conduct a full evaluation, the tool allows a certain flexibility. All cases of health outcomes can be included, regardless of their strict attribution to climate change. For instance, a sensitivity analysis can be conducted by extrapolating past climate-related health impacts (e.g. heat-related mortality and/or morbidity) into the future, regardless of the proportion that would be attributable to climate change.

Given the multitude of climate-sensitive exposures and outcomes, and the complex pathways linking climate change and health, the analyst team should focus on a limited set of specified outcomes. Such outcomes can be univocally identified through an internationally accepted system, such as the International Classification of Diseases 10th edition (ICD-10) issued by the World Health Organization (WHO, 2011b). For national context on inpatient hospital morbidity, the World Health Organization Regional Office for Europe (WHO EURO)’s European hospital morbidity database (HMDB) (WHO EURO, 2015) provides data on hospital discharge by detailed diagnosis, age and sex, which have been submitted by countries in the WHO European Region (comprising 53 countries)².

2.3.4. **Timeframe of analysis and discount rates**

The tool can be applied both prospectively and retrospectively, that is, the start year for the damage cost assessment can be in the past, and the timeframe can lead up to the present or into the future. It allows for a variable number of single-year with user-defined start and end years, both in the“Health costs” and in the“Adaptation costs” sheets. The first year of the analysis should be entered in the first “year” column of the worksheet, and all future years will be updated.

The timeframe of the economic evaluation will be largely determined by that of the underlying health impact assessment. However, the prospective timeframe considered in the assessment must be carefully considered. Generally, longer timeframes (e.g. by the end of the century) are more appropriate. They allow for a better ascertainment of the additional burden brought about by health impacts of climate change, since these are expected to increase over time. However, policy planning tends to focus on shorter timeframes.

² see complete list at [http://www.euro.who.int/en/countries](http://www.euro.who.int/en/countries)
Another important consideration in the determination of the timeframe of analysis is discounting, specifically the choice of discount rate. A discount rate is applied to express future costs or benefits at today’s equivalent value. The higher the discount rate, the less future economic impacts are worth in the present. Thus, imposing a high discount rate for health damages projected far into the future diminishes their relative importance today. The issue of discounting in the context of climate change adaptation has been discussed elsewhere and is beyond the scope of this document. However, the prevailing scientific consensus tends to support the notion of small (3% or less) and/or declining discount rates (Goulder & Williams, 2012). Expressing costs in currency values in the present year is usually most meaningful for decision-makers.

2.4. **Worksheets “Health Costs” and “Economic values”: Estimating the local cost of health damage from climate change**

2.4.1. **Data inputs for health damage costing**

The data needed for the estimation of the economic cost of health damage are listed in table 1 below, along with their labels in the spreadsheet:

<table>
<thead>
<tr>
<th>Category</th>
<th>Label</th>
<th>Variable</th>
<th>Definition (Unit)</th>
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<tbody>
<tr>
<td>Health impact</td>
<td>D1</td>
<td>Morbidity attributable to climate change</td>
<td>Incident cases (number)</td>
</tr>
<tr>
<td></td>
<td>D2</td>
<td>Premature mortality attributable to climate change</td>
<td>Deaths (number)</td>
</tr>
<tr>
<td>Health service use</td>
<td>D3</td>
<td>Outpatient consultations</td>
<td>Proportion of cases seeking care (%)</td>
</tr>
<tr>
<td></td>
<td>D4</td>
<td>Outpatient visit rates</td>
<td>Average number of visits per case seeking care (number)</td>
</tr>
<tr>
<td></td>
<td>D5</td>
<td>Inpatient admissions</td>
<td>Proportion of cases admitted from within all cases seeking care (%)</td>
</tr>
<tr>
<td></td>
<td>D6</td>
<td>Length of inpatient stay</td>
<td>Average number of days per inpatient admission (number)</td>
</tr>
<tr>
<td>Health care unit costs</td>
<td>D7</td>
<td>Full unit cost of outpatient care</td>
<td>Full cost per outpatient service provided (LCU)</td>
</tr>
<tr>
<td></td>
<td>D8</td>
<td>Full unit cost of inpatient care</td>
<td>Full cost per inpatient service provided (LCU)</td>
</tr>
<tr>
<td>Cost of lost productive time</td>
<td>D9</td>
<td>Value of productive time loss</td>
<td>Opportunity cost of productive time lost to disease (LCU)</td>
</tr>
<tr>
<td></td>
<td>D10</td>
<td>Days off productive activities</td>
<td>Days of productive time lost to disease (LCU)</td>
</tr>
<tr>
<td>Cost of mortality</td>
<td>D11</td>
<td>Value of life</td>
<td>Relevant value of a statistical life (LCU)</td>
</tr>
</tbody>
</table>
Most of the figures related to these variables can be filled in directly into the “Health cost” sheet. For the calculation of the cost of lost productive time and cost of mortality, however, additional inputs must be filled into the “Economic values” sheet. These additional inputs are listed in table 2 below.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Unit</th>
<th>Default or suggested value available?</th>
</tr>
</thead>
<tbody>
<tr>
<td>National average wage (annual)</td>
<td>LCU</td>
<td>No</td>
</tr>
<tr>
<td>National GDP per capita</td>
<td>LCU</td>
<td>No</td>
</tr>
<tr>
<td>Opportunity cost of time (compared to average wage)</td>
<td>%</td>
<td>Suggested at 30%, see section 2.4.2.2 Cost of productive time lost</td>
</tr>
<tr>
<td>Working days per year (for daily rate calculation)</td>
<td>Days</td>
<td>No</td>
</tr>
<tr>
<td>Annual discount rate of future income</td>
<td>%</td>
<td>Suggested 0% to 3%, see section 2.3.4. Timeframe of analysis and discount rates</td>
</tr>
<tr>
<td>Value of a statistical life (from international study, benefit transfer)</td>
<td>LCU and Million USD</td>
<td>Default at income elasticity of 0.7, 0.8 and 0.9. If better estimate available, overwrite.</td>
</tr>
</tbody>
</table>

Once these variables and parameters have been entered into the spreadsheet, the costing calculations are performed in order to provide an overall estimate of health damage cost. This estimate is obtained by adding up the cost of health care, the cost of mortality and the cost of productive time lost to disease. In turn, the cost of healthcare is calculated differently depending on whether the outcome is treated on an in-patient basis or not. All formulas are listed in table 3.

<table>
<thead>
<tr>
<th>Type of cost</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full health costs</td>
<td>= Full health care costs + Health-related lost productive time costs + Premature mortality costs</td>
</tr>
<tr>
<td>Full health care costs</td>
<td>= Full outpatient costs + Full inpatient costs</td>
</tr>
<tr>
<td>Full outpatient costs</td>
<td>= Health cases × Proportion of patients seeking outpatient care × Number of outpatient visits per patient seeking treatment × (Full unit cost of health service per consultation + Full patient transport cost per visit + Pharmacy unit cost)</td>
</tr>
<tr>
<td>Full inpatient costs</td>
<td>= Health cases × Proportion of patients seeking outpatient consultation × Hospital admission rate (admissions per outpatient) × Average length of hospital admission × (Full unit cost of inpatient health service per day + Full patient transport cost per visit)</td>
</tr>
<tr>
<td>Health-related lost productive time costs</td>
<td>= Health cases × Average number of days off productive activities × Economic value of a day spent sick</td>
</tr>
<tr>
<td>Premature mortality costs</td>
<td>= Number of deaths × Value of a statistical life</td>
</tr>
</tbody>
</table>

The relevant outputs can be found on either a cumulative or annualized basis in the “Health cost” spreadsheet. The main output is in D12: Full damage costs, but others can be excerpted as needed.
2.4.2. Valuing morbidity: methodological choices and rationale

Several methodologies have been developed for the calculation of both market and non-market costs of cases of illness, also known as morbidity, which can be readily applied to the morbidity attributable to climate change or climate-related exposures. A commonly used approach is the “Cost of illness” (COI) method which captures costs related to a case of the outcome(s) considered. COI studies commonly consider three categories of costs (Pervin et al., 2008): 1) Direct costs, including healthcare costs and other costs directly caused by illness like the cost of a caregiver time or direct economic losses; 2) Indirect costs, mainly resulting from the loss of productive time or impaired ability to work, or premature death; and 3) Intangible costs reflecting the value associated to the avoidance of pain and suffering, and their limiting effects. In this tool, we will focus on the first two categories, i.e. specifically healthcare-related costs and the cost of productive time lost to disease.

2.4.2.1. Cost of healthcare

It is important to note that all costs included in an economic evaluation on a societal level should be, as far as they can be estimated, completely unsubsidized costs. Since the health impacts and its healthcare usage consequences considered in the evaluation are unplanned for, accounting for out-of-pocket cost only would severely underestimate their true societal cost. In addition, these excess health impacts will require a share of new resources, but will not necessarily require additional resources in every part of the system. For instance, building and capital costs, staff and overhead are typically not affected significantly with the addition of a new case to be treated. Medications, supplies and chemicals used for laboratory tests and bus fares are, however, all additional costs that at some point involve additional cash outlay by the health system or the patient. While it could be useful in some instances to estimate both the full costs and the marginal costs associated to the health impacts, this tool features only full costs for the sake of simplicity and ease of application at the local level.

Health service use

The variables related to the use of health services typically associated to a single or a subgroup of health outcomes are a key component of the evaluation. The assumption that every patient will seek formal healthcare for a certain condition is unrealistic. Healthcare seeking behaviour, even in settings with almost universal access, is a complex reality that depends on several variables, both individual and at the population level (Macassa et al., 2014). Once a person accesses the formal healthcare systems, however, reasonably complete data usually exist about frequency of visits, resource use and other cost-relevant variables. Whether those data are collected and compiled on a routine basis is a different matter. Table 4 below specifies the type of information required and possible sources.

Table 4. Health service parameter needs and possible sources

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

Obviously, locally relevant data are always preferable if they are reliable. The order of preference in table 4 is by no means grading the quality of the sources, but rather ordering them according to local relevance. In absence of local data sources or locally relevant literature, national data on health service...
use can be used. There is a considerable number and variety of such data sources in European
countries (both EU, and to a lesser extent, non-EU). While a review of such sources is beyond the
scope of this report, these data repositories should be the first go-to option for local authorities in
absence of locally generated data.

Ultimately, for the purposes of a quick interim evaluation, data can be extrapolated from international
sources. Some important sources at the regional level include:

- Eurostat healthcare database (EUROSTAT, n.d.);
- Organization for Economic Cooperation and Development (OECD) health statistics database
  (OECD, n.d.-b); and
- WHO EURO “Health for all database” (WHO Regional Office for Europe, n.d.).

All of these databases include indicators on health care utilization and expenditure of potential
relevance for this costing tool, such as: average length of stay, by type of hospital; outpatient contacts
per person per year; total health expenditure as proportion of GDP / PPP (i.e. adjusted by Purchasing
Power Parity) $ per capita / public vs. private; pharmaceutical expenditure, PPP$ per capita; and
private households’ out-of-pocket payments on health as % of total health expenditure, among others.
While these indicators would not be optimal in the costing of health damage from climate change per
se, they could be useful to provide context for the costing outputs.

In addition, and for the “hotel” component of the cost of inpatient outcomes, that is, costs that are
associated with inpatient bed occupancy regardless of the specific treatment, such as food, cleaning
services, facilities, etc., a series of default values are proposed in Annex 2. These values are excerpted
from the WHO-CHOICE database (WHO, n.d.) for countries of the WHO European Region, including
those in EU28.

Full unit costs of outpatient healthcare

“Outpatient” healthcare loosely refers to patients that attend a healthcare facility without staying
overnight. This distinction has important consequences regarding the use of healthcare resources, as
well as the availability and reliability of information. While “inpatient” facilities, like hospitals,
usually have comprehensive and centralized health information systems this is less commonly the case
for “outpatient” facilities.

Unit costs should include all aspects of treatment, including fixed costs (e.g. staff and medical and
non-medical equipment) as well as variable costs (e.g. supplies, medications and laboratory tests).
Unit costs should be as specific as possible to each type of disease, but ultimately a theoretical
treatment scenario should be built based on established guidelines or expert advice.

As not all patients with a particular disease will receive exactly the same treatment, the average cost
per patient should be estimated. For most diseases, the consultation costs at public clinics and
hospitals within a country will be similar, particularly in settings with publicly paid or heavily
subsidized health systems. Variation may occur mainly in the supplies and medications used and, in
some instances, diagnostic laboratory tests. For some diseases, unit costs vary by age group, so the
costs should be assessed case-by-case. As mentioned, the price of publicly subsidized treatments and
medications does not represent their full cost to society, which is best estimated as the cost of
unsubsidized, privately purchased goods and services. To ensure that the full costs of resources are
captured, the prices or tariffs of any publicly subsidized services should be adjusted to omit the
subsidy element (WHO, 2010b). Services at public facilities, such as medication prices, should be
compared with those of private pharmacies or health care providers. Furthermore, the available unit
cost data should be assessed for completeness and national representativeness.

For patients who buy their medications from private pharmacies or retailers, the average prices in
those pharmacies should be used as the unit cost. The prices of medications are assumed to include a
mark-up for the cost of pharmacy staff, distribution and transport and a (small) profit.

Formal outpatient health care is likely to require transport to a health care establishment, so travel
costs per return visit are also required. Travel costs include the costs to both the patient and any
accompanying people. The unit cost should reflect the average transport cost for people attending any
formal health care facility (clinic or hospital). For outpatients, the main cash outlays will be for taxi
fares and bus tickets, since outcomes requiring ambulance transport are also likely to require inpatient
admission. Ambulance costs are not included in this category and, when possible, should be covered in the costs of health care. When possible, the fuel cost for patients who use their own vehicle should be estimated and included. The average unit cost should reflect that for patients who use a mixture of forms of paid transport and for those who live close enough to walk or cycle to the nearest formal facility.

Again, for the “hotel” component of the cost of outpatient outcomes, a series of default values are proposed in Annex 2. Those costs represent an estimated cost per outpatient visit, and include all cost components except drugs and diagnostics.

**Full unit costs of inpatient healthcare**

Inpatient healthcare is the care given to a patient who is admitted into a healthcare facility and stays for one or more nights. Typically, resource use and cost information are more complete for inpatients than for outpatients, for various reasons. Firstly, inpatient facilities like hospitals usually have comprehensive and centralized health information systems; secondly, inpatient care is comparatively much more expensive than outpatient care, for a wide variety of reasons resulting in the need for more expensive inputs to care; as a result, cost and reimbursement for inpatient care is commonly tightly accounted for, particularly if the system relies on one or a few main payers (i.e. national health insurance funds). In this tool, the inpatient cost per day should be estimated when possible and multiplied by the average length of stay per disease to estimate the total cost per admitted patient. If only the cost per admission is available from a study, the cost per day can be estimated on the basis of the average length of stay (in days) recorded in the study. Alternatively, the cost per admission can be inserted in the “Cost per day” cells, and enter the number “1” in the “Average length of stay” cell. Possible sources for healthcare cost data are laid out in box 1.

When selecting data on healthcare costs for analysis, it is important to know the level of care to which those costs apply. For example, unit costs from studies conducted in tertiary hospitals should not be used when most patients are treated in primary facilities, as that would artificially inflate health damage costs in the calculation.
2.4.2.2. Cost of productive time lost

A value, or range of values, for the “Opportunity cost of time (compared to average wage) (%)” must be entered in the “Economic values” worksheet of the tool. This parameter reflects the clear economic implication from illness regarding the time lost for productive activities, be it paid employment or other productive activities.

The value of time lost for productive activities due to illness has been researched most thoroughly in the field of transport economics (Gwilliam, 1997). It can be inferred from information on what the sick person would have been doing with his or her time, were s/he not sick:

- If the person would have been working in a remunerated activity, the value of the lost production or income would be recorded as the economic loss (including wages) due to their illness;
- If the person would have been working in a non-remunerative activity, the cost of replacing the person would be recorded, for instance by the average or minimum wage. The fact that an activity is not remunerated, does not mean it does not have societal value; and
- If the person would have been enjoying leisure time, a value related to suffering from the pain and inconvenience of the sickness and not being able to undertake leisure activities would have to be recorded.

Due to the complexity of aggregating economic losses from such a variable mix, some studies have applied an average value of productive time lost - 30% of the average GDP per capita - to represent the overall opportunity cost of sickness time for the entire population (Hutton, 2008). This reflects an average for working populations, non-working populations and schoolchildren. If the majority of sick people are working, however, this percentage would be an underestimate of the value of productive loss.
The value of time lost to illness should be based on a representative figure, such as the average wage, median wage or GDP per capita (see Box 2 for additional information). The annual value should be converted to a daily value on the basis of the number of working days per year.

**BOX 2 – Where to find data on cost of productive time lost**

There are many sources for the costing of lost productive time. Most often, national institutes of statistics and/or line ministries (e.g. finance, economy, labour, etc.) maintain databases at different levels of disaggregation. In the absence of data estimated at the local level, national averages can be used.

If no other estimates are available or for a quick preliminary evaluation, a range of international organizations provide national-level indicators of countries in the European region (understood as the 53 countries that comprise the WHO European region) that can be used to calculate cost of lost productive time:

- Think tanks (OECD, n.d.-a; WIWI, n.d.);
- The EU (EC, n.d.); and
- Other international organizations (IMF, n.d.; UN, n.d.).

Another useful source of population-level measurements of time spent on paid or unpaid work are the “Time use surveys”. Data on time spent on productive household and leisure activities is crucial to understanding and assigning a value to time lost to illness. Several countries in the WHO European Region, including most EU-28 countries, have conducted time use surveys (UNDESA, 2015). These can be used as one more input in the estimation of the opportunity cost of a productive day lost to illness. Moreover, time use surveys have been used jointly with meteorological records to ascertain loss of work time in climate-exposed sectors due to heat, as well as loss of leisure time in the general population (Graff Zivin & Neidell, 2010).

2.4.3. **Valuing mortality risk: methodological choices and rationale**

Various techniques can be used to ascertain the acceptability of trade-offs at the societal level between risk of death and money. Frequently, these techniques rely on surveys from which a “value of a statistical life” (VSL) is derived, representing the economic benefit for a given time that a population places on preventing the risk equivalent to one case of premature mortality value.

There are other approaches to the valuation of an avoided fatality. One possibility is assuming an equal value to each remaining life year, an approach known as “Value of a Statistical Life Year”, or VOLY, in which age variation is explicitly taken into account, as opposed to the generally age-independent VSL approach. Crucially, the choice of mortality valuation metric (VOLY or VSL) leads to large differences, with higher estimates when applying VSL values. This is a major and far from resolved source of uncertainty in economic terms. Treating all individuals as equivalent for valuation purposes (as is usually the case with VSL) is a frequently contested notion, given the potentially large difference in life-years lost between elderly and younger individuals due to environmental risk factors. On the other hand, the epidemiological basis on years of life lost, and particularly of their valuation in terms of willingness to pay, is much thinner. This has led to a predominance in the practice of VSL as the norm in regulatory impact assessment with VOLY used for sensitivity analysis (OECD, 2012) and it is the reason why mortality risk valuation in this tool is done through VSL. Another possibility is aggregating the income foregone by the premature death of an individual, a method known as the “human capital approach”. However, this technique is widely considered to severely underestimate mortality risk costs in all but the most severely deprived settings.

In summary, each methodology has advantages and disadvantages, but age-independent VSL is the most widely used by national and international regulatory agencies. The method proposed in this toolkit is VSL, with or without benefits transfer, based on documented estimates of willingness to pay.

Ideally, VSLs should be locally ascertained. Various studies have derived VSLs in the European context (Bickel et al., 2006; Chanel & Luchini, 2012; Holland et al., 2005). If no reliable estimates of
VSL exist in a certain location, specifically relevant VSL obtained elsewhere can be extrapolated through “benefits transfer” (OECD, 2010) adjusting the proportional difference between the GDP of the two countries and the assumed or observed “income elasticity” (OECD, 2011). The adjusted VSL estimate at the policy site $VSL_p'$ can be calculated as:

$$VSL_p' = VSL_s \left( \frac{Y_p}{Y_s} \right)^\beta$$

Where $VSL_s$ is the original VSL estimate from the study, $Y_s$ and $Y_p$ are the income levels in the study and policy context, respectively, and $\beta$ is the income elasticity of VSL (in terms of Willingess To Pay, or WTP, for reducing the mortality risk). In this context, “income elasticity” refers to the change in VSL associated with a change in income. As for the value of $\beta$, several discussions on the appropriate value are available in the literature. In general, however, it is assumed to be close to 1.0 for the general public, as suggested by Viscusi (2010). VSL values should be extrapolated cautiously, in particular when differences in GDP per capita are large. For several reasons, including differences in income elasticity and risk perceptions, direct extrapolation is bound to severely affect the validity of the VSL.

In the Excel™-based tool, a series of VSL estimates are proposed in the “Economic values” sheet based on benefits transfer from EU-wide values into specific countries. These are suggested default values, and should be over-written if better or more relevant estimates are available, by choosing the option “Enter own value” from the drop-down value.

2.5. **Worksheet “Adaptation Costs”: Estimating the local costs and benefits of health adaptation to climate change**

2.5.1. **Data inputs and interim outputs for adaptation costing**

Table 5 lists the data inputs necessary to estimate the cost of each adaptation activity. Each variable is explained below.

<table>
<thead>
<tr>
<th>Label</th>
<th>Variable</th>
<th>Items</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Adaptation actions</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>A2</td>
<td>Service / Resource use actions</td>
<td>Service, Resource use actions</td>
<td>N/A</td>
</tr>
<tr>
<td>A3</td>
<td>Responsible implementing agent</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>A4</td>
<td>% of final cost incurred by</td>
<td>Implementing agent, Households/beneficiaries, Other agent</td>
<td>Percentage</td>
</tr>
<tr>
<td>A5</td>
<td>Actual resource use and unit cost</td>
<td>Unit of measurement, Units consumed, Full unit price, Marginal (cash) unit cost</td>
<td>Various, Number, LCU, LCU</td>
</tr>
<tr>
<td>A8</td>
<td>Allocation of cost to activity</td>
<td>N/A</td>
<td>Percentage</td>
</tr>
<tr>
<td>A12</td>
<td>Period undertaken and costs incurred</td>
<td>Year</td>
<td>1 if cost incurred that year; 0 if not</td>
</tr>
</tbody>
</table>

Below is a short description by variable:

- A1-Adaptation actions: All general adaptation activities are listed here, divided by main responsible actor (e.g. Department of health, department of urban planning, etc.) and by
whether costs are recurrent on an annual basis or whether they are investments valid over several years.

- **A2-Service / Resource use actions:** Each activity involves one or more “actions” or services which involve the use of resources. Since costing is the goal of the exercise, only actions which involve identifiable units of measurements and unit costs should be listed.

- **A3-Responsible implementing agent:** For the purposes of costing, the analyst should pre-define the main actors and institutions that will implement the activity, under the assumption that implementers are the ones for which resources should be budgeted. In the worksheet, the level of disaggregation of the implementing unit should be kept general for clarity; details can be provided in additional documentation.

- **A4-Percentage of final cost incurred by:** These cells reflect who pays which percentage of the final service. Obviously, these should add up to 100% and the values should be explained in the additional documentation. Similarly, when the “Other” column is used, a footnote should be added stating who bears these costs. All this information is important for the discussion on the total costs to be financed by each sector or agency. How the costs are actually financed (e.g. a tariff, foreign donation, etc.) is a separate consideration, not reflected in the calculations.

- **A5-Actual resource use and unit cost:** This section contains four items:
  - “Units of measurement” show the units of the data in the following column to the right. The units depend on the specific action (e.g. “inpatient hospital days”, “number of trained personnel”, etc.).
  - “Units” refers to the numbers of units consumed in this activity.
  - “Full unit price” reflects the full, unsubsidized, cost of the activity. If unit cost estimations were conducted before or after the base year, adjustments should be made.
  - “Marginal cost” includes resource uses that lead to an additional cost, like treating an additional patient (like the cost of medicines and supplies) or requiring an outlay in money (cash or credit). Equipment and health personnel are usually not included in financial cost; the costs for new investments to increase capacity, including human resources, are counted as financial costs. The price paid should be used.

- **A8-Allocation of cost to activity:** This cell reflects the allocation of costs to the designated activity, as the proportion of costs that have to be paid from new budget sources.

- **A12-Period undertaken and costs incurred:** This section reflects the timespan of the investment or of the recurrent cost. Years in which the cost incurred or the investment is made should be filled in with a “1” and those in which this was not the case with a “0”. The tentative timespan of 10 years can be customized.

Once all these inputs have been filled into the corresponding cells, some interim outputs are calculated. These are listed in table 6:

### Table 6. Interim outputs of adaptation cost calculation

<table>
<thead>
<tr>
<th>Label</th>
<th>Variable</th>
<th>Items</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>A6</td>
<td>Full costs</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>A7</td>
<td>Financial costs</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>A9</td>
<td>Full costs allocated to activity</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>A10</td>
<td>Financial costs allocated to activity</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>A13</td>
<td>Full allocated cost by year</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>A14</td>
<td>Financial allocated cost by year</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>A15</td>
<td>Costs incurred by financing agent</td>
<td>Full allocated cost to implementing agent</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Full allocated cost to household / beneficiary</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Full allocated cost to other agent</td>
<td></td>
</tr>
</tbody>
</table>
Below is a short description by interim output:

A6-Full costs: the complete cost incurred as a result of multiplying units consumed by full unit price.

A7-Financial costs: the additional cash cost incurred, it is the result of multiplying units consumed by financial unit price.

A9-Full costs allocated to activity: as long as the activities listed are “specific adaptation” this cost will be the same as A6-Full costs. Otherwise, it will reflect the proportion of the activity cost imputed to health adaptation.

A10-Financial costs allocated to activity: as long as the activities listed are “specific adaptation” this cost will be the same as A7-Financial costs. Otherwise, it will reflect the proportion of the activity cost imputed to health adaptation.

A13-Full allocated cost by year: this reflects the full cost imputed to the specific year, if the activity is undertaken, and zero otherwise.

A14-Financial allocated cost by year: this reflects the financial cost imputed to the specific year, if the activity is undertaken, and zero otherwise.

A15-Costs incurred by financing agent: reflects the full cost incurred by each category of agents; the financial cost can be calculated by substituting column A9 (Full cost allocated) by A1- (Financial costs allocated) in the formula.

2.5.2. Theoretical basis for the “Adaptation costs” worksheet

Types of adaptation and consequences for costing and decision making

Adaptation is defined by IPCC as “The process of adjustment to actual or expected climate and its effects” (IPCC, 2014). In human systems (on which this deliverable focuses), adaptation is intended to reduce harm or attain benefits from hitherto unrealized opportunities. Adaptation can be categorized according to various criteria (Smit et al., 1999):

- Purposefulness;
- Timing;
- Temporal and spatial scope;
- Effects;
- Form; and
- Performance.

A detailed discussion on the categorization of adaptation is beyond the scope of this deliverable, but some considerations are important here. This is the case for the criterion of ‘purposefulness’. A certain share of adaptation is, and will continue happening “in response to experienced climate and its effects, without planning explicitly or consciously focused on addressing climate change” (IPCC, 2014). This type of adaptation is commonly referred to as “autonomous” or “spontaneous” adaptation. Important as it is, this deliverable does not focus on this kind of adaptation, since it does not address the additional expected impacts of climate change. Instead, we focus on adaptation that happens as a result of a deliberate policy decision by a public institution or agency, usually termed “planned adaptation”.

Regarding timing, a clear distinction should be made between responsive/reactive action (that is, in response to current impacts) versus anticipatory/proactive adaptation. Reactive policy action to protect the population from climate impacts tends to be more costly and less able to identify win-win solutions (Fankhauser, 2006; Hope, 2009). Similarly, when planning adaptation there needs to be a clear, commonly understood view on whether it is a short-term or a long-term effort, with a specific timeframe, and the specific geographical scope covered by the measures.

The purpose of this deliverable is providing local authorities with tools to effectively engage in adaptation, specifically in planned anticipatory adaptation in the short and long terms, and with a focus on the local level. Within that category, one more distinction is crucial for an adequate overview and costing of adaptation; namely, the specificity of the interventions regarding health outcomes. According to that specificity, we categorize adaptation as “general” or “specific”. Those two categories are used for costing in the tool, and elaborated on below.
The worksheets can be applied at any level of administration, but are specifically targeted at local administrations and simplified in order to minimize the data requirements. Relevant parts of different worksheets can be filled in by different partners and reassembled thereafter.

For the calculation of the cost of adaptation, the worksheets require specification of activities, the quantity of resources or services required and their unit prices. This allows future updates involving changes in quantities or prices. Similarly, implementing actors are associated with adaptation actions for clarity. Additional important considerations include:

Financial costs versus full costs: like in the case of health damage, a distinction should be made between financial costs (which in this case represents additional budget to be found and raised for adaptation) and full costs, which include financial and non-financial costs, referring mainly to resources that are already paid for and should be used for a different purpose (such as public employee staff time and buildings). Like in the case of health damage costing, in the tool we propose only to include full costs, both for simplicity and to make sure that all economic implications of the proposed activities are taken into account.

Timeframe of payment: not all costs are one-off, or payable in the short-term. In the tool, a 10-year time horizon is proposed as an example because of the uncertainty about health impacts, responses and their costs in the long-term. Future costs are discounted to the present value at the selected discount rate. Costs are disaggregated into investments (paid at the start of a programme but with a lifetime of more than 1 year) or recurrent items, such as operations and maintenance, or other routine service provision. Since some activities may be implemented for a limited period, the worksheet requests the analyst to specify when, within the 10-year period, an activity is expected to be carried out.

The expected duration of investment must be recorded so that planning agencies know approximately when a re-investment is needed. It also allows the calculation of annual equivalent costs. For activities with a limited life span, the starting and end year can be entered. For activities that are required each year, a start date “1” and end date “10” can be entered.

*Actors implementing health adaptation and consequences for costing*

Local governments play a crucial role in developing and implementing local climate adaptation strategies in general as well as health adaptation action in particular. However, various stakeholders should ideally be involved from the very beginning to increase awareness, ensure the consideration of different kinds of expertise and perspectives, and create ownership on the policies developed. Health adaptation is inherently limited in reach and effectiveness if driven by institutions alone without uptake and support from societal actors. In particular, businesses and citizens play a major role in adaptation which should be encouraged and facilitated by the relevant public authorities. Several reasons strengthen the case for the promotion of private-led adaptation, including the innovation capacity of the private sector, and the increase in overall community resilience attainable through the empowerment of individuals. Beyond these purely practical considerations, there is a clear element of environmental and social justice in the participation and inclusion of a broad representation of the community in the adaptation process – for more on the governance of adaptation, see RAMSES deliverable 7.1, sections 3.2 and 3.3 (De Pryck et al., 2014).

Moreover, effective health adaptation must be inter-sectoral in nature, since most of the interventions that can protect the population from climate impacts lie beyond the competencies of the health sector. Key sectors whose participation is required for effective health adaptation include:

- Water supply and wastewater service providers;
- Industry and energy suppliers;
- Transportation;
- Urban planning and land use;
- Housing and infrastructure;
- Meteorological services;
- Emergency services; and
- Social welfare services.
This collaboration is crucial: since climate-related health risks in general and in cities specifically are systemic, this must be reflected also in their responses, with clearly defined roles and responsibilities. Before recruiting sectoral actors for implementation, however, the adaptation interventions themselves must be planned, as a coordinated, rational and affordable response built on the foundation of current sectoral policies, existing physical and institutional infrastructure, effectiveness and resource availability.

Some of these adaptation actions will be implemented by sectors other than the health sector, and for primary purposes other than, or additional to health protection. This entails implications for cost apportionment. The first, crucial one, is that a complete and clear cost-benefit analysis of health adaptation is an unlikely prospect for the analyst.

The apportionment of what types of intervention can and should be classified as “health adaptation” is not a trivial point. The case of a public agency promoting the building or reinforcement of flood defences, or the insulation for public housing buildings can serve as an example. These two interventions are prime examples of resilient infrastructure and architecture – see RAMSES deliverable 2.1 Synthesis review on resilient architecture and infrastructure indicators (Kallaos, Wyckmans, & Mainguy, 2014). However, they are also clear cases of health adaptation: flooding protection contributes to avoiding mortality, injuries and long-term mental and chronic conditions (WHO, 2013b); adequate insulation protects residents from a multitude of risks, including extreme heat and cold (Vasconcelos et al., 2011; WHO, 2011a). And yet the health argument may not be accounted for explicitly in the policy appraisal of these interventions, even if they are labelled as “adaptation”. Moreover, the analyst can simply not determine which proportion of the cost, if any, should join the costs of “health adaptation”.

These cross-cutting actions likely have protective effects across the board, for several or all climate-sensitive health outcomes are usually called “General adaptation”. Examples of general adaptation actions are:

- Strengthening health systems, including primary care and public health services
- Integrating consideration of climate change into health planning
- Building capacity in the health workforce
- Raising awareness and conducting advocacy on climate impacts and adaptation
- Building climate-resilient infrastructure
- Strengthening epidemiological surveillance for climate-sensitive disease
- Multi-hazard early warning systems and emergency management plans

General adaptation at the local level can be implemented by local level or national level agencies, representing the health sector and other sectors with relevant competencies.

On the other hand, the adaptation actions specific to health conditions are usually categorized as “specific adaptation”, and they include activities and costs ascribed to treat or prevent a single disease or health condition. Typical “specific adaptation” interventions would include hospital care, vaccination or community sensitization, health campaigns for a single health issue, or other interventions likely to prevent a specific health issue. Inputs for the costing of this type of adaptation are to be filled into the worksheet “Specific adaptation”. The specific inputs are listed in section 2.5.1 Data inputs for adaptation costing.

There is no widely accepted solution for the overall costing (including general and specific interventions) of health adaptation. One alternative would be to focus on adaptation-relevant items promoted exclusively under the health umbrella or by the health sector. This approach, however, is incomplete since it is widely agreed that no effective health protection against climate risks can be implemented without actively involving other sectors and without promoting adaptation in other sectors with benefits for health. Moreover, assuming that other sectors will engage in health-protective adaptation on their own is not an option for the health sector, whose responsibilities include advocating for the integration of health in all policies (WHO, 2008). For practical purposes, the following rules of thumb are proposed:

- When planning health adaptation, all interventions that could reasonably and effectively protect health from climate-induced risks should be developed and advocated for, regardless
of whether their primary purpose is health-oriented and the main implementing actor(s) are mainly addressing health issues.

- When costing health adaptation, health-protective adaptation implemented for other purposes or general protection could be taken as a “public good” and thus not included in the costing, keeping in mind the caveats mentioned in the previous paragraph and cautiousness in the interpretation of summary outputs like benefit-to-cost ratios.

In this methodology, the suggestion is to cost only specific adaptation, albeit the relevant proportion of the costs of general adaptation can also be included in the “Adaptation costs” spreadsheet.

### 2.6. Worksheet “Outputs”: Summary of adaptation costs and overall indicators

Ultimately, the goal of this health adaptation costing exercise is to obtain summary indicators for promoting and/or planning adaptation policy. Therefore, clarity is crucial. Moreover, since investments and new sources of funding may be needed, the relevant costs and payees need to be clearly laid out. The cost disaggregation should at least include:

- Full versus financial costs, since this has crucial budgeting implications;
- Recurrent versus investment costs, by year; and
- Costs by implementing agent.

For this reason, a “Cost of adaptation summary” table is presented in the “Outputs” spreadsheet. It lists both “total costs using existing 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 can support decision-making. These would be the usual outputs of cost-effectiveness and/or cost-benefit analysis. As applied to this case, they would be:

\[
BCR = \frac{\text{Benefits from averted damage through adaptation activity}}{\text{Cost of adaptation activity}}
\]

\[
CER = \frac{\text{Cost of adaptation activity x}}{\text{Outcome cases averted by adaptation activity x}}
\]

Where:

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

In the “Outputs” spreadsheet six “Final summary outputs” are presented:

- Total cost of health damage attributed to climate change for the selected outcomes (Average annual undiscounted health cost);
- Health damage cost avertible through adaptation (Avertible average annual undiscounted health cost);
- Benefit-cost ratio;
- Cost per case averted (Reflecting costs and health benefits over 15 years, or until 2100); and
- Cost per death averted (Reflecting costs and health benefits over 15 years, or until 2100).

It is important to bear in mind an important caveat about the benefit to cost ratio. This is due to two main reasons: 1) Because of the limited scope of the estimation of health damage, the estimation of averted costs due to adaptation is inherently limited, a limitation that is directly at odds with the traditional “all encompassing” nature of social cost-benefit assessment; and 2) The cost of adaptation cannot be accurately calculated, for the reasons presented in subsection 2.5.2. Theoretical basis for the “Adaptation costs” worksheet and consequences for costing and decision making.

In addition, the effectiveness of specific health adaptation measures is often not accurately determined. This often has to do with the population-wide nature of health adaptation, where decreases in mortality
and morbidity would be difficult to attribute accurately, particularly for common outcomes with multiple potential causes. For instance, there is rather limited evidence on how effective heat-health action plans are in preventing heat-related mortality and morbidity. A recent review on the matter (Toloo et al., 2013) suggested that heat warning systems are effective in reducing mortality and, potentially, morbidity, but that such effectiveness “may be mediated by cognitive, emotive and socio-demographic characteristics”. Moreover, the authors stop short of providing pooled estimates of decrease in morbidity or mortality. Other studies that do provide estimates (e.g. Fouillet et al., 2008) make the assumption that any unexpected decrease in mortality is attributable to prevention, a contentious matter given the heavily mediated interactions mentioned before.

The evidence of direct preventive effect of adaptation in other climate-related health outcomes may be equally scarce. That is the case, for instance, for mortality and injury related to extreme weather events like floods, where socioeconomic components, as well as behavioural and individual traits heavily determine the outcome risk. In other areas, like water-borne, food-borne and vector-borne diseases, evidence on the effectiveness of interventions may be substantial, but the additionality component of climate change may not be determined.

For the purposes of economic analysis, a sensitivity analysis is a viable option. In the absence of hard numbers on the effectiveness of adaptation, a sensitivity analysis would help the analyst determine the “break-even” point, that is, the minimum proportion of burden of disease that adaptation should avert in order to become cost-beneficial. In the tool, the varying estimates of effectiveness of health adaptation would take the form of inputs (%) into the parameter “Proportion of climate-change attributable health impacts averted through adaptation actions” in the “Outputs” sheet.

3. References


EU. (2013b). Climate change adaptation: Empowerment of local and regional authorities, with a focus on their involvement in monitoring and policy design. Brussels, Belgium.


Annex 1. Online resources for the evaluation of climate-related health impacts and co-benefits of mitigation in Europe

- World Health Organization methodologies to estimate Environmental Burden of Disease at the national level (Climate change is currently –as of September 2015- under revision. Available online at: http://www.who.int/quantifying_ehimpacts/national/en/

- World Health Organization methodologies and tools for health impact assessment in general http://www.who.int/hia/en/

- Information on selected categories of climate-sensitive health outcomes:
  - In general:
  - Vector-borne diseases:
  - Food-borne and water-borne diseases:
  - High temperatures:
    - (cCASHh project) http://www.euro.who.int/__data/assets/pdf_file/0008/96965/E82629.pdf
    - (EuroHEAT project) http://www.euro.who.int/__data/assets/pdf_file/0009/95913/E92473.pdf
    - (PHASE project) http://www.phaseclimatehealth.eu/extreme-events
  - Flooding:
    - (PHASE project) http://www.phaseclimatehealth.eu/publications/floods

- World Health Organization methodologies to estimate health economic benefits of increased physical activity through walking and cycling, available online at: http://www.heatwalkingcycling.org/

- World Health Organization briefing on cobenefits from mitigation in various sectors, available online at: http://www.who.int/hia/green_economy
Annex 2. "hotel" component of hospital costs in countries of the WHO European Region, on an inpatient and outpatient basis.

The estimates and explanatory text are excerpted from the WHO CHOICE manual and database (WHO, n.d.). These estimates represent only the "hotel" component of hospital costs, i.e., excluding the cost of drugs and diagnostic tests but including costs such as personnel, capital and food costs. These are estimated costs that, in principle, can be thought of as 'average' values of unit costs for the country, based on specific assumptions regarding the organisation of health services and operational capacity. The Inpatient Unit Costs presents the estimated cost per hospital bed-day. The table on Outpatient Unit Costs presents the estimated cost per outpatient visit, and include all cost components except drugs and diagnostics. Estimates are presented in US$ (PPP) for the year 2008.

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