BASE

BOTTOM-UP CLIMATE ADAPTATION STRATEGIES TOWARDS A SUSTAINABLE EUROPE

Title: BASE common case study approach

Summary: This report outlines the shared starting points, research practices and questions to be answered in case studies to ensure comparability of results and their ability to feed into WP6 & WP7. Chapter 2 assesses the state of the art in research and practice of adaptation in seven sectors to fine-tune case studies. Chapter 3 outlines the common understanding adaptation policy, planning and pathways. Chapter 4 establishes a common framework for the assessment of costs, benefits and effectiveness of adaptation measures. Chapter 5 explores participatory and deliberative methods in adaptation. Chapter 6 formulates the key common questions.

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SEVENTH FRAMEWORK PROGRAMME

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Contents

Executive Summary

The common case study approach report outlines the shared starting points, research practices to be used and questions to be answered in BASE case studies, in order to maintain the comparability of results and to ensure that the results can feed into further work in WP 6 and WP7. The common case study report 1) assesses the state of the art in the published research on (including reports from FP7 related projects) and practice of adaptation in key sectors in order to fine-tune BASE case study research plans for maximum contribution (Chapter 2); 2) outlines a common way of understanding adaptation policy, planning and pathways (Chapter 3); 3) establishes a common framework for the assessment of costs, benefits and effectiveness of adaptation (Chapter 4); 4) identifies the ways in which stakeholder and public participation is examined or practiced in the case studies (Chapter 5); 5) formulates the core research questions to be addressed in case studies (Chapter 6).

The review of the state of art in the research on and practice of adaptation in key sectors highlights that there is limited empirically grounded research on and thus evidence from adaptation case studies. The case studies that do exist only provide partial information, and information on costs, benefits, effectiveness and implementation of adaptation is particularly sparse. The review results indicate that BASE case studies can make a substantial contribution by extending the evidence base on adaptation, and that focusing on providing evidence on costs, benefits, effectiveness and implementation of climate change adaptation would help BASE to make a particularly strong contribution to the EU state of the art.

BASE case studies acknowledge that in the European Union adaptation is governed by an evolving multi-level solution that involves EU directives and policies, national adaptation strategies and programmes, as well as a variety of sub-national and local policies, plans and regulations. Sectoral policies with other primary goals can also hinder or promote adaptation. Therefore, BASE cases will map the multi-level institutional setting within which the case studies are embedded, to understand the degree of horizontal and vertical interplay, policy coherence, integration and mainstreaming of adaptation. This is needed to assess the prospective effectiveness of adaptation measures in case studies as well as the limits, barriers and opportunities for adaptation. The mapping is also need to complement the evidence base generated in WP2 on adaptation policy with sectorial and sub-national evidence, and to contribute to the establishment of adaptation pathways in WP7.

BASE case studies will assess the costs, benefits and effectiveness of adaptation by using a cost-benefit analysis, multi-criteria analysis or other economic evaluation approaches, or combinations of these. The BASE cases involve retrospective and prospective assessments focusing on different sectors, which makes it difficult to apply a completely uniform economic assessment practice in all cases. The direct benefit of adaptation in the case studies will be the cost of avoided adverse climate change impacts. Indirect or side benefits will also be taken into consideration where relevant. The costs of adaptation measures include investments necessary for deploying them, operation & maintenance costs and – where possible – transaction costs for implementing these measures. In cost-benefit analysis, results will be calculated using nationally recommended discount rates, as well as with BASE-wide low and high alternative discount rates. **Uncertainty** will be addressed by employing sensitivity analysis to explore at least **two** alternative climate change scenarios and **two** socio-economic scenarios. Multi-criteria analysis and other alternative evaluation approaches will be used alongside CBA to examine those advantages and disadvantages of adaptation measures that are difficult to monetize. The processing of results will be facilitated by the use of a common assessment software.

The common case study approach also identifies key information demands on methodological approaches to stakeholder and public participation. In most studies, the use of participatory methods will be identified and characterised. A subset of cases will develop and apply participatory methods in on-going, political decision-making/planning and

implementation processes. The common case study report develops a diagnostic of participatory arrangements as well as a framework for collaboration amongst BASE partners about their use and development. It also establishes the best practice to be followed in terms of research ethics.

Finally, the common case study approach report formulates the key common questions as a key instrument for maintaining the comparability of cases and the transferability of case results to WPs 6 & 7. These questions relate to the climatic and socio-economic context of adaptation, motivations for adaptation, the institutional setting within which adaptation takes place and the range of actors involved in it, and the costs, benefits, effectiveness and uncertainties related to adaptation measures. The questions also direct attention to barriers and opportunities for implementing adaptation measures, and policy and other reforms that could foster adaptation to climate change on the ground.

1 Introduction

By: Jouni Paavola (UniLeeds) and Xin Li (UniLeeds)

The assessment of adaptation policies, strategies and measures faces several difficulties, including the assessment of uncertainty relating to climate change impacts (Dessai and Hulme, 2004), insufficient knowledge of costs and benefits of adaptation strategies, balancing the equity aspects of impacts (i.e. income distribution) and adaptation policies, difficulty in the implementation of adaptation policies, and etc. Two broad types of approaches are used in the assessment of adaptation: top-down approaches and bottom-up approaches. The majority of existing adaptation studies have adopted top-down approaches (UNFCCC, 2007, Adger et al., 2007, World Bank, 2010). For example, the Intergovernmental Panel on Climate Change (IPCC) presents a guideline to evaluate adaptation strategies in the early 1990s, using a top-down approach (Carter et al., 1994). The guideline consists of seven steps for the assessment (see Figure 1).

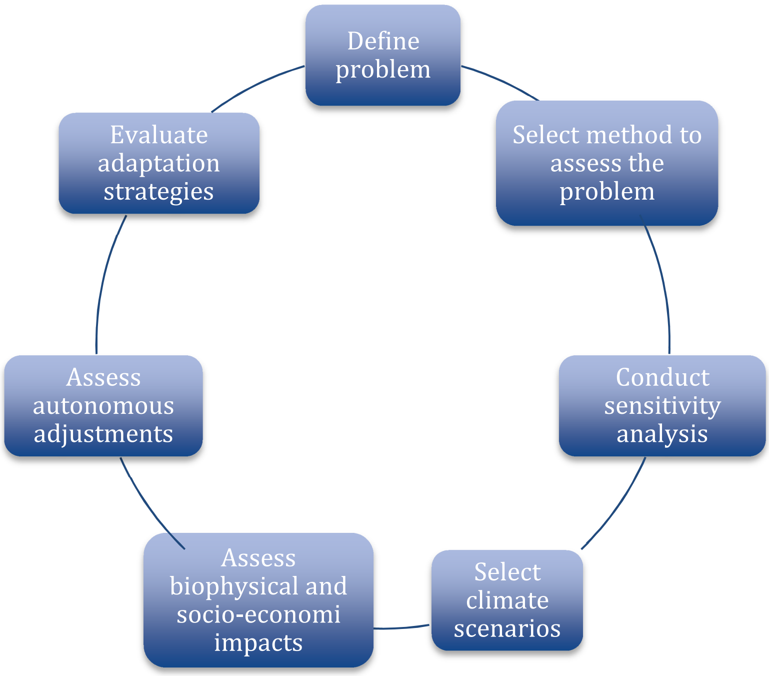

Figure 1 Seven steps in evaluating climate change adaptation strategies

Source: Carter et al. (1994)

Top-down adaptation strategies are typically based on aggregate costs and benefits across sectors to reach nation-wide economic figures. While these studies are of value for national policy makers, they are less useful for local governments, businesses and non-governmental organisations who will deliver adaptation on the ground and will need to plan for it. Adaptation policies and strategies, which are different from mitigation policies that reply on international coordination, involve decentralised decisions which need to incorporate more context-specific adaptation measures required at local scales (Agrawala et al., 2008a). Thus, adaptation policy created with a top-down approach might not be effective immediately at local level (Downing, 2012).

Focusing on the vulnerability of a system, bottom-up approaches examine the adaptive capacity that are needed to improve the robustness of the system and the robustness of adaptation options in the context of climate change (Wilby and Dessai, 2010). Bottom-up processes usually require trust (raised through community building) and include knowledge-sharing, co-design of local decisions between citizens, policy makers and other stakeholders. Moreover, they require more integral adaptation measures and implementation with consequent feedback and participatory actions within top-down strategies and implementation actions.

Jones (2010) points out that top-down and bottom-up approaches are different in terms of spatial coverage and institutional scale. Top-down approaches often start from the global, regional or national scale to inform climate adaptation policy; whilst bottom-up approaches start from the local- or community scale to assess climate impacts and adaptation. Figure 2 describes the direction of top-down and bottom-up approaches.

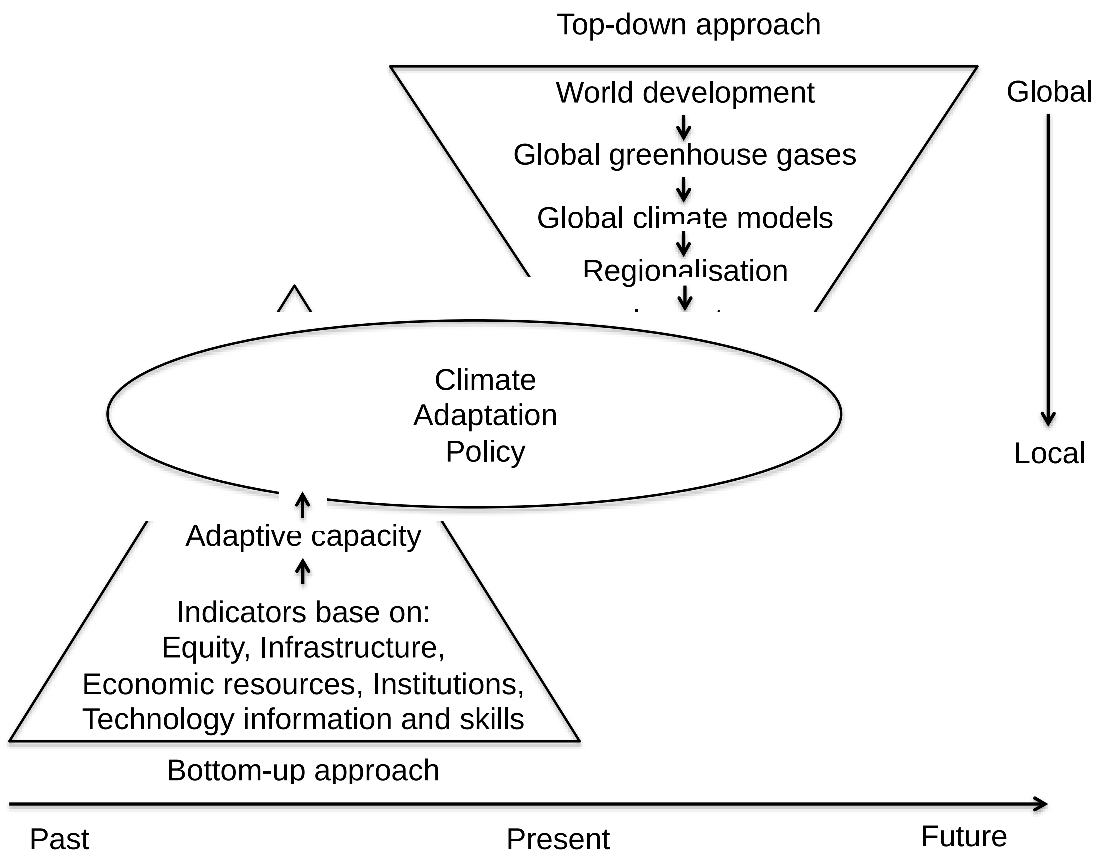

Figure 2 Direction of top-down and bottom-up approaches

Source: Dessai and Hulme (2004)

In 2011, Frank et al. (2011) conclude that most climate adaptation research to date has focused on specific technological interventions and socio-economic aspects of adaptive capacity. A review of EU's Climate Adapt database suggests that this is still largely the case in 2013, as a vast amount of the case studies revolve around specific technological interventions or different tools for monitoring etc. (e.g. the projects Adapt2Change, BIOTAGENE, ENSAT, AQUAVAL). At the sectoral level, the assessment on costs and benefits of adaptation strategies focus on key sectors, such as water resources, energy, infrastructure and agriculture (Agrawala et al., 2008a). Adger and Vincent (2005) in their review of studies on costs and benefits of adaptation strategies conclude that there is generally low knowledge on detailed analysis of the costs and benefits of adaptation. This is particularly true regarding local adaptation measures.

The **B**ottom-up Climate **A**daptation Strategies towards a **S**ustainable **E**urope (BASE) project addresses the need to research on sustainable climate adaptation strategies by combining bottom-up and top-down strategies. The purpose of WP4 and this deliverable is to outline a strategy for assessing adaptation needs and their costs, benefits and effectiveness from the viewpoint of those who will plan for and deliver adaptation.

To gather insights from the local level, the BASE project will examine climate change adaptation case studies from across regions in Europe. These regions represent different climatic and socio-economic areas across Europe, and the case studies have been selected to reflect this regional distribution. Figure 3 presents the geographical location of case studies in BASE as well as the main sectors and spatial levels addressed in each case study

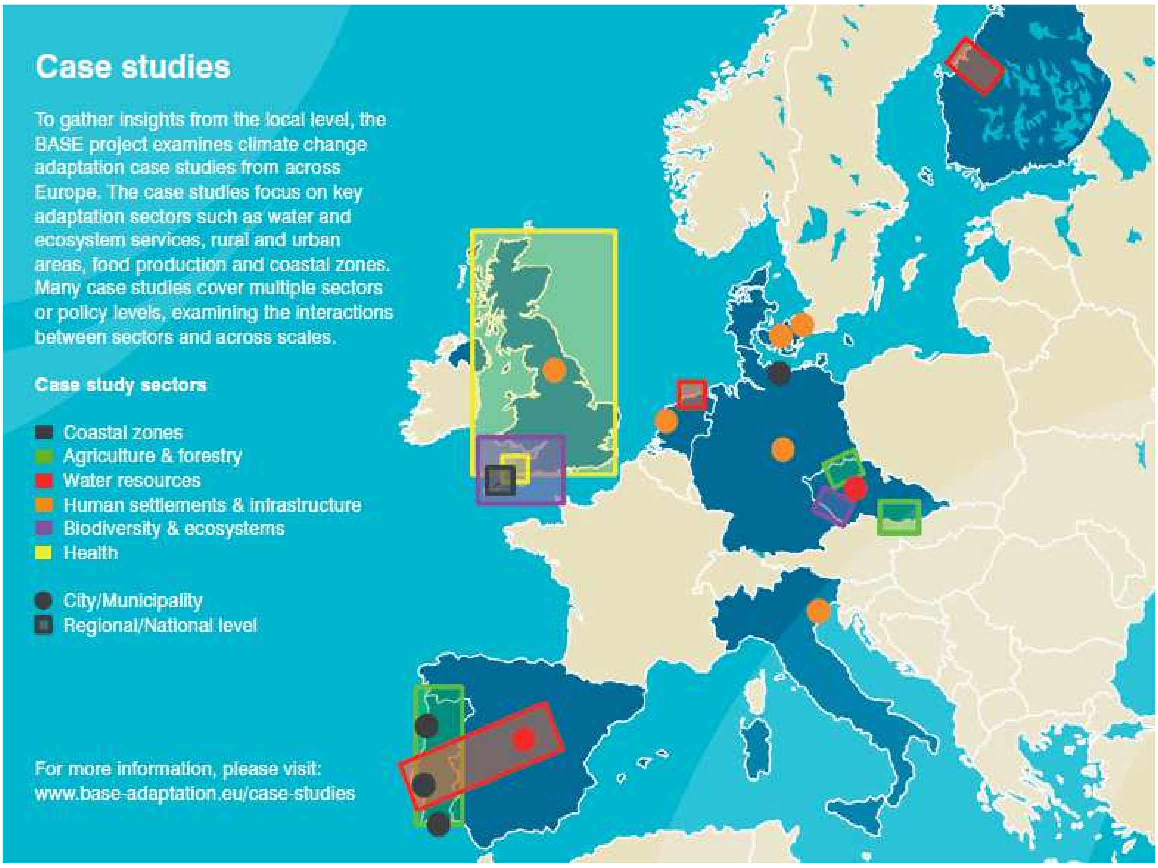

Figure 3 Geographical locations of case studies in BASE

As can be seen from Figure 3, BASE case studies focus on six key sectors, including coastal zones, agriculture and forestry, water resources, human settlements and infrastructure, biodiversity and ecosystem services, and human health. Each sector will include a number of case studies (See Chapter 2). All case studies will be analysed from multiple perspectives, including a policy perspective (See Chapter 3), an economic perspective (See Chapter 4) and a perspective on public participation (See Chapter 5).

This deliverable outlines how BASE seeks to coordinate case study research and to ensure the comparability and generalizability of case studies and their usefulness to top-down modelling efforts. The key solutions for achieving these aims are 1) common starting points (Chapter 6), 3) methodological transparency and shared research practices (Chapters 3-5) and 3) core and supplementary research questions to be addressed by the case studies

(Chapter 6). Additionally, a shared Case Study Living Document (CSLD) template (Appendix 1) is used to milestone and guide reporting from bottom-up case study research so that the results can be shared between the tasks in WP 5 and between relevant work packages during the on-going research efforts.

The common research strategy is not intended to prescribe a strict, uniform approach to case studies. This would not be feasible given the heterogeneity of cases: some of them are ex post evaluations, others are forward-looking, and there are researcher-led detached assessments as well as case studies that seek to instigate adaptation processes and to study them. Furthermore, the resourcing of different case studies is quite different and case study groups also have varying expertise portfolios. The approach outlined in this deliverable seeks to achieve coordination and comparability without imposing uniformity. Organisational solutions such as case study sub-groups composed of partners and people working on cases in the same sector provide additional instruments for coordination as well as sharing and sourcing of expertise.

In what follows, the chapter 2 takes stock of existing literature and research in the key sectors on which BASE case studies focus, in order to outline the state of art and to identify the greatest potential for making a contribution through the case studies. Chapter 3 outlines how case studies are embedded in policy/institutional setting and how the linkages between that setting and case studies can be examined and what sort of questions they pose for research in case studies. Chapter 4 outlines the research practices for economic assessment of adaptation measures in case studies. Chapter 5 in turn outlines how stakeholder engagement and public participation solutions and strategies can be investigated in case study research. Chapter 6 discusses briefly the key common starting points which include timeframes, scenarios and the use of adaptation pathways approach in examining adaptation needs and solutions in the cases. Chapter 6 also articulates the core questions that case studies ought to answer, as well as supplementary questions that some of them are placed to answer. Appendix 1 includes the Case Study Living Document which will be used to structure and pace the generation of research results in cases.

2 State-of-the-art research and practice of adaptation cases

2.1 Introduction

The main objective of this chapter is to assess the state of the art in the published research on and practice of adaptation in key sectors in order to fine-tune BASE case study research plans for maximum contribution. The review of the state of the art highlights that there is limited empirically grounded research on and thus evidence from adaptation case studies. The case studies that do exist only provide partial information, and information on costs, benefits, effectiveness and implementation of adaptation is particularly sparse. In this chapter, six key sectors are examined, including coastal zone, agriculture and forestry, water resource, human settlement and infrastructure, biodiversity and ecosystem services, and human health. Each of the following subsections address issues such as potential impacts of climate change to relevant sectors, methods and approaches used in previous studies on adaptation and potential contributions of BASE case studies to the literature.

2.2 Adaptation in coastal zone

By: Grit Martinez (EI), Nico Steljes (EI), Benjamin Boteler (EI), Jenny Tröltzsch (EI)

Coastal zones are understood as the stretch of land between land and ocean, but there are several definitions of this stretch of land. In general coastal zones are understood as particularly vulnerable regions. They have been greatly modified by mankind. A number of cities are located on coasts*;* hence coasts are often highly populated and produce a high gross domestic product (GDP). A number of different economic sectors depend on coastal areas: tourism, transport (shipping), fisheries, etc. which lead to a fragile environment and climate change effects can increase the already existing pressure.

For any defined biophysical coastal or marine ecological system (i.e. a coastal zone of a country or of a group of nations; a particular watershed and its near shore contiguous area; a large marine ecosystem) there are associated human and institutional ecological systems. So, for example, if we are considering adaptation measures to climate change at European Coasts, the biophysical ecology is defined by the effects (e.g. water use, influx of sediments and pollutants, ecosystem degradation, river flooding, shoreline erosion, storms, relative sea level rise, aggregate extraction etc.) on the coast and the marine environment. The human ecology consists of those humans and their behaviours that affect the coast and ocean directly (coastal communities, constructions, tourism, marine traffic, agriculture) or the coastal and marine environment (development, off shore wind parks, aqua-culture). The institutional ecology consists of those policy and management institutions (state, regional, national, international) whose policies and rule-making affect strategies and measures taken to defined human ecology.

In the recently adopted EU adaptation strategy, coastal areas are named as one of the regions that are at risk. The climate-ADAPT web-portal is considered as the ‘one-stop shop’ where all information about adaptation should be found. For coastal areas, there are 50 case studies, 15 adaptation options, 68 Research and knowledge projects, and 12 tools listed. Within the case studies these 15 options are described. They range from beach nourishment, to desalination projects or improving existing damns and dikes.

2.2.1 Threats of climate change

For coastal areas there are two direct impacts from climate change: **sea level rise** and **storm surges**. Sea level rise estimated by IPCC (2007b) for this century ranges from 20 up to 59 cm in a global average. Depending on the local conditions these projections may vary. More severe damages may arise from single storm events that can lead to a storm flood. So far, the IPCC is rather uncertain how storm events will develop in the future concerning climate change.

Climate Change may also have an impact on **coastal ecosystems**. Changing temperature, salinity and water quality in coastal waters may be affected directly or indirectly by climate change. This may have an impact on the flora and fauna of coastal areas.

From these impacts on natural coastal conditions impacts on **socio-economic aspects** may arise. They can be understood as indirect effects. Here, questions of vulnerability or risks of coastal communities have to be asked. How are infrastructures, private properties or land-use patterns affected by climate change? Does climate change have an impact on economy sectors (tourism, fishing, and shipping)?

2.2.2 Responses / Adaptation

If we only focus on the threats of sea level rise and storm surges, there are different strategies for the direct coast line on how to cope with the threats:

- Do nothing
- Retreat
- Defend

While the strategy ‘doing nothing’ may become insufficient with climate change, new strategies are needed. One way could be, to put more emphases on coastal defence. This means strengthen the existing or building new measures. Retreat could mean, moving existing coastal defence measures more inland.

There are different ways on how to proceed with these options. Building a dike (like Timmendorfer Strand) would be a way of defending the coast line. Managed retreat of dikes (like done in the UK) is a way of retreating. Also, measures mixing retreat and defend strategies may be applied, especially when looking at ecosystem based approaches (e.g. building with nature).

Another question is how participatory processes are integrated in these strategies. For example in Timmendorfer Strand they used participatory methods to decide on the strategy and how this strategy should be executed.

Responses to the indirect effects is rather divers. Here, links to other subgroups become more evident. For example, how can infrastructure or houses at the coast be adapted to climate change?

2.2.3 Research in coastal climate adaptation

Different research approaches have been or are currently conducted concerning climate adaptation on coastal zones. Focusing on research projects, these range from a local to an international perspective. For example, the project BaltCica (Climate Change: Impacts, Costs and Adaptation in the Baltic Sea), funded under the Baltic Sea Region Programme, looked for different adaptation measures in different case studies around the Baltic Sea.

Baltadapt, funded under the same programme, developed a transnational climate change adaptation strategy for the Baltic Sea Region.

The project RADOST (Regional Adaptation Strategies for the German Baltic Sea Coast) develops adaptation strategies for the Baltic coastline of Germany through a dialogue between academics, economists, policy-makers and the public. One main research field is coastal protection in times of climate change.

The Portuguese CHANGE project focused on the effects of climate change on the coast and was aiming at understanding the governance and participation issues. A national program in France is financing the project COCORISCO (Knowledge, Understanding, and Management of coastal risks) from 2011 to 2014. Another project from France is ADAPTALITT (Adaptation capabilities of coastal societies to coast erosion-submersion related to climate change) were several study sites along the coastline of France are chosen. BiKliTour is a project routed in Germany, where Tourist regions are seen as model regions for developing adaptation strategies in the context of biodiversity, tourism and climate change.

Toolbox, Tips and Case Studies were developed in the European Project ImCore (Innovative Management for Europe's Changing Coasts) from 2008 to 2011. The project ComCoast (Combined functions in coastal defence zones) developed and demonstrated innovative solutions for flood protection in coastal areas. Both projects were funded under the Interreg programme.

More projects related to coastal adaptation can be found at this webpage: http://infobase.circle-era.eu/search.jsp

2.2.4 Economics of adaptation in coastal zones

As a result of sea level rise the coastal ecosystems will be significantly reduced and a significant amount of the population is threatened by flooding and enhanced erosion. The most existing studies on damage costs and adaptation costs of coastal flooding and erosion are top-down-studies. There are two main studies that have examined in detail the damage costs associated with climate change and its impacts on sea level rise leading to coastal flooding. These studies derive from two major studies: the ClimateCost study (Brown et al., 2011) and the PESETA project (Richards and Nicholls, 2009).

Both studies include a quite similar damage cost assessment with the same types of impact, over the same periods. The ClimateCost study is a slightly more updated assessment, which provides medium-term estimates. Both studies estimate values for effects of adaptation and the same types of adaptation options.

Error! Reference source not found. The reports estimate annual damage costs for a very detailed set of analyses, which have examined a range of different climate and sea level rise scenarios. Following mid-point estimates are included:

Table 1 Overview of published EU annual damage costs from climate change induced sea level rise and related coastal flooding (€b)

	Baseline costs (€bn/year)	**2020s (€bn/year)**	**2050s (€bn/year)**	**2080s (€bn/year)**
Brown et al (2011)	1990-2000: €2.7 (2005 prices)	€5.2 (2005 prices)	€10.6 (2005 prices)	€25.4 (2005 prices)

	Baseline costs (€bn/year)	2020s (€bn/year)	2050s (€bn/year)	2080s (€bn/year)
Richard & Nicholls (2009)	1995: €1.8 (1995 prices)	€6.0 (1995 prices)	Not estimated	€13.8 (1995 prices)

Source: Hjerp et al. (2013)

Richards and Nicholls (2009) split different types of damage cost, e.g. flood damage, salinization or migration. Flooding damages are the largest share of total damage costs. The two studies also examine adaptation options and costs and conclude that they provide very significant benefits compared to costs of implementation, especially in the longer-term.

Both studies include data on adaptation measures. Brown et al. (2011) analyse the potential costs of adaptation in the EU and the damage costs using the DIVA Model. In the model, set up for coastal regions, it is possible to apply different adaptation strategies. Two approaches of adaptation are used in this study. First: No upgrade in adaptation measures is conducted. The defence level is held at a baseline from 1995 and is maintained at this level. Second: Results of cost-benefit analysis of adaptation are included. Measure construction is continued and an increase in height is based on a cost-benefit analysis. The approaches focus on flooding and coastal erosion. The included adaptation options are dike building and beach nourishment. This approach results in reduced damage costs for flooding and land loss. But damage costs for salinization remain, because other measures and technologies are required (e.g. freshwater injection barriers, groundwater pumping).

Richards and Nicholls (2009) examine adaptation measures based on pre-set or user defined decision rules. Then these measures influence the estimation of effects (physical and socio-economic). Adaptation measures include: higher flood dikes; beach and wetland nourishment. The estimated adaptation costs are 279 million to 1,717 million Euros/year for 2080 depending on used climate scenarios.

Parry et al. (2009) estimate top-down adaptation costs for sea level rise between 13 and 26 bn. US$ per year. Damage costs for land loss are expected to be around US$ 8 billion. One fourth of that value is caused by climate change. It is mentioned that damage costs are only partially included.

Individual case studies for adaptation measures or strategies exist only on a limited basis. Different case studies exist for the dike to protect Venice (Chiabai and Nunes, 2006). Chiabai and Nunes (2007) estimate the impacts of climate change on coastal tourism, clams' aquaculture, damages to urban infrastructure, damages resulting of closing of economic activities and social damage caused by city's usability. The estimated costs for climate change are between 105,4 and 161,5 million Euro in 2030 (discounted). Costs of adaptation measures are calculated for private activities such as water pumps, elevation of building, tanks, etc, with 0.6 million Euro and for adaptation measures for harbour activities (rental mooring and mooring) with 0.9 and 1.5 million Euro in 2030 (discounted).

Bigano et al. (2006) analyse costs of inaction concerning land lost to seal level rise and optimal coastal protection infrastructure in Italy. The resulting adaptation costs to protect the Italian coast are between 0.0003% and 0.0011% of GDP in 2020.

De Bruin (2011) applies a multi-criteria analyse for adaptation options in Netherlands, including options regarding coastal areas. Furthermore, she indicates cost and benefits for some options as far as available. But the results show that much of the information which are needed for cost-benefit analyses is not yet available, especially on benefits. Further the paper includes a cost-benefit analysis for spatial planning of a newly built urban area at the coast (Zuidplaspolder). Four adaptation options were analysed in the case study.

Also, Linham and Nicholls (2010) discuss the costs and benefits of coastal protection as adaptation measure. Costs are mainly included based on coastal protection projects which are not linked with climate adaptation. Benefits were discussed qualitative.

2.2.5 Where can/will the coastal zone case studies of BASE make important contributions

Four different coastal case studies will be examined in the Base project.

- **Timmendorfer Strand, Germany**

Timmendorfer Strand is a seaside resort, situated on the Baltic coast in the Lübeck Bight (Germany - Federal State Schleswig-Holstein). From 1998 to 2011, the municipality of Timmendorfer Strand developed and implemented a coastal protection strategy using a participatory process. The community is located in lowlands and has around 9000 inhabitants. Tourism is the main economic sector; around 200000 tourists spend their holidays in Timmendorfer Strand with a total of 1.2 million overnight stays.

Already in 1999 first discussion about an integrated flood protection concept for the community of Timmendorfer Strand started. It was agreed that the concept should be accepted by all involved stakeholder. Therefore, analyses of various social and economic parameters were performed. With these data and scientific principles, an innovative method for active public participation (the so-called sensitivity analysis) was applied. The results of this participatory process were used as a basis for a design competition among selected consultants. These three steps (valuation, sensitivity analysis and the competition of ideas) were used for the first time in a participatory ICZM-process. The completion of the project was in 2011 with a total cost of around € 30 million.

The case study, led by the Ecologic Institute, will focus on a cost-benefit analysis of the already constructed coastal defence system. While the costs of the measure can be defined rather clearly, assumptions about the benefits are not as distinct. Data is drawn from statistical sources, but will also be backed-up by literature and experts interviews on a local level.

- **Kalundborg Municipality, Denmark**

Kalundborg Municipality has carried out a thorough and path-breaking participatory approach with local stakeholders and citizens to prepare for a climate adaptation plan. The case study is retrospective and the climate adaptation plan will be adopted by the end of 2013. This implies that the adaptation measures have not yet been implemented and the effect of these can't yet be evaluated. The case study will contribute to the BASE objectives by studying Motivations for adaptation; The institutional setting within which adaptation takes place, The range of actors involved, The costs, benefits, effectiveness and uncertainties related to adaptation measures. Special focus will be on the experience gained from the different elements is the decision making process and on the interaction between the participatory elements. Existing data from the participatory process will be used together with interviews that will be initiated with a broad selection of local politicians, officials, stakeholders and citizens who have been involved in the CA process. Among other things we will study whether and how the participatory approach have influenced the final adaptation strategy.

- **Vagueira, Portugal**

This case study area extends from the South of Aveiro Harbour along a coastal stretch of nearly 10 km, between the sea and the “Ria de Aveiro”, a vast lagoon crucial for economic activities and natural balance in the region.

The area includes the coastal stretch of 4 different parishes, from the south end of Aveiro harbour (Barra) to Praia da Vagueira. In this territory 3 different coastal urban settlements were developed, each of them with a distinct history and social composition. Barra, right next to the main city of Aveiro (district capital) is mostly composed by permanent residences. To the South, Costa Nova is the most ancient settlement, traditionally occupied by a mix of fishermen and tourists (high social classes from the inland of the region), whereas Vagueira was only a small fishermen village until the late 80s.

Vagueira is particularly vulnerable, as part of the buildings (from the late 80s) are below sea level and the urban beach, which is vital for touristic activities has been retreating rapidly over the last decade, despite a seawall and groynes built to protect the seafront. Apart from assessing environmental impacts and vulnerability, the study of Vagueira will also comprise an economic, social and institutional dimension. This case study is lead by FFCUL and involves the collaboration of local University (Aveiro) as well as local and regional stakeholders (decision makers, entrepreneurs, inhabitants, etc…)

- **South Devon Coast, England**

The South West’s long coastline attracts ca. 21 million tourists a year and is home to more 50% of the Marine Conservation Society’s designated best United Kingdom beaches.

This case study, led by the University of Exeter, focuses on one area of this long shoreline, the South Devon coast. This section of coast a major tourist destination and is home to a commercial fishing industry. It consists of major urban tourist centres such as Torbay and smaller coastal communities. A significant feature of the coastline is the hard rock geology (mainly sandstones, limestones, slates and scales) which makes for a dramatic cliff landscape. Crucially this landscape leaves little room for adaptation strategies like managed realignment as there is little space for retreat. Therefore, many local communities are potentially under threat from rising sea-levels and a predicted increase in the volume and severity of Atlantic storms (UKCIP, 2005). Moreover, the mainline rail line to London runs parallel to the coast sandwiched between the base of the cliff and the beach and already suffers damage and closure in severe winter storms. Currently, towns and strategic infrastructure in this region are mainly protected by hard engineering such as sea walls and artificial breakwaters.

With these impacts in mind, this case study will examine the costs and benefits of adaptation on the South Devon coast. It will also look at how public authorities, communities and key sectoral stakeholders (e.g. fishing and tourism representatives) view adaptation priorities and the key factors that are shaping their approach to developing adaptation strategies.

2.3 Adaptation in agriculture and forestry sectors

By: Anders Branth Pedersen (AU), Doan Nainggolan (AU), Helle Ørsted Nielsen (AU), Blanka Louckova (CZEG), Eliska Lorencova (CZEG), Sabine Weiland (UFZ), Ana Iglesias (UPM) and André Vizinho (FFCUL)

2.3.1 Agricultural climate adaptation

Agriculture is a key sector for the study of climate adaptation as agricultural production is widely affected by both biophysical impacts of climate change as well as the resulting socio-economic impacts (FAO, 2007). Farmers are used to cope with year to year changes in climate, but human-induced climate change is expected to accelerate the need and magnitude of farmers' adaptation (Wheeler and Tiffin, 2009). The European Commission (EC, 2013b : 13) expects that impacts of climate change on agriculture will be increasingly visible towards 2050.

The analysis below is primarily oriented towards agriculture and only little towards forestry as only one case study in BASE (the Portuguese) will have forestry as a component.

2.3.2 The challenge

Biophysical impacts on agriculture and forestry can roughly be divided into the following categories (FAO, 2007 : 2):

- Physiological effects on crops, pasture, forests and livestock (quantity, quality)
- Changes in land, soil and water resources (quantity, quality)
- Increased weed and pest challenges
- Shifts in spatial and temporal distribution of impacts
- Sea level rise and changes to ocean salinity
- Sea temperature rise causing fish to inhabit different ranges

Socio-economic impacts are for instance (ibid):

- Decline in yields and production
- Reduced marginal GDP from agriculture
- Fluctuations in world market prices
- Changes in geographical distribution of trade regimes
- Increased number of people at risk of hunger and food insecurity
- Migration and civil unrest

The direction of effects can be both positive and negative for the agricultural sector and the effects will vary between different regions. Overall, FAO (2007) expects for Europe that impacts could be mostly positive for agriculture. For instance, some regions will increase yields and see some pests disappear, which will be positive from an isolated viewpoint of agricultural production in that region - but might be negative from an ecosystem viewpoint or from a viewpoint taking account of all European regions. Effects will often vary over time, short-term benefits might turn into long-term costs.

FAO (2007:5) operates with two main types of adaptation: Autonomous and planned adaptation. Autonomous adaptation refers to, for instance, the reaction of individual farmers to changing precipitation patterns, thus uncoordinated actions among directly involved farmers. Planned adaptation measures "are conscious policy options or response strategies, often multi-sectoral in nature, aimed at altering the adaptive capacity of the agricultural system or facilitating specific adaptations". FAO lists a number of major classes of adaptation (ibid: 6-7) and remarks that climate change adaptation needs to be directed simultaneously along six interrelated lines (For a full description of the categories see FAO 2007: 6-7):

- Legal and institutional elements (decision making, institutional mechanisms, legislation, regulatory tools, governance and coordination, networking etc.)
- Policy and planning elements (e.g. risk assessment and monitoring, analysis, strategy formulation, sectoral measures)
- Livelihood elements (food security, hunger, poverty, non-discriminatory access)
- Cropping, livestock, forestry, fisheries and integrated farming system elements (food crops, growing season, land use planning, soil fertility etc.)
- Ecosystem elements (species composition, biodiversity, resilience ecosystem goods and services)
- Linking climate change adaptation processes and technologies for substitution of fossil fuels, promoting full renewable resources (mainly produced in a decentralized way), biofuels, etc.

As mentioned, the six lines are considered by FAO as being interrelated. It can be added that some of them are very overlapping. For instance, what is the precise difference between institutional elements, policy elements and planning elements?

The European Commission is also focusing on the need for *planned* adaptation within the agricultural sector and points to the fact that the task is not only about developing technological solutions, but also about adjusting farm management and structures. A key challenge is that “climate risks are only one aspect influencing farmers’ decisions, which involve many other socio-economic and market considerations”; besides providing the right incentives for adaptation it is a precondition that farmers have sufficient knowledge and guidelines (EC, 2013c : 11). EU intentions are to integrate agricultural climate adaptation better in the Common Agricultural Policy, such as integration of climate adaptation in the 2014-2020 Rural Development Programmes (EC, 2013b, EC, 2013c).

Local adaptation strategies may influence farmers to adapt to climate change by creating incentives, but the effectiveness of municipal or regional adaptation strategies will depend on the ability and will of farmers to adapt. Additionally, adaptation strategies may interfere with other policies directed at agriculture, which might provide the farmers with mixed signals.

2.3.3 Research in agricultural climate adaptation

In 2011, Frank et al. (2011) concluded that most climate adaptation research to date has focused on specific technological interventions and socio-economic aspects of adaptive capacity. A review of EU’s Climate Adapt data base suggests that this might still be the case in 2013, as a vast amount of the case studies revolve around specific technological interventions or different tools for monitoring etc. (e.g. the projects Adapt2Change, BIOTAGENE, ENSAT, AQUAVAL). Only scant data appears to be available about the precise costs and benefits of agricultural climate adaptation. The existing literature on agricultural climate adaptation might be divided into three headlines: risks and opportunities, costs/benefits and implementation.

Risks and opportunities

Based on the existing literature it is possible to list a number of risks and opportunities and adaptation options (see Table 2). Adaptation options might be divided into adaptation options at the farm (autonomous adaptation) and adaptation measures at policy-level (planned adaptation). Generally, policy instruments/measures are defined in different ways in the policy instrument literature; some studies (OECD, 1994, Vedung, 1998, Mickwitz, 2003) identify three general types of policy instruments, based on the varying degree of authoritative force included: Regulation (e.g. limit values, prohibitions etc.), economic instruments (e.g. taxes, quotas and grants) and information/advisory tools. All three types of instruments have a potential to affect the incentives of the farmers.

Table 2 Adaptation options for European agricultural/forestry production (adapted from Iglesias et al., 2012, Smit and Skinner, 2002, Olesen and Bindi, 2002)

Main risks (RS)/opportunities (OP)	(Farm-level) adaptation options (autonomous adaptation)	Adaptation options/measures/supports beyond farm scale (mostly at policy level) (planned adaptation)
Expansive spatial shifts in climatic suitability for crop choice and cultivation in the north (OP)	Altering portfolio of land allocation across different crops; changing land use; altering cultivation practices; diversifying crops; introducing new crops and varieties	Stimulation of innovation - technological and biotechnological advancement - including development of new, more productive crop varieties; monitor and control unintended aggregate consequences of farm scale change in production patterns. Create farmer incentives for more environmentally-friendly practises (e.g. for new cultivation methods, new silvicultural practises etc.) if the consequences are negative; provision of information and advice (e.g. through extension services)
Climate regime that potentially favours increase in crop yields and livestock productivity (OP)	Adjusting sowing and planting dates; adjusting time of farm operations; altering the use of external inputs (e.g. fertilizer application in the case of crop production); expanding livestock farming to new areas; increasing stocking rate	Innovation - technological and biotechnological advancement - including development of new, more productive animal breeds; monitor and control unintended aggregate consequences of farm scale change in production patterns. Create farmer incentives for environmentally friendly practises if the consequences are negative (e.g. if more pesticides are being used); provision of information and advice (e.g. through extension services)
Increased hazards associated with increased precipitation (e.g. waterlogging, floods) (RS)	Improving drainage systems; improving soil physical properties management; reducing grazing pressure or increasing intensive rotational grazing; changes in soil management practices (ex: Keyline design, subsoil plowing, direct seeding); changes in forestry management (change tree composition and crop selection), changes in silvicultural practises; enhancing flood plain management; restoring/creating wetlands;	Zoning system; integrated catchment management; development of early warning system; other types of information/advice on the risks and opportunities; installation of hard defences; encourage farmers to become ‘custodian’ of floodplains (e.g. through reward system)

Intrusion and inundation of agricultural lands due to sea level rising (RS)	Improving drainage systems; substituting crops; changing location of production from vulnerable areas	Zoning system, development of early warning system; installation of hard defences; insurance system
Increased pest, disease, and weed problems (RS)	Livestock vaccination; introduction of pest resistant crop varieties; increased use of pesticides; Integrated pest management. Ecosystem restoration.	Incentives for reduced pesticide use, ecological farming, Integrated Pest Management, good crop selection, changed silvicultural practises, ecosystem restoration etc. (e.g. through pesticide taxes, grants, regulations, information); innovation - technological and biotechnological advancement - including development of pest resistant varieties;
Intensified drought and water scarcity problems due to decreased total precipitation (RS)	Reforestation and ecosystem restoration; intensive rotational grazing; Keyline design; implementing water conservation measures; improving irrigation efficiency; improving water allocation and distribution; changing location of production; introduction of drought tolerant or less water intensive crops and varieties	Create farmer incentives for desired behaviour (e.g. water-saving practises/technologies) through regulation, economic instruments and/or information). Innovation - technological and biotechnological advancement - including development of climate resilient varieties;
Crop yield decrease (RS)	Altering portfolio of land allocation across different crops; altering cultivation practices; diversifying crops; altering the use of external inputs (e.g. fertilizer application in the case of crop production); changing land use; changing farming system; introducing new crops and varieties; farm financial management especially through purchase of crop insurance and investment in crop shares and futures	Create incentives for appropriate crop selection, alternative cultivation methods, changes in silvicultural practises, forestry guidelines, soil management practises, through regulation, economic instruments and/or information. Innovation - technological and biotechnological advancement - including development of more productive crop varieties
Deterioration of livestock conditions (RS)	Intensive rotational grazing, Keyline design, ecosystem regeneration. Introducing more heat tolerant species/breeds; adjusting time for different operations and breeding; altering pasture composition; complementing grazing with supplemental feeding; increasing shelter and heat protection	Ecosystem regeneration policies; information on how to cope with changes. Innovation - technological and biotechnological advancement - especially development of climate resilient varieties; provision of information and advice (e.g. through extension services)
Certain crops become unsuitable under the new climate regime (RS)	Substituting with different varieties or cultivars	Innovation - technological and biotechnological advancement - especially development of climate resilient varieties; provision of information and advice (e.g. through extension services)
Contraction of areas suitable for agriculture in the south (RS)	Changing land use; diversifying household income source; ecosystem regeneration	Programs to promote and facilitate livelihood diversification (e.g. through grants); provision of information and advice (e.g. through extension services). Create incentives for e.g. ecosystem restoration, appropriate crop selection, alternative cultivation methods, and changes in silvicultural practices. Changes in forestry guidelines, changes in soil management practices

Water quality deterioration (RS)	Minimizing nutrient leaching; increasing fertilization efficiency; aerating ploughing equipment; new cultivation methods Minimizing use of pesticides. Ecosystem restoration.	Ecosystem restoration – e.g. allowing water to flow; create incentives for agroforests, policulture and permaculture methods; regulate drilling for water capture; Innovation - technological and biotechnological advancement - including development of highly efficient fertilizers; provision of information and advice (e.g. through extension services); regulating use of nutrients and pesticides
Soil quality degradation and desertification (RS)	Soil conservation and remediation actions	Zoning system; provision of information about potential and tested soil conservation measures; financial support to stimulate farm adoption of measures that demand high up-front investment
Increased frequency, magnitude, and duration of extreme events with greater risk of production loss (RS)	Changing location of production from vulnerable areas; taking on board a wide range of financial management measures including crop insurance, investment in crop shares and futures, and diversification of household income sources	Development of early warning system; provision of information and advice (e.g. through extension services); solidarity fund; appropriate compensation and assistance programs; promoting effective and efficient insurance scheme

As mentioned above, analytically climate adaptation actions can be separated into ‘autonomous adaptation’ and ‘planned adaptation’. Other interesting distinctions from an analytical viewpoint could be public vs. private actions, proactive vs. reactive vs. on-going, authoritative vs. non-authoritative policy instruments, short-term vs. long-term, farm level vs. EU-level (or other scale), responding to negative vs. positive impacts of climate adaptation etc.

Zebisch et al. (2005) analyse the current and potential future impacts on seven climate sensitive sectors in Germany, including agriculture, forestry, and nature conservation, and evaluate the present degree of adaptation and the adaptive capacity of these climate-sensitive sectors to global change.

A number of other studies analyses climate adaptation options. For instance: Gbetibouo et al. (2010) analyse climate adaptation strategies of farmers in South Africa, and suggest through a multinomial logit analysis of climate adaptation responses that access to water, credit, extension services and off-farm income and employment opportunities, tenure security, farmers' asset base and farming experience are key to enhancing farmers' adaptive capacity. Grothmann and Patt (2005) analyse the different psychological steps in taking action. They develop a socio-cognitive Model of Private Proactive Adaptation to Climate Change (MPPACC), which can be used to detect important bottlenecks in taking action - including risk perception and perceived adaptive capacity. The model is tried on a German and a Zimbabwean case. Chambwera et al. (2011) analyse ‘packages’ of coordinated climate adaptation responses in five developing countries and assess the costs of implementation.

Analytically, ‘adaptation pathways’ (Haasnoot et al., 2012a, Haasnoot et al., 2013) can be used ex ante to map possible alternative climate adaptation options within agriculture. Haasnoot et al. (2013 : 8) involve a case study with adaptation pathway relevance for agriculture. Additionally, adaptation pathways might be used ex post to map the intervention logic of any given implemented adaptation measure.

Costs and benefits

Climate change can be considered an exogenous shock to the economy and adaptation and mitigation are responses to that shock, but according to Callaway (2004, cited in Wheeler and Tiffin (2009 : 31)) these two types of responses will differ, as adaptation is essentially a private good, whereas mitigation is a public good. The sole beneficiary by a farmer adjusting his planting dates or switching his crops to adapt to climate change is basically the farmer himself. However, as Wheeler and Tiffin (2009) remark, this is probably an oversimplification, as there are aspects of adaptation which are public goods. For instance, a farmer having wetlands on his farmland may solve flooding problems in the nearby city. Furthermore, when a farmer switches crops due to climate change, it may affect world market prices (Wheeler and Tiffin, 2009) or the new crop may affect the local ecosystem. The distinction between public and private adaptation goods is an important aspect of adaptation. For instance, it is important for whether we can expect farmers to take action or whether government intervention is needed. All things being equal, it is probable that more farmers are interested in saving the farm (through climate adaptation) than saving the world (through climate mitigation). Additionally, the distinction might be important for discussions of who should be financing agricultural climate adaptation and climate mitigation as those who benefit from actions are different. But government intervention can be needed under both circumstances.

As mentioned, the literature on costs and benefits of climate adaptation in agriculture is sparse. Existing studies have largely used top-down approaches and have mainly incorporated a limited selection of autonomous adaptation options in an attempt to assess the economic impacts of climate change, making it difficult to extract the specific adaptation actions. Ciscar et al.'s (2011a) study of the economic consequences of the 2080 climate projections under the PESETA project is an example. Currently, a PESETA II project is running, which is focused on multi-sectoral assessment (including agriculture) of CC impacts in Europe for the period 2071-2100 (see http://peseta.jrc.ec.europa.eu/).

Apparently, those studies of climate adaptation of costs and benefits which have been performed are primarily focusing on the benefits. E.g. Tan and Shibasaki (2003) use a model that integrates GIS and crop combination and productivity simulators to estimate the benefits of agricultural adaptation to climate change in Europe. However, Iglesias et al. (2012) contains a qualitative evaluation of potential costs and benefits of a range of adaptation measures and rank them (low, medium, high) (see also the table above). At a smaller scale, Lewis and Witham (2012) identify key positive/negative impacts of climate change on agricultural commodities like wheat and barley and find e.g. that of particular significance are temperature changes, water availability, and CO_2 fertilization. Leclère et al. (2013) specifically model farm-level *autonomous* adaptation in Europe and among the conclusions are that "although the response is variable among major European crops autonomous adaptation makes climate change much more beneficial to crop yield, especially in central Europe (i.e. roughly from Northern Italy to South Sweden) where reductions in pasture could occur in favour of cropland" (Leclère et al. (2013: 13); see also Kerr et al. (2008)).

Using a top-down approach McCarl (2007) calculates that adaptation costs will be between $11.3 billion (with mitigation scenario for 2030) and $12.6 billion (without mitigation scenario) – see Agrawala et al. (2008b) and Wheeler and Tiffin (2009) for some criticism of the method. Wheeler and Tiffin (2009:34) conclude that 'costed studies on the local and regional scale are also scarce in the literature'. Logar and Bergh (2013) assess different methods for assessing drought costs (damage costs and costs from adopting policy measures). Chambwera et al. (2011) analyse potential packages of coordinated adaptation responses in five developing countries in a very comprehensive report. Some current projects also plan to assess costs and/or benefits. E.g. the ACLIMAS project (running 2012-2015) funded by the European Union, and focusing on six Mediterranean countries, has among the objectives to "evaluate the on-ground sustainability of the proposed adaptation measures considering the economic, social and environmental dimensions at farm level" (see www.aclimas.eu).

Implementing climate adaptation policies – barriers and opportunities

Adaptive capacity is variable. A meta-case study of Bussey et al. (2012) focusing on adaptive capacity in 33 case studies, including agriculture, forestry, biodiversity and ecosystem services demonstrates that adaptive capacity varies with context and is affected by the complexity, technology, leadership, institutions and imaginative resources inherent to the actual social system. Adaptive capacity is here defined as a 'measure of the human ability to respond to threats and stimuli in the social and natural environment'. Parallel, Crane et al. (2011) analyse climate adaptation as a dynamic process which is socially embedded and they contrast this to more static modelling studies of climate adaptation. They analyse two case studies in the US and Mali and highlight how adaptive processes and technologies are more than simple technical responses to biophysical conditions.

Furthermore, ability, will and motivation of those actors expected to adapt, or those actors expected to make other actors adapt (e.g. street-level bureaucrats (Lipsky, 1980), agricultural advisors etc.), is of high importance for the magnitude of actions taken. Arbuckle et al. (2013) show that the relationships between farmers' beliefs and attitudes toward adaptive and mitigative action differ in systematic ways – farmers who believed that climate change is occurring due to human activity were significantly more likely to support adaptive actions. Farmers who attributed climate change to natural causes, were uncertain or did not believe that climate change is occurring were less likely to support adaptation and mitigation strategies. Additionally, Frank et al. (2011) show that social identity among Mexican farmers mediates between risk perception and adaptation through influence on farmer motivation and the authors propose to add 'social identity' to the climate adaptation models; and Mertz et al. (2009) analyse Senegal farmers' perceptions of climate change and the strategies for coping and adaptation and conclude e.g. that change in land use and livelihood strategies is driven by adaptation to a range of factors, where climate does not seem to be the most important. Pedersen et al. (2012) show that a relatively large proportion of Danish farmers (32 pct.) are less motivated by economic incentives, and on the other hand highly professionally motivated, when they make decisions regarding pesticide use, and therefore they do not respond as much to economic policy instruments (for instance pesticide taxes) within the Danish pesticide policy as other Danish farmers do. It is plausible that the same differences can be observed regarding climate adaptation actions, making it relevant to analyse what motivate farmers to make climate adaptation. Similarly, the European Commission (EC, 2013c : 11) underlines that climate risks are only one aspect of many, influencing farmer decisions.

Needless to say, governance aspects are important too. Farmer (2011) explores cross-scale governance between EU and member states:" The analysis identifies a number of different types of 'information' transmission between the different governance scales. Information includes a range of governance issues, including transmission of rules. These are exact 'information' transmission (water quality standards), national elaboration of information transmitted (adapting to climate change), national simplification of information transmitted (industrial pollution control), distributed information transmission On national transposition), fuzzy transmission of information (interpretation of Good Ecological Status) and barriers to transmission (available funding)". Mickwitz et al. (2009) analyse climate policy integration in six European countries. Blom-Zandstra et al. (2009) analyse conflicting and synergistic properties of different climate adaptation strategies for agricultural and natural environments in Netherlands. Urwin and Jordan (2008) analyse to what degree sector policies support or undermine potential adaptive responses. Furthermore, they use both a top-down and a bottom-up approach and find that "neither approach offers a complete picture of the potentially enabling or constraining effects of different policies on future adaptive planning, but together they offer new perspectives on climate policy integration". Næss et al. (2005) examine the role of institutions in climate adaptation in Norway and have three findings: First, "the institutional framework for flood management in Norway gives weak incentives for proactive local flood management. Second, when strong local political and economic interests coincide with national level willingness to pay and provide support, measures are often carried out rapidly at the expense of weaker environmental interests. Third, we find that new perspectives on flood management are more apparent at the national than the municipal level, as new perspectives are filtered by local power structures". Policy coherence (vertically and horizontally) is a potential important theme in BASE as many Member States are implementing adaptation strategies which are interacting with other sector policies – for instance within the Common Agricultural Policy and within the Water Framework Directive (Olesen and Bindi, 2002, Iglesias et al., 2012).

Therefore policy instrument choice is important too. Pataki et al. (2011) find that market-based instruments dominate the adaptation toolbox. Additionally, 'soft' tools, such as guidelines/information, are promoted to be developed, even in cases for conflict resolution between sectors or policy fields (Pataki et al., 2011). The mix of policy instruments (Howlett and Rayner, 2007) is important for effective policies. New policy instruments are being implemented in climate adaptation policies, but they interact with climate mitigation policies, agricultural policies etc. in other and often older policy areas. Consequently, sector policies might be in conflict.

A number of case studies exist regarding the role of knowledge. For instance, Asplund et al. (2013) analyse climate framings in two specialized farming magazines and the connected interpretation of the farmers. This is relevant for adaptation, as Asplund et al. (2013) demonstrate that farmers' opinion on whether climate change is induced by human activity affects their will to support adaptive actions. Farmer (2011) might be of relevance as well by focusing on information transmission between EU and the member states. There does not seem to be studies addressing how farmer knowledge feeds into the adaptation planning process – BASE could potentially be making a contribution here.

Regarding stakeholder involvement and research in participatory processes there does not seem to be studies explicitly evaluating stakeholder involvement in climate adaptation within the agricultural sector. On the other hand, there might be elements of stakeholder participation or participatory analyses in some of the mentioned projects in the Appendix.

Urwin and Jordan (2008) research is important from a methodological BASE perspective as they demonstrate the importance of having both a top-down and a bottom-up perspective.

2.3.4 Where can/will the agricultural case studies of BASE make important contributions

In BASE there are agricultural case studies on:

- Climate adaptation responses to flooding problems in two Danish predominantly rural municipalities.
- Climate adaptation responses to drought and water availability problems in two regions of the Czech Republic.
- Drought adaptation in the region of Alentejo in Portugal.
- Climate adaptation in the Tagus River Basin of Spain.

The agricultural case studies will provide an overview of the status and the focus of climate adaptation efforts in case communities and countries, indicating what kinds of risks and opportunities farmers are aware of, respond to and how they respond. Likewise they will provide a state of the art review of national and EU adaptation responses for the agricultural sector and its effect on the ground.

The agricultural case studies will add to the sparse literature on costs and benefits of climate adaptation in agriculture. Some of the case studies will provide knowledge on specific industries - hop and wine production in the Czech Republic, and sugar production in Denmark.

The Danish case studies will contribute to the literature regarding barriers and opportunities to climate change adaptation, focusing on policy coherence/integration vertically and horizontally. Thus key questions concern the interaction between local climate adaptation responses and the strategies at local, regional, national and EU level and the use of knowledge in decision-making processes regarding climate adaptation among key actors at the local level. The Danish case study uses document analysis, in-depth interviews with key stakeholders and develops of a questionnaire to the farmers in the two municipalities – it is planned to have some similar questions to farmers in the Danish and the Czech case studies to make comparisons possible, and maybe in the Portuguese case too.

The Czech case studies in Ústí Region and South Moravian region aims to investigate current and potential adaptation measures (with special focus on ecosystem-based approaches) and strategies in the agricultural (particularly hop growing, respectively wine growing regions) and water sector to deal with the changing climate. The case studies will investigate perceptions of local stakeholders as well as barriers and opportunities of adaptation policies. If possible, the case studies will try to investigate costs and benefits of adaptation measures, particularly related to drought and water availability. Semi-structured interviews with relevant stakeholders and questionnaire-based survey to the farmers (developed together with Danish CS) are planned.

The Portuguese case study will analyse the adaptation to drought in the Alentejo region as a case study with several projects that are implementing measures for the adaptation to Droughts and Water Scarcity. The replication potential is high since the adaptation measures from farms, organic farms and Eco-Communities can potentially be adapted to and applied in all farms in the Alentejo and Mediterranean region. The case study will seek answers to questions (based on the Alentejo Region) like: How can the Mediterranean region best adapt in an integrated and sustainable way to extreme events such as droughts? How can food security be improved and food production made more resilient in the Mediterranean region? How is Climate Change perceived in the Alentejo region by the stakeholders that have intervention on the landscape? How can communication and decision processes on mitigation and adaptation for Agriculture and Forestry be developed to become more transparent and legitimate? The case study will provide qualitative data on adaptation measures to drought and quantitative and qualitative evaluation of the full costs and benefits of such adaptation measures. Methodologically, information based on questionnaires to farmers and relevant stakeholders will be gathered. The case study will also use participatory methods.

The case study of the Tagus River Basin in Spain addresses adaptation from the water demand and supply point of view. Agriculture in the Tagus basin suffers the most adverse effects from water scarcity as it is by far the largest water consuming sector. As climate change impacts are expected to notably worsen conditions the adaptation of agriculture has recently received increased attention in the scientific and policy debate. However, the situation becomes more complicated when water needs for agricultural and natural systems exceed the total water availability and the attempt to satisfy the total agricultural water need is the main cause of natural protected areas having poor ecological conservation status. When this occurs the optimal provision of ecosystem services for both agricultural and natural systems cannot be reached separately and therefore it should be pursued for both systems as a whole rather than independently. The work in the Tagus basin relies on the assessment of adaptation strategies with the purpose of building resilience to water scarcity by combining modelling with the consultation of experts and principal stakeholders. Table 3 indicates some key research questions that will be addressed in the case study.

Table 3. Tagus case study

Research question in the Tagus case study	Main implications for building resilience to water scarcity
How do stakeholders perceive the need to adapt to an increased water scarcity?	Agreement on perceptions of water scarcity risks and choices for water allocation
What are the best adaptation options to ensure resilience to water scarcity?	Maximizing ecosystem services provision and other relevant socio-economic criteria

There are strong links from the agricultural case studies to BASE ecosystem services cases as all case studies will be addressing some ecosystem aspects too.

Questionnaires and qualitative interviews

In the agricultural subgroup the plan is to share stakeholder interview guides for qualitative interviews among the BASE partners in the subgroup. Part of the content in these interview guides will be the same across countries, while some aspects will be country specific.

Furthermore, the Czech and the Danish case studies will perform quantitative studies by sending surveys to farmers in the case study regions/municipalities (in Denmark there might be performed a national survey among farmers too).

The Portuguese case study will contain a questionnaire too addressing many of the same subjects mentioned above – the prime focus in this survey will be what innovative drought adaptation measures the farmers are implementing.

The Spanish case study will also be addressing some of the above mentioned aspects by focusing on farmer perception (and other stakeholders' perception) on the need for adaptation to climate change. In the Spanish case study this is assessed through qualitative interviews. Studying farmers and public support for agricultural adaptation policies can play a key role in successfully adapting the sector to climate change. Thereby, the case studies will address support for adaptation policies.

It is planned to design the interviews during Autumn 2013 and apply them in the field during the winter 2013

Finally, it is planned to have some identical questions in the surveys to make comparisons possible across countries. These questions constitute the following Common Research Questions of the Agriculture and Forests BASE Subgroup, including

- How do farmers percept climate adaptation and the need for climate adaptation actions? What is their risk perception? How are farmers motivated?
- What climate adaptation actions have farmers already taken (if any)? And what are the costs? Are there any experienced benefits? (this information is needed for WP3 and WP6)?
- How is climate adaptation knowledge disseminated from the top (municipality, government etc.) to the bottom (farmers)? (for WP2)
- How is climate adaptation knowledge fed into the top (municipality, government etc.) from the bottom (farmers)? (for WP2)

- Do farmers experience any conflict between climate adaptation policies and other policies (e.g. in the CAP)? (for WP2)

2.4 Adaptation in water resources sector

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2.4.1 Managing the unavoidable

Challenges to water management

Water management is becoming increasingly complex in developing and developed countries. Water resources provide employment opportunities to rural population, support ecosystems and food production. However, water is an increasingly scarce resource in many regions. Water management include a large range of technical, economic and social factors. Rainfall (green water) is water in its natural condition and it is therefore highly exposed to natural variability. Water in rivers or storage in reservoirs (blue water) is also exposed to natural variability but can be managed. The debate on water for agriculture and water for nature is an environmental problem that has been in the centre of policy debates in (World Bank and the United Nations, 2010) and has generated media attention, often focusing on perceptions and personal values. Adding the climate change aspect, environmental beliefs become more complex and public opinion is further polarized (McCright and Dunlap, 2011, Dietz et al., 2007).

Climate change is only one of many pressures faced by water management today and in the future. However climate change is a very significant pressure since it has a direct impact on all aspects of water for people. A range of adverse impacts include reduced water availability and more frequent extreme events, such as droughts and floods (Alcamo et al., 2007, Arnell and Delaney, 2006, Arnell, 2004, Arnell et al., 2004, Easterling et al., 2000, Nijssen et al., 2001, Rosenzweig et al., 2004, World Bank and the United Nations, 2010, IPCC, 2012). These negative impacts may put water resources management, certainly at the level of individual land managers and regions, at significant risk (summary of evidence in IPCC, 2007a, Bates et al., 2008).

In order to understand the process of reaching future goals for water under climate change, science has developed a set of tools to understand uncertainty (Moss et al., 2010), assess future impacts (Elmer et al., 2012), and facilitate policy development (Howden et al., 2007, Ciscar et al., 2011b, IPCC, 2012).

The challenges of climate change will have to be met through adaptation. Adaptation here is defined as the adoption of actions that have significant potential to reduce the impact itself or the influence of the driver on the impact. Understanding the adaptation strategies for water management as a whole requires a multi-dimensional analysis at the global level that requires information on: a measure of the potential impacts and a measure of the potential limits (social and physical) to adaptation.

In the beginning of the 21st century water resources seem to stand at a crucial juncture. Projections remain complex and uncertain (Vorosmarty et al., 2010), not least due to changes in population, consumption patterns and environmental policy (Satterthwaite et al., 2010). Research and technology have been unusually vigorous and have shed light on many possible innovations (desalination, water reuse, reforestation, among others). Part of this transformation is due to the pressure of increased population and policy to face social values on the environment.

Responding to multiple challenges

Evaluating adaptation of the water resources sector to climate change is not an easy task, due to the broad range of objectives of water policy – from social choices for the allocation of water to technical alternatives. Society is becoming increasingly concerned about environment as population water needs continue to grow, and climate change imposes further limitations.

Water is increasingly becoming limiting factor for sustainable economic growth and development. Its allocation has significant impacts on overall economic efficiency, particularly with growing physical scarcity in certain regions. Greater water supply variability further increases vulnerability in affected regions. Water also has become a strategic resource involving conflicts among those who may be affected differently by various policies (Wechsung and Naumann, 2008).

Efforts to develop adaptation policies have been met with a lack of concrete local measures that are understood and supported by citizens. Even in areas of strong environmental commitments, the success of various policy proposals has been mixed, reflecting a perception that the public views adaptation to climate change as opposed to economic development.

The likelihood of climate change impacts will continue to increase as long as adaptation strategies are not put in place. However defining the adequate strategies requires multiple efforts from the understanding of impacts to the selection of alternatives that respond to local development priorities. As result there are many different methods for evaluating the needs for adaptation. Modelling the system at risk provides a measure of the potential need for adaptation and the benefit of the intervention. At the same time, the implementation methods range from expert judgement to cost-benefit analysis.

Scenarios of water availability

Patterns and trends of climate studies show that the effects of climate change will ultimately affect water resources availability and thus have an impact on water management. The consensus is that the effect will accentuate the extremes with more pronounced drought and flood periods. Certain regions dependent on water (e.g. major farming areas, or large population centres) will experience more water scarcity, thus stressing the need for adaptation strategies. Hydrological stress is expected to increase in central and southern Europe. For the 2070s, the percentage of surface area under conditions of severe water stress is expected to increase from the current 19% to 35%. Populations living under water stress conditions in regions from 17 countries of Western Europe are projected to increase by between 16 to 44 million. It is also predicted that the volume of certain rivers may diminish up to 80% during summer seasons; reservoirs may lose resources due to decrease of rainfall and droughts frequency will be increased. A reduction of average natural water resources will produce increasingly more frequent and more intense episodes of water shortage. It is also foreseen that climate change will produce alterations in the variability of water resources, intensifying the frequency and magnitude of extreme events, like floods and droughts, which will produce important impacts on the population. Climate change is expected to result in an increased water demand; higher temperatures are expected to lead to increased water demand for irrigation and urban supply, hydroelectric potential of Europe may decrease 6% in average and between 20 and 50% in the Mediterranean region. However, industry may not increase consumption of water because of technology efficiency.

Water quality is also expected to deteriorate. There are many possible routes of interaction, such as reducing the flow available for pollution dilution, the temperature increase, with consequent changes in the activity of biological processes, chemical modification of the flow of water through the soil, with the alteration of the transport of nutrients and pollutants, and so on. Although there are many processes involved, the results so far point to a likely deterioration of water quality, especially in areas where the natural river regime has been significantly altered.

Natural ecosystems will be altered in a diversity of ways. The challenge of environmental management consists on anticipating the negative effects of climate change by means of the analysis possible scenarios and on adopting management strategies that are positive in the current situation and do not worsen the situation in case of adverse climate change.

Scenarios of water resources availability are developed from climate projections but need to take into account water management, infrastructure and demands. In water scarce regions, the impacts of climate change on natural resources will affect water uses through water resource systems, which perform functions of regulation, transportation and distribution of water resources. In these regions, water resources systems are highly developed and they have achieved a profound transformation of the natural characteristics of water resources to accommodate the needs of demands. Hydraulic infrastructure plays a critical role to make water available to users by overcoming the spatial and temporal irregularities of the natural regimes.

In the Mediterranean, climate change impacts on water will have a large impact on human water security and biodiversity (Vorosmarty et al., 2010). There are several hundred studies on the potential impacts of climate change on water resources in the Mediterranean which apply many different approaches. According to Gleick and Palaniappan (2010), more and more watersheds appear to have passed the point of “peak water”, a concept related to the sustainability of water management. These studies have different focus – from ecosystems to water pricing to recreational water–, a wide range of time-frames, different scenarios and spatial scales that vary from the local to the global analysis. Although the results are diverse and sometimes contradictory, a common element is that one of the primary impacts of climate change will be a reduction of water availability in the Mediterranean.

In the North of Europe climate scenarios project increases in air temperature and precipitation during the 21st century and these will results in changes in hydrology. Seasonal changes in discharges in Finland are the clearest anticipated impacts of climate change. Floods caused by spring snowmelt are expected to decrease or remain unchanged, whereas autumn and winter floods caused by precipitation increase especially in large lakes and their outflow rivers (Veijalainen, 2012).

Nordic catchments can be very responsive to even limited variation in precipitation and temperature in terms of river flow and chemistry (Bouraoui et al., 2004). Predicted changes in precipitation and temperature increases the nutrient load from catchments to water bodies in future climate (Rankinen et al., 2009).

Meier et al. (2012) state that due to the increased temperature and increased net precipitation in the Baltic catchment area the decomposition of organic material in the sediments will be accelerated and the nutrient loads from land will increase. Both processes accelerate eutrophication in the Baltic Sea. Eriksson Hägg et al. (2010) have estimated a 3-72 % increase in total nitrogen flux from catchments surrounding the Baltic Sea by 2070.

Climate adaptation in the north of Europe requires changes in current water resources management measures. Changing the management practices and permits of many of the regulated lakes in Finland will become necessary during the 21st century in response to climate change induced shifts in hydrological regime (Veijalainen, 2012). According to Meier et al. (2012), nutrient load reductions performed under current legislation will not be sufficient to improve the water quality at the end of the century. Efficient allocation of water protection measures requires detailed analysis of different sources of loading (Rankinen et al., 2009).

Nevertheless many of these projections do not take into account the effects of policy. The solution to climate problems will imply social changes, a progressive increase of water demand management and a consensus reallocation of water availability to prioritised users. The agreement on essential uses remains a controversial issue across the region. In this process, policies regulating water usage, water accessibility and hydraulic infrastructure, will play a critical role in making water available to users by overcoming the spatial and temporal irregularities of natural regimes.

To summarize, areas exposed to drought and water scarcity are very sensitive to climate change, because the current high degree of water resources use, the imperative need to allocate more water for environmental uses and the narrow margin which is available to improve water availability. Climate change in these regions is perceived as an intensification of existing pressures, which will imply strong reductions in water availability and further increases in water demand. This will lead to the intensification of water management conflicts, due to the competition for water among different social agents and the degradation of water quality through the alteration of the hydrological cycle. In some regions, current water uses cannot be maintained in the future. If climate predictions are right, reductions of up to 50% of average annual runoff will lead to a deep crisis of the ecosystem, society and the whole socioeconomic model, based largely on highly productive agriculture and tourism industries. The solution to those problems will imply profound social changes, progressive reduction of water demand and reallocation of water availability to those uses that are deemed socially as more appropriate.

Scenarios of flood intensity and frequency

According to the IPCC report "Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation" (IPCC, 2012), "there is limited to medium evidence available to assess climate-driven observed changes in the magnitude and frequency of floods at a regional scale because the available instrumental records of floods at gauge stations are limited in space and time, and because of confounding effects of changes in land use and engineering. Furthermore, there is low agreement in this evidence, and thus overall low confidence at the global scale regarding even the sign of these changes. There is low confidence (due to limited evidence) that anthropogenic climate change has affected the magnitude or frequency of floods, though it has detectably influenced several components of the hydrological cycle such as precipitation and snowmelt (medium confidence to high confidence), which may impact flood trends. Projected precipitation and temperature changes imply possible changes in floods, although overall there is low confidence in projections of changes in fluvial floods. Confidence is low due to limited evidence and because the causes of regional changes are complex, although there are exceptions to this statement. There is medium confidence (based on physical reasoning) that projected increases in heavy rainfall would contribute to increases in rain-generated local flooding, in some catchments or regions. Earlier spring peak flows in snowmelt- and glacier-fed rivers are very likely, but there is low confidence in their projected magnitude."

2.4.2 Approaches to evaluate water resources adaptation

Modelling

Climate change can alter regional water requirements through two pathways: sector-level changes in biophysical water demand (i.e., agriculture, urban, ecosystems responses) and adaptation policy responses (i.e., EU Water Framework Directive). These changes are best documented by modelling approaches.

Models provide means to represent regional variations of the effect of a warming climate on soil-moisture, evaporative losses and changes in precipitation, irrigation, water availability and urban or tourist use. Döll (2002) offers for the first time a global analysis of irrigation requirements under climate change. Her results highlight that two-thirds of the global area equipped for irrigation in 1995 will possibly suffer from increased water requirements, and on up to half of the total area (depending on the measure of variability), the negative impact of climate change is more significant than that of climate variability. Strzepek et al. (1999) use a suite of models to evaluate changes in water supply and demand for agriculture in the USA. Following the same methodology, Rosenzweig et al. (2004) define scenarios of water resources for agriculture in a changing climate in five major agricultural regions: USA, Europe, China, Brasil and Argentina that account for almost two thirds of the total global food trade. Iglesias et al. (2012) evaluate the need for additional irrigation as an adaptation strategy considering scenarios of urban water demand are driven by changes in population and lifestyles. Population is expected to increase slightly, projections of increased GDP result in lifestyle changes that demand more urban water (from collective living to single home living). Unless GDP growth is decoupled from urban and industrial water use it is likely that the demands from these sectors will continue to grow. The calculation of changes in irrigation requirements aim to reach demand satisfaction according to assumptions on technological capacity of the country, limited by the country environmental flow requirements. Logar and Bergh (2013) provide an overview on methods for the assessment of the costs of droughts. Reviews of flood damage evaluation methods are provided by Meyer and Messner (2005), Messner et al. (2007), Merz et al. (2010), Green et al. (2011).

Evaluation of water resources reallocation

Regarding climate change predictions, water resources re-allocation seems to be a key adaptation measure to tackle water scarcity problems (Grantham et al., 2010, Varela-Ortega et al., 1998). However, there are some potential solutions to water allocation problems such as changes in infrastructure, land-use or limitations of irrigation that may not be well accepted by the whole society (Iglesias et al., 2011b) and decision-making processes often can lead to conflicts among different stakeholders. Thus it is essential to incorporate the interests of the different stakeholders affected by the consequences of these processes, including policy makers, farmers and the public (Conde et al., 2005, Semenza et al., 2011). The Water Framework Directive (EUWFD), which represents a benchmark in the design of water policies in Europe, greatly promotes stakeholders and public participation in decision- and policy-making processes. Relly and Sabharwal (2009) claim that there is a growing demand for the processes used to allocate resources to be transparent, based on scientific evidence, and deliver outcomes that are in the public's interest. This reinforces the need to study public preferences for climate change adaptation measures in order to incorporate public opinion into policy- and decision-making processes. Thus a better understanding of how stakeholders' perceive climate change, adaptation policies, and the factors or predictors influencing their support for adaptation policies can be a helpful tool in the development of these decisions and policies.

The European Floods Directive (FD) (European Parliament and the Council, 2007) also takes climate change adaptation into account. Member states have to undertake a preliminary flood risk assessment within their river basins, and have to compile flood hazard and risk maps at an appropriate scale in order to serve as a basis for flood risk management plans. The directive requires that "the likely impact of climate change on the occurrence of floods shall be taken into account …" in the periodic reviews of flood risk assessments and risk management plans (European Parliament and the Council, 2007). At least for the development (and review) of flood risk management plans participation is promoted: "Member States shall encourage active involvement of interested parties in the production, review and updating of the flood risk management plans" (European Parliament and the Council, 2007).

Participatory approaches

Public concern of the state of the environment has grown rapidly and this has also increased interest in participatory decision making (Mustajoki et al., 2004). Consequently, public approval has become an important decision objective, and the public participation a common element in environmental decision making processes. However, the large number of stakeholders also induces a large number of conflicting views, and transparent and structured processes are needed to reach participants' shared understanding of the problem and collective build a proposal that reaches consent.

Cost-benefit evaluation of concrete measures

Cost benefit analysis is used for the evaluation of concrete measures where costs associated with action and inaction are well documented. McEvoy and Wilder (2012) evaluate the potential impacts of proposed climate change adaptation interventions in the Arizona–Sonora border region, focusing on desalination —the conversion of seawater or brackish groundwater to fresh water—as an adaptation response that can help meet growing water demands and buffer against the negative impacts of climate change on regional water supplies. However, the uneven distribution of costs and benefits of this expensive, energy-intensive technology is likely to exacerbate existing social inequalities in the border zone.

Gersonius et al. (2013) evaluated the role of flexible options to face flood risk. Flexibility will restrict the effect of erroneous decisions and help avoid maladaptation. Real In Options (RIO) analysis can facilitate the development of an optimal managed/adaptive strategy to climate change. The authors show the economic benefits of adopting a managed/adaptive strategy and building in flexibility, using RIO analysis applied for the first time to urban drainage infrastructure.

De Roo et al. (2012) have recently reported a multi-criteria optimisation of scenarios for the protection of water resources in Europe. Multi-criteria as well as cost-benefit evaluation for regional adaptation options of water scarcity management have been conducted by Meyer et al. (2011) for the Elbe River basin (see also Grossmann et al., 2011).

Cost-benefit analyses for flood risk management options have already a quite long tradition in policy, in particular in the UK (MAFF, 1999, Pearce and Smale, 2005). The current challenge is to consider the dynamics of flood risk (due to climate and socio-economic change) in such evaluations (Elmer et al., 2012, Meyer et al., 2012).

Learning from expert judgement

In many cases the attributes of adaptation strategies are not clear from the studies. In such cases, expert judgement is often used to make proposals (Mukheibir and Ziervogel, 2007, Mukheibir, 2008). de Bruin et al. (2009) describe an inventory of climate adaptation options and ranking of alternatives in The Netherlands, including options for water for agriculture. The study evaluates the options based on stakeholder analysis and expert judgement, and presents some estimates of incremental costs and benefits. The qualitative assessment focuses on ranking and prioritisation of adaptation options.

Evaluating the role of institutions

Berman et al. (2012) evaluate the role of institutions in the transformation of coping capacity to sustainable adaptive capacity. The study identified four key challenges to understand the transformation of coping to adaptive capacity include (1) the concealed nature of adaptive capacity; (2) the temporal trade-offs between coping and adaptive capacity; (3) the limited focus to date on rural communities, and; (4) the lack of empirical evidence. Agrawal (2008) provides a clear review of adaptation to climate change, highlighting the role of local institutions. Huntjens et al. (2012) propose a theoretical improved institutional design, and Groves et al. (2008) identify concrete actions for water management institutions.

Understanding public choices

Understanding public choices on environmental issues has evolved from the rational choice logic that explains choices based on self-interest (Sears and Kinder, 1985) to the analysis of beliefs of individual groups (Davis and Shipp, 2009, García de Jalón et al., 2013). Regardless of the sociological theory behind the process, sociologists tend to accept that those actions —not opinions— are explained by interests and resources rather than values and beliefs. Why do individuals adopt certain choice? Addressing the social and psychological causes behind the individual choice, is beyond the aims of this study, but we provide an understanding of the main drivers that shape motivations and barriers.

Environmental commitment and climate change concern are not driven by the same social characteristics, as we would have expected. This reflects the theory that choice is driven by both cultural and rational approaches. The individuals that have relatively well formed views about climate change are guided by values and beliefs that result from education and social responsibility. In contrast, individuals that may suffer personal costs derived from their decision reflect a rational actor model.

Public choice for adaptation in the European Union has been documented based on extensive surveys (Eurobarometer, 2009); in USA with more analytical approaches (Shwom et al., 2010). Perceptions and policy choices are often complex and reflect local values (Leiserowitz, 2006).

Studies concerning people's support for adaptation policies have been less numerous that those dealing with social perception of climate change. There is a number studies which assess people's support for adaptation policies by asking respondents directly how much they would be willing to pay for some adaptation measures to climate change (Fisher et al., 2012, Ku and Yoo, 2010, Solomon and Johnson, 2009, Zografakis et al., 2010). In this field there is also a growing literature highlighting the factors that influence stakeholders' willingness to adapt to climate change.

Planning new investments

Planning and developing irrigation is always a local choice (Mehta et al., 2012, Törnqvist and Jarsjö, 2012). Heumesser et al. (2012) define a method for investment in irrigation systems under precipitation uncertainty in Austria, assessing the optimal timing to invest into either irrigation system in the planning period 2010 to 2040. They then investigate how alternative policies, (a) irrigation water pricing, and (b) equipment subsidies for drip irrigation, affect the investment strategy.

Local needs and capacities

Local needs and capacitates are based in the potential for capacity to develop new infrastructure systems (Zimmerer, 2011, Siebert et al., 2007) or implementing improved technology for irrigation, desalinisation (Abufayed and El-Ghuel, 2001), water re-use technology (Trinh et al., 2013), alternatives of groundwater management (Causapé et al., 2006, Garrido and Iglesias, 2008), water harvesting (Moges et al., 2011, Oweis and Hachum, 2006), capacity to develop insurance or capacity to develop water markets (Garrick et al., 2009).

Although local needs set the scene for adaptation, cooperation is always a priority for adaptation that includes water resources management, as shown for example in the case of trans-boundary water management (Dieperink, 2000, Sadoff and Grey, 2002, Vugteveen et al., 2010).

Upscalling local initiatives is often impossible (Rodríguez et al., 2006), but knowledge transfer should play a major role in the development of adaptation strategies, especially the strategies that include local resiliency as a major component of the adaptation assessment needs. Kuhlicke et al. (2012) provide guidance for social capacity building for natural hazards, considering the social capacities of organisations as well as local communities.

Evaluating trade-offs

The need for developing win-win strategies to avoid the potential conflicts that may arise due to climate change impacts have been stressed endlessly (Carraro, 2007, Fankhauser et al., 1999). Given the costs and lack of incentives associated with promoting adaptive capacity, adaptation is unlikely to be facilitated through the introduction of new and separate policies, but rather by the revision of existing policies that currently undermine and the strengthening of policies that promote adaptation (Howden et al., 2007, Iglesias et al., 2011b). Finding common ground between competing claims is a serious challenge to policy development. Nevertheless, this challenge needs to be addressed to ensure the coherence and efficiency of policy measures under a changing climate (Juhola and Westerhoff, 2011).

Water availability and policy assessment

Three factors are at play in regulated water resource systems: stream flow variability, storage capacity and yield reliability. These are usually linked through storage-yield-performance characteristics, which describe how a system is able to supply its demands and with what reliability. There is a wide range of techniques which can be applied for this purpose, from relatively simple regression functions relating these variables to highly complex water resource systems models. Usually, these complex simulation or optimization models are used in River Basin Management Plans in areas prone to water scarcity. The result of the analysis is an estimation of the reliability of supply for each demand present in the system.

The Water Availability and Policy Assessment model (WAPA) (Iglesias et al., 2011a) may be used to compute the water availability and demand-reliability curve, which provides a simple way to evaluate water availability under different policy and climate change scenarios. WAPA model architecture, system management options, system performance evaluation and demand performance analysis. The model has been applied to evaluate economic decisions of drought policy and water policy in the Mediterranean (Iglesias et al., 2013). The model links water supply, demand and management allowing the analysis of policy options. The model computes water availability and reliability as result of implementing climate or policy scenarios.

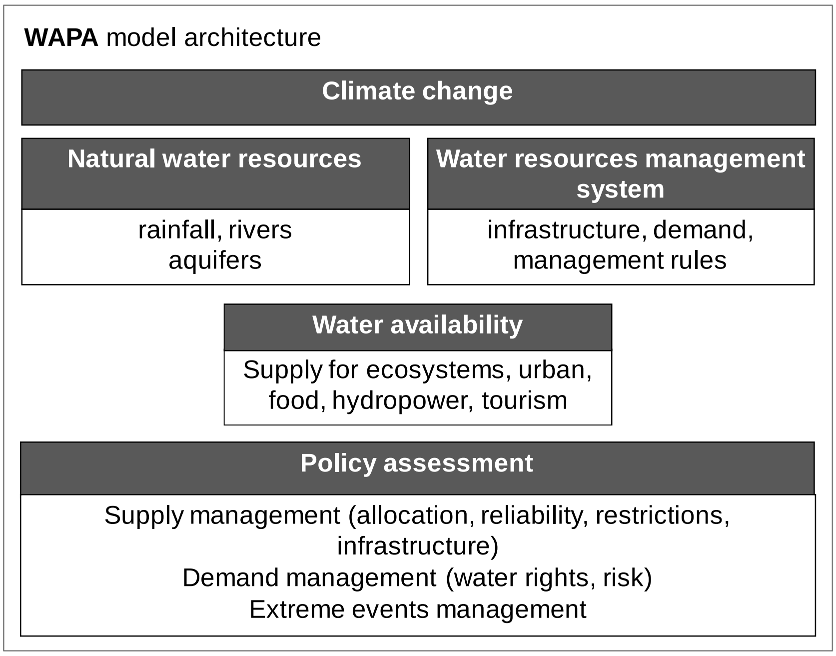

Figure 4 Architecture of the Water Availability and Policy Assessment model (

Source: Iglesias et al. (2011a)

2.4.3 Where can/will the water case studies of BASE make important contributions

In BASE the adaptation studies of water management are closely inter-linked with the agricultural and rural development studies, and include:

- Climate adaptation in the Tagus River Basin of Spain and Portugal that will incorporate urban areas and health (In Spain only). The trans-boundary component of this case study will deal with water availability from Spain to Portugal and the political issue and strategic/policy challenges to overcome.
- Climate adaptation responses to flooding problems in two Danish predominantly rural municipalities.
- Climate adaptation responses to drought and water availability problems in two regions of the Czech Republic.
- Drought adaptation in the region of Alentejo in Portugal.
- Adapting flood risk management and river basin management plans to climate change in Kalajoki River Basin in Finland.

  The case study aims to identify possibilities to achieve “climate proof” river basin management plans (RBMP) and flood risk management plans (FRMP) according to Floods and Water Framework Directives. The case study focuses on comparing alternative management choices and their impacts in Kalajoki river basin in Western Finland. The case study supports on-going planning processes. The research questions are: What is the adaptive capacity of river basin and flood risk management measures? How to find synergies between flood risk and river basin management? What are the costs and benefits of flood risk management measures? What is the acceptability of measures among stakeholders and citizens? What are the possible future adaptation pathways in flood risk management?

The studies carried out in BASE include modelling of the benefits of flood risk management measures, assessing the climate change impacts on nutrient leaching and farming practices, participatory multi-criteria decision analysis (MCDA) of flood risk management measures as well as a survey of the acceptability of measures.

The case study contributes to BASE project by providing data on costs and benefits of different adaptation measures in water sector. Additionally, the case study offers examples and experiences on involving stakeholders in adaptation planning. Kalajoki case study has also strong links to BASE case studies dealing with human settlements and infrastructure as well as biodiversity and ecosystem services.

2.5 Adaptation in human settlements and infrastructure

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This subsection aims to provide a state-of-the-art review of climate change adaptation studies on cities and infrastructure. It starts with an introduction of the significance of cities and infrastructure in human society. Subsequently the challenges that are faced by cities and infrastructure due to climate change are explained. Then approaches used in climate change adaptation studies are introduced, which is followed by a selection of recent case studies. Finally, a brief introduction of BASE case studies is given.

2.5.1 The significance of cities and infrastructure in human society

Cities become increasingly important due to growing populations and a shifting balance to a more urbanized world (Jordan and Schout, 2006). Urban area accounts for less than 2% of the earth's terrestrial surface, however the population residing in urban areas represents half of the world's population. By 2030, the proportion is expected to increase to 60% (Hall et al., 2009). The degree of urbanization in European countries is even higher with around three quarters of the population living in cities (EEA, 2012b). On the one hand, cities are highly vulnerable to a variety of climate change impacts such as flooding, heat waves, sea level rise, air pollution, and etc. On the other hand, cities have unique advantages in responding to climate change because cities are concentrations of economic, social and technical assets, which are vital in designing and implementing adaptive policies (Hunt and Watkiss, 2011). In addition, cities can response faster and more effective to climate change impacts than nations since they are closer to the local community (World Bank, 2010). Infrastructure refers to complex physical assets, including communications, transport, power grids, water supply, waste treatment, and buildings which provide fundamental facilities and services for the functioning of economy and society (EEA, 2012b). Adapting infrastructure to climate change could also open up opportunities to promote economic growths and create jobs In the EU (EC, 2013a). For these reasons, cities and infrastructure are important in tackling the threats of climate change.

2.5.2 Challenges facing by cities and infrastructure

Cities and infrastructure are vulnerable to climate change impacts. The Intergovernmental Panel on Climate Change (IPCC) third assessment report (TAR), climate change impacts are summarised by impact type and settlement type[1] (IPCC, 2001). The report identifies twelve types of potentials impacts, including flooding and landslides, tropical cyclone, water quality, sea-level rise, heat and cold waves, water shortage, fires, hail and windstorm, agriculture productivity, air pollution, permafrost melting and heat islands, and indicates their degree of importance at both urban and rural scale. In the IPCC fourth assessment report (AR4), types of climate change impacts are further categorised into two groups: those related to extreme weather events, such as tropical cyclones and extreme rainfall; and those associated with gradual effects, such as sea-level rise and temperature changes (Wilbanks et al., 2007). Two of the main conclusions from AR4 are that 1) extreme weather events are more likely to cause negative impacts on industry, settlement and society than gradual climate change; 2) vulnerabilities to climate change depend on geographic, sectoral and social characteristics. The following subsections focus on studies that address climate change impacts in the EU specifically from both extremes and gradual changes.

Extreme weather events and their impacts to cities and infrastructure in Europe

Heat-waves

During the heat wave that hit Europe in 2003, up to 70.000 persons were estimated having died across Europe (EEA, 2012b). During the heat wave, often elderly or persons with cardio-vascular problems with a significantly higher share of women died because of the prolonged period of high day and night temperatures (Robine et al., 2008). The phenomenon was particularly intense in urban areas where temperatures, especially night time temperatures, can exceed those in the countryside by even 10 degrees. The main reason for the effect lies in the modification of patterns of radiation and evapo-transpiration in built up areas. Thresholds for high temperatures, which denotes a thermal discomfort index that combines air temperature and humidity (Baccini et al., 2008), are varying between different climatic areas of Europe (see Table 4 below).

Table 4 Thresholds for high temperatures in European cities

Athens	32.7°C	**Ljubljana**	21.5°C	**Rome**	30.3°C
Barcelona	22.4°C	**London**	23.9°C	**Stockholm**	21.7°C
Budapest	22.8°C	**Milan**	31.8°C	**Turin**	27.0°C
Dublin	23.9°C	**Paris 24.1**	24.1°C	**Valencia**	28.2°C
Helsinki	23.6°C	**Prague**	22.0°C	**Zurich**	21.8°C

Source: EEA (2012) p.20

The European Environment Agency (EEA) provides an interactive map on the heat wave risks of European cities (EEA, 2012b). It contains historical data of past hot days (>35°C) and warm nights (>20°C) having occurred between 1961 and 1990 and projections of hot

[1] For details of the impacts and settlement types, see IPCC (2001), Table 7-1

days and warm nights between 2021 and 2050, and between 2071 and 2100[2]. Based on the map, the number of hot days and warm nights will increase significantly in Europe. Although the impacts in the past have been limited to some areas in Spain, France, Italy and Eastern Europe between 1961 and 1990, it will, in a future of a changed climate, affect most of the continental Europe except the peninsular Scandinavians Between 2071 and 2100 (see Figure 5).

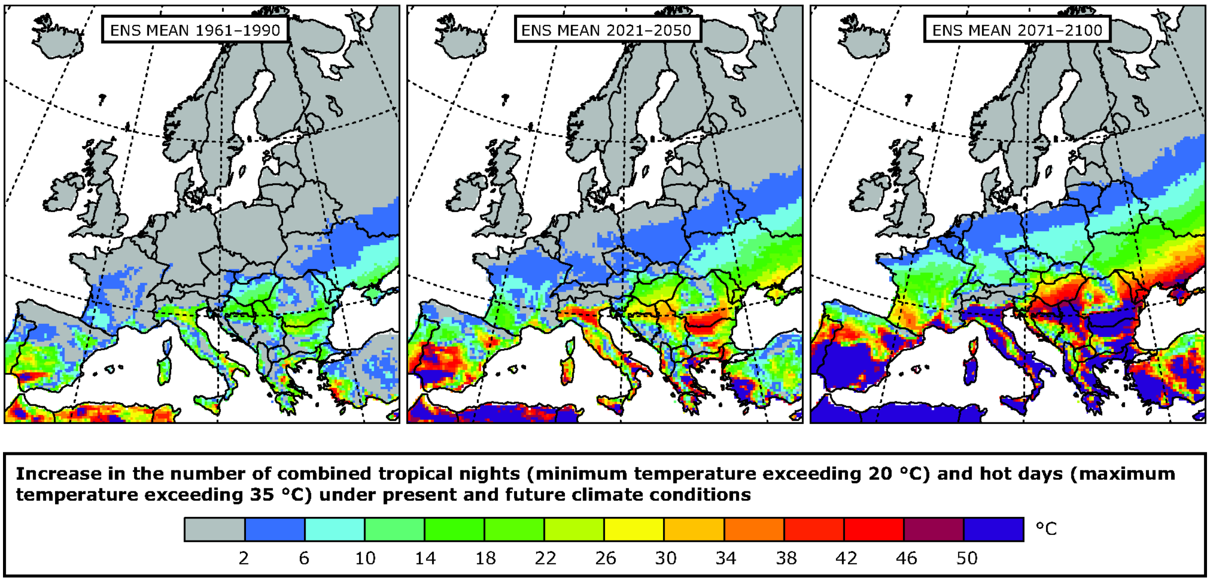


Figure 5 Number of hot days (>35 °C) and warm nights >20 °C in the EU

Source: EEA (2012b)

In London, one third of the summer time may have higher temperature than the current Met Office heat wave temperature threshold by 2050 (Hall et al., 2009). Currently, city such as Manchester and Stuttgart have adopted adaptation strategies to reduce the impacts of heat waves, which are most likely to induce health problem to the elderly, children and infirm (EEA, 2012b).

Extreme rainfalls and riverine flood

Extreme weather events are identified as a significant threat to the infrastructure of transport system, energy system and buildings. For example, 10% of total annual road maintenance costs in Europe, which amount to 0.9 billion euros, are associated with extreme weather events, such as extreme rainfalls and floods (Nemry and Demirel, 2012). The large and growing population in urban areas reduces the area available for flood management and expose the area to flood risks (Jongman et al., 2012, EEA, 2012b). Additional investments are needed to prevent thermal power generators from more frequent flood risks (Rademaekers et al., 2011). Flooding risk also has implications on urban planning policies on land use, construction materials, flood management, and so on.

[2] Details of the interactive map on heat wave risk of European cities can be found from http://eea.maps.arcgis.com/home/webmap/viewer.html?webmap=d4124af689f14cbd82b88b815ae81d76

Water scarcity and drought

One of the other major impacts of climate change is drought. In most of arid or semi-arid regions, precipitation in all seasons has decreased during the last century, which resulted in water supply shortage in these regions (Folland et al., 2001). Drought events have affected many parts of the Europe. For example, in 2003, droughts affected 100 million people, over one third of the EU territory (EC, 2007). Total economic costs reached 8.7 billion euros. It also affected large parts of southern, western and northern Europe in 2011 and 2012. It is projected that climate change is likely to worsen the impacts in the EU (EC, 2012).

Gradual climate change (slow onset change) and their impacts to cities and infrastructure in Europe

Gradual temperature increase

Further to the extreme events which are expected to become more intense and cause greater impacts in the future, also the change in mean climatic conditions may require changes in the way, cities are built and managed. For instance, projections show that the annual mean temperature in European countries is expected to rise between 2°C and 5°C by 2100 which could lead to more frequent heat waves in Europe (van Engelen et al., 2008). Temperate increase could also lead to health impacts, such as heat related death, and vector and waterborne diseases in Europe (EC, 2013a).

Sea-level rise

The rise of sea level is highly likely to impact coastal cities (Hanson et al., 2011). In Europe, A number of megacities are located near rivers and oceans for ease of transportation, such as Rotterdam. According to the World Bank (2010), 70% of the large cities in Europe are likely to be influenced by rising sea levels, which also could affect energy infrastructure, such as off-shore transmission lines and wind turbines (EC, 2013a).

Precipitation change

Precipitation patterns are likely to change that may result in drier summers and wetter winter in the EU. Increasing precipitation can lead to surface flooding in urban areas (Kaźmierczak and Cavan, 2011). Increasing precipitation combined with quicker melting of ice stored in mountainous areas can lead to increased river discharges and thus riverine flooding (Arnell and Gosling, 2013, Schneider et al., 2012).

2.5.3 The state-of-the-art approaches in recent adaptation studies

Cities and infrastructure are concentrations of economic, social and physical assets. It could cover a wide range of issues in climate change adaptation studies, such as coastal regions, flood risk management, energy and water system and so on. Thus, it is difficult to distinguish cities from these adaptation studies. Cities furthermore represent very specific combinations of vulnerabilities and adaptation options to be considered, thus attempts for global, continental or even national adaptation costs in urban areas would be confronted with a long series of assumptions and generalizations. The Climsave project (www.climsave.eu/climsave) includes in its integrated assessment platform a module dedicated to urban growth, which acts rather as a driver for future change (increase in sealed surfaces), rather than providing indications on adaptation needs for urban areas (Holman and Cojocaru, 2013). Research projects focussing on urban areas up to now mainly concentrated on options for increase in sustainability (BASE and SUME, addressing both urban metabolism, and thus, inter alia, urban heat island effects) or oriented to the policy tasks of vulnerability assessment and implementation of strategies increasing resilience as CORFU addressing urban flood risk, Harmonise, focussing resilience of infrastructure. Further to FP7 projects some conceptual approaches focussing on bottom up strategies have been described in recent adaptation studies. We review them briefly to identify possible inputs to the case studies in the BASE project.

Adaptation Tipping Point

The study by Kwadijk et al. (2010) on long-term water management planning in the Netherlands provides an assessment of adaptation measures in a bottom-up way. Unlike traditional top-down approaches which use climate scenario as the starting point, the authors use the concept of 'adaptation tipping points' (ATP), which examines the effectiveness of existing water management strategies in dealing with extreme weather events at the beginning, and then helps to identify the tipping point when alternative strategies are needed.

Adaptation Pathways

The idea of ATP is incorporated in the development of adaptation pathways approach (Haasnoot et al., 2011, Haasnoot et al., 2012b). Adaptation pathways is described as '*an analytical approach for exploring and sequencing a set of possible actions based on alternative external development over time'* (Haasnoot et al., 2013). The approach starts with a description of the current and future situations. Then it assesses problems associated with the situations and highlights actions can be used to deal with the problems. The concept of ATP is introduced to identify the thresholds that additional actions are needed. The authors highlight that the timing of the adaptation point, namely the sell-by date, is scenario dependent. In order to visualize the development of adaptation pathways, the adaptation pathways map are included in this approach. The adaptation pathways approach allows for adjustments and modifications of adaptation options with new information emerges over time. It takes into account the changes in the understanding of potential risks of climate change, changes in the tolerance level of people as well as other unforeseen factors to ensure the adaptation strategies are up-to-date or the perceived level of risks is acceptable.

Adaptive policymaking

Although the adaptation pathways approach is flexible with emerging information, it does not cover a monitoring system, which helps to examine the effectiveness of selected adaptation options. Kwakkel et al. (2010) develop an adaptive policymaking approach. A basic plan of adaptation is designed at the beginning. Then, vulnerabilities of the study area and opportunities associated with the adaptation options are examined to increase to robustness of the basic plan. A contingency plan is included in the policymaking process as well as a monitoring system to examine the effectiveness of adaptation options.

Dynamic adaptive policy pathways

Based on the concepts of adaptive policymaking and adaptation pathways, Haasnoot et al. (2013) introduce an approach to design a dynamic adaptive policy in supporting decision-making for water management in the Netherlands. In Figure 6 the steps in the approach are outlined.

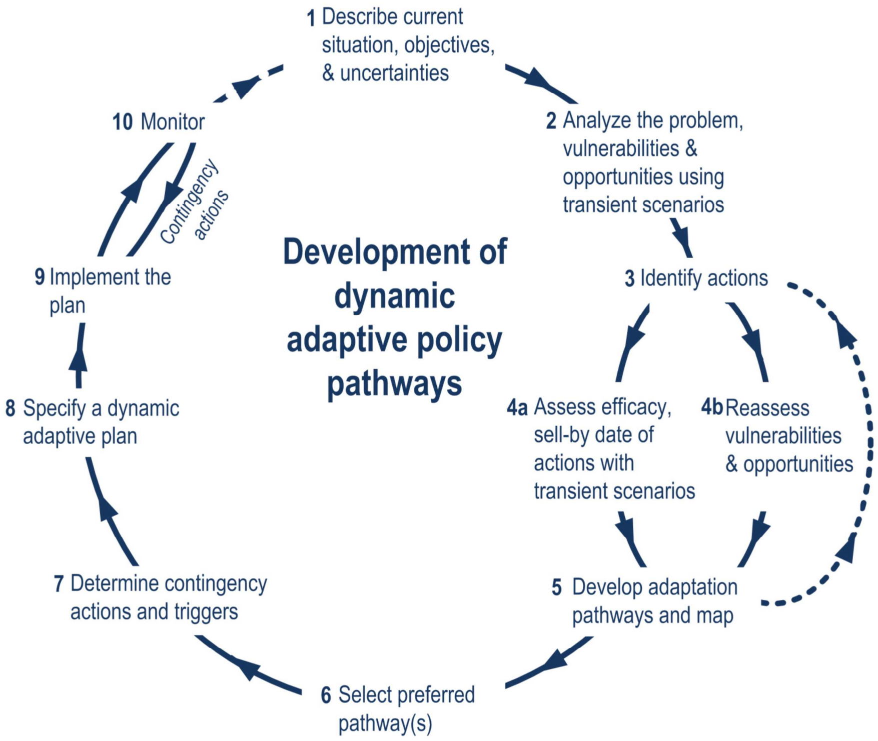


Figure 6 the Dynamic Adaptive Policy Pathways Approach

Source: Haasnoot et al. (2013) Figure 4

Discussion

Sustainability and adaptation research should be concerned with a wider and deeper understanding of changes throughout time and space. Adaptation research often resort to a methodology framework that is mostly concerned with either understanding or assessing what has been done or with future visions of communities and individuals (such as future workshops, scenario methods or back casting). A stronger focus on current and present challenges could help move forward effective adaptation strategies that inspire local communities because they represent opportunities for changing towards more attractive socio-ecological and socio-technical systems.

In examining climate change adaptation strategies, it is important to address issues such as the use of scenarios (transient scenarios vs. static scenarios), potential impacts valuation (direct impact vs. indirect impacts), uncertainty and coverage (the impact category, spatial and temporal factors). It is also important to identify the existence of thresholds, such as adaptive capacities of infrastructure (e.g. energy grids, urban drainage system). A monitoring system should be included to ensure the effectiveness of adaptation options. Besides, a component of visioning is also important, where society (at its own level) states where it wants to move forward, once adaptation could/should take advantage of this inner motivation as well as answering societies' expectations (including on what to do about climate change scenarios). Last but not least, a mapping of what society needs already today that could be integrated into the adaptation strategy, once some adaptation measures or even pathways can help answering or solving.

2.5.4 Selected case studies on cities and infrastructure

Case studies on specific sections

Sewer and storm water system

Olsson et al. (2013) analyse the sewer water system in response to extreme rainfalls in the city of Arvika in Sweden. The study begins with a projection of extreme short-term rainfall intensities due to climate change impact. Then it assesses the capacity of existing sewer and storm water system in dealing with both current and projected rainfall intensities. Two alternatives are considered in the research: system upgrade with and without climate change. The authors conclude that climate change may have a significant impact on the extreme short-term precipitation in Arvika, although the magnitude of impact has large uncertainty. Despite the additional costs, a system upgrade should take into account the climate change impact because of the long lifespan (50-100 years) of sewer and storm water system. A similar study is presented by Zhou et al. (2013) focusing on the city of Aarhus in Denmark with an extension of a cost-benefit analysis on the examined adaptive measures.

Flooding risk management

De Moel et al. (2013) assess flooding reduction measures in the unembanked area of Rotterdam, the Netherlands. The study focuses on damage reduction from sustainable spatial planning at building level. Several measures are considered in this study, including appropriate zoning functions, elevation of buildings or an area, and retrofit buildings with wet or dry waterproof. Land use and building datasets are used to determine the damage values on each type of building (e.g. damage of industrial and garden complex land use would cost 1,800 euros and 0.04 euros per square metre, respectively). The total damage values are evaluated based on the simulation of inundation depth maps for six different return periods. The study concludes that flooding damage to the unembanked area of Rotterdam can be substantial with an annual cost of EUR 36 million. Industrial land-use represents the largest share, which highlights the importance of appropriate zoning functions. Although adaptive measures are effective in dealing with flood risks, climate change impacts could double the risk by 2100. One of the drawbacks of this study is that the costs of different measures are not included.

Comprehensive study on specific cities

New York City

New York is considered as one of the pioneers in climate change adaptation at city level. Solecki (2012) reviews the development of climate change adaptation strategies in New York. First, a government agency - New York City Department of Environment Protection (NYC DEP) - launched an initiative in response to the potential risks associated with climate change on water system in New York in 2004. One of the missions of the initiative is to create the NYC DEP Climate Change Task Force. The Task Force has made a significant contribution on the production of the NYC DEP Climate Change Program Assessment and Action Plan, which highlighted the potential impacts of climate change and adaptation options for the water system in New York. The work is considered as a milestone and similar research is carried out by other government agencies soon after the NYC DEP. A comprehensive plan to develop a sustainable city, PlaNYC 2030, was released in 2007. The primary target in the PlaNYC was to set a target of reducing GHG emissions and further expanded to include climate change adaptation. An inter-agency task force was created in 2008 to identify the risks of climate change on the city's critical infrastructure. Regional authorities and private companies, which are responsible for the operation and maintenance of critical infrastructure, are included in the task force. A group of experts (such as university scholars, private sector experts, legal and insurance experts) are invited to form the New York City Panel on Climate Change (NPCC), which provide knowledge and technical support to the task force. The core component of the NPCC's work is to assess the climate change impacts on infrastructure such as energy, water and communications, examine the effectiveness of current policy in dealing with future climate change impact and highlight adaptation options.

One of the most comprehensive assessments on regional adaptation strategies was undertaken by Rosenzweig and colleagues for New York (Rosenzweig et al., 2011). The study used case studies to identify climate risks, vulnerability, adaptation strategies for eight sector, including water resources, coastal areas, ecosystems, agriculture, energy, transportation, telecommunications, and public health. The analysis investigated potential damages associated with climate change impacts and costs of adaptation strategies for each of the eight sectors using cost-benefits analysis. The authors concluded that without adaptation, total economic costs associated with climate change impacts in the eight sectors would reach $10 billion annually by 2050s. It can be reduced significantly if adaptation efforts are taken. At sector level, the economic losses without adaptation and costs and benefits of adaptation are listed in Table 5.

Table 5 Estimated costs and benefits of adaptation in eight sectors in 2050s

Sector	Component	Cost of annual incremental climate change impacts at mid-century for selected components, without climate change ($million)	Costs and benefits of annual incremental climate change adaptation at mid-century for selected components($million)
Water Resources	Flooding at Coastal Wastewater Treatment	116 - 203	Costs: 47 Benefits: 186
Coastal Zones	Insured losses	44 – 77	Costs: 29 Benefits: 116
Ecosystems	Recreation, tourism, and ecosystem service losses	375 – 525	Costs: 32 Benefits: 127
Agriculture	Dairy and crop losses	140 – 289	Costs: 78 Benefits: 347
Energy	Outages	36 - 73	Costs: 19 Benefits: 347
Transportation	Damage from 100 year storm	100 – 170	Costs: 290 Benefits:1,160

Communications	Damage from 100 year storm	15 – 30	Costs: 12 Benefits: 47
Public Health	Heat mortality and asthma hospitalization	2,290 – 6,100	Costs: 6 Benefits: 1,640

Source: Adapted from Rosenzweig et al. (2011) Annex III, Table 1.1

London

Hall et al. (2009) developed an Urban Integrated Assessment Facility (UIAF) to simulate climate, land use as well as socioeconomic changes in London. The study begins with an introduction of the challenges that London is facing and focuses on a wide variety of drivers can shape the future of cities, including demographic, economic, land use, technical and behavioural changes alongside climate change. Scenarios at global and national level are used to simulate the socioeconomic change, which are then used as inputs to model changes in regional economy and land use. The simulation results are used to project the climate change impacts, such as flooding, heat waves, and droughts in London up to the 2100s. It is concluded that '*no single policy will enable cities to grow whilst reducing emissions and vulnerability to climate change impacts – a portfolio of measures is required'.* Furthermore, the Environment Agency initiated Thames Estuary (TE) 2100 project (Environment Agency, 2012). The project aims to develop a long-term flood risk management plan for London and the Thames estuary up to 2100. A key feature of this project is that it is flexible to the changes in the adaptive capacity (financial and technical capability), the uncertainty in future climate projections and the varying socioeconomic scenarios over the next hundred years. Cost-benefit analysis was used to evaluate flood management options, including improvement of the existing flood defence system, flood storage and the installation of barriers.

Cape Town

Mukheibir and Ziervogel (2007) present a methodology for developing a local municipal adaptation plan (MAP) on the example of city of Cape Town that is at risk from projected climate-induced warming and changes in precipitation variability. The authors present a ten-step process for development of an integrated climate change adaptation plan (Figure 7) and emphasize that the procedure should be complemented by two cross-cutting processes: i) stakeholder engagement and ii) adaptive capacity assessment. Example of vulnerability (current and future) to climate change for the city of Cape Town is provided, based on a desktop assessment of existing reports. Actions and possible interventions for the most important sectors - urban water supplies, storm waters, fires and coastal zones are suggested. Low local human capacity and limited knowledge and understanding of climate issues at local and municipal level are according to the authors the main potential barriers that hamper the implementation of a municipal adaptation plan.

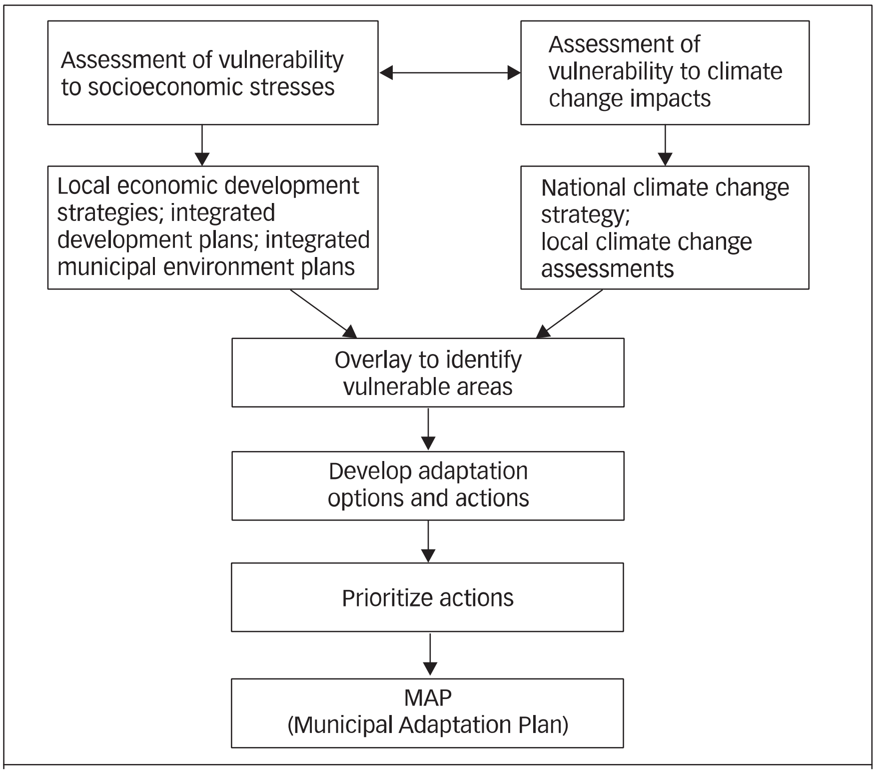


Figure 7 Process for developing a Municipal Adaptation Plan

Source: Adapted from Mukheibir and Ziervogel (2007)

Reflections on cities and infrastructure case studies

Climate change adaptation studies on cities and infrastructure should start with a description of the investigated area, such as demographic, socioeconomic factors, which could provide illustration of the background information of case study areas. It is also important to select an impact category. As addressed in the IPCC AR4, vulnerabilities to climate change depend on geographic, sectoral and social characteristics. Understanding the historical trend and future projections are key issues to the success of climate change adaptation strategies. However, static projections are not flexible in dealing with changes in the future. Thus, It is important to include dynamic aspects in the projection (such as transient scenarios, reflections and reassessments), which could include new information when future unfolds. A monitoring process needs to be included to examine the effectiveness of adaptation strategy. Last but not least, from an economic perspective, adaptation strategies need to be evaluated in terms of adaptation cost and avoided damages resulting from adaptation, regardless of the approaches selected (top-down approach or bottom-up approach). Cost-benefit analysis is one of most popular tools to estimate expenditures and economic losses associated with climate change impact. Table 5 in this review (from the New York case) provides an example of the expected results from cost-benefit analysis in the BASE case studies.

2.5.5 Where can/will the cities and infrastructure case studies of BASE make important contributions

In BASE, there are case studies on cities and infrastructure in Prague, Leeds, Cascais, Rotterdam, Jena, Venice, Copenhagen and Madrid. In general, the case studies will contribute to the BASE by

- Providing overviews on adaptation strategies to manage climate change impacts such as flooding and heat waves at specific city.
- Providing in-depth analysis on future impacts of climate change on cities and infrastructure.
- Designing modelling framework (based on the input-output anlaysis) to evaluate direct and indirect effects of adaptation measures.

In order to allow comparability and consistency across the analysis performed by case studies, all cities and infrastructure case studies need to answer four overarching research questions:

1. What are the main drivers and triggers of adaptation and of adaptation strategy?
2. Which adaptation options and pathways are considered and assessed?
3. What are the costs and benefits of adaptation?
4. How and what adaptive actions are implemented and what are the main drivers of implementation?

The next session gives brief introductions of each case study.

Prague case study

The case study focuses on improving flood risk management in Prague and on promoting more adaptive approaches that take into account full range of possible flood protection measures. The main aim of the research is 1) to evaluate the adaptive capacity of the city to floods and analyse the process of adaptation in relevant sectors; 2) evaluate current adaptation measures and together with stakeholders develop potential measures that will better cope with future uncertainty. Main research questions are as follows: Is Prague resilient towards flooding? What is the adaptive capacity of city and how it can be improved? What are possible future adaptation scenarios and pathways, what are their costs and benefits? What are the attitudes of different stakeholders to particular measures? The research will be carried out through participatory methods (participatory add-ons to Adaptation Pathways) and the potential adaptation measures will be assessed through Multi-Criteria Analysis or Cost Benefit Analysis. The case study will compile new information on process of climate change adaptation in the Eastern European country and identify main bottlenecks in this process that can be afterwards compared with other urban BASE studies.

Leeds case study

The case study aims to develop and rigorously evaluate adaptation strategies for managing urban flood risk in the Leeds city region. Research questions of Leeds case study are: what are the existing adaptive measures in urban flooding management in Leeds? What are the future impacts of flooding to the Leeds city region? How to improve existing adaptive measures of flood management in the future? What are the costs and benefits of existing/improved adaptive measures? The case study will evaluate the direct impacts of flooding events such as building damage and its knock-on effects through supply chains. A combination of input-output analysis and cost-benefit analysis will be used to examine various flood risk management options. The case study will contribute to the BASE project by designing a new modelling approach to assess the macroeconomic effects of climate change adaptation measures, which will be used in the Rotterdam case study for comparison The modelling framework could provide quantitative evidence in the selection of adaptive measures in the future.

Cascais case study

The case study aims to review existing literature according to the new IPCC climate and socio-economic scenarios and to monitor and evaluate adaptation measures focusing on the impacts of floods and heat waves in Cascais. Key research questions are: what could determine the adaptive capacity (and vulnerability) in the case study? How successful are the cases in advancing adaptation (adaptive capacity)? Which factors should we pay attention to in efforts to increase adaptive capacity? How to create fruitful interaction between top-down and bottom-up processes in cities adapting to climate change? Where should the focus be in developing sustainable adaptive communities? How can climate change adaptation be streamlined into decision making in the health sector? How are climate change impacts perceived by the public? How can communication and decision processes on mitigation and adaptation be developed to become more transparent and legitimate? The case study will use participatory session with different stakeholders based on Visioning, back casting and 'Community Mapping' tools in the assessment stage. It also includes monitoring and participatory session during the planning period for adaptation measures. Cost and benefit analysis will be used in evaluating adaptation measures.

Rotterdam case study

The focus of this case study is to give an integrated perspective on both planned and autonomous adaptation in the city of Rotterdam, combining as much types of impacts as possible, with a main focus on water (flooding and drought) and heat. The study aims at creating pathways for adaptation measures, assess costs and benefits for these measures and seek for combinations and synergies between these measures to efficiently deal with future uncertainty in urban planning (based on the concept of Adaptive Delta Management). We also aim at understanding cascading effects of adaptation measures and increased resilience at the Rotterdam city level on the regional and national economy. The research will be carried out by distilling data already available and building an overarching database for the metropolitan region of Rotterdam. Based on several research programs into specific domains (heat, surface flooding, resilience of urban landscapes, river and marine flooding, etc.) this is integrated for an urban perspective. Additional data collection by means of interviews, and additional (input-output) modelling will be executed in close collaboration with local stakeholders. Analysis of this data in both quantitative (e.g. cost benefit analysis, i/o modelling) and qualitative ways gives an integrated perspective on main adaptation impacts for the most important (urban) sectors; relations between the impacts and sectors; the cascading effects of adaptation into the region; and the costs and benefits of mainstreaming adaptation.

Jena case study

The analysis of the Jena case study which is carried out by the Helmholtz Centre for Environmental Research GmbH - UFZ is twofold. On one hand it is retrospective as it reflects the development of the urban adaptation strategy by focusing on various aspects. This includes inter alia drivers and barriers of the process, data requirements, use of decision support tools, the identification and coordination of key actors across different scales and problem solving strategies which have been pursued. On the other hand the UFZ team is supporting the on-going adaptation activities as well as reflecting on them. UFZ is involved in the implementation process by carrying out comparative economic assessments of potential measures to facilitate the prioritization of these adaptation options by the decision makers. This direct support not only assists the local actors but also fosters the further development of a multi-criteria decision support system for climate adaptation PRIMATE which is been used by UFZ. The analysis of the implementation of the strategy evaluates the progress which has been made so far and depicts best practice solutions for fostering the acceptance by and involvement of key stakeholders.

Venice case study

The case study aims at quantifying efforts undertaken by private and public actors to adapt their premises and urban structures (pavement levels) and services (alert systems and emergency services) to increasing sea levels in the historic centre of Venice. A particular aspect to be potentially explored is the relationship between public investments (raising pavement levels) and private investments (raising ground floor levels). The case study will use quantitative information on physical transformation for the estimation of private investments (types of adaptation measures implemented) and on public investments (public expenditure). Damages will be calculated using damage function for buildings on the base of expert judgements and on existing valuation studies with regards to the usability of public spaces. The cost benefit relation between public and private investments in adaptation and damages will be assessed. The analysis will be based on evidence (survey material) on the structure and levels above tidal datum for ground floor units, and the protection measures put into place on the one side and calculations of damages and avoided damages due to protection measures. This case study will provide analysis and description of an on-going process of adaptation in an urban context.

Copenhagen case study

The Copenhagen case centres on dynamics and drivers of climate adptation decision making and the actual decision it-self, i.e. Copenhagen is a case of strategic adaptation to impacts of climate change of authorities in a metropolitan area. The aim of the case study is to investigate the drivers of adaptation strategies of Copenhagen, with a specific focus on a) level of participation in decision making processes; and 2) the adaptive capacity of the city governance.

The study addresses the overall question of which drivers have promoted adaptation to climate change in Copenhagen? Specifically, the study respond to the key questions of what is the adaptive approach in Copenhagen, i.e. what has promoted the development of adaptation as a strategy and which measures, tools and procedures are included and linked to the overall development of the urban area? How does the city integrate different social actors, including citizens, experts and stakeholders, in developing responses to climate changes, in particular how can participation be enhanced. The case study will focus on strategic initiatives within the sectors of flooding, green infrastructure/urban nature which according to pilot investigations in Copenhagen are the most pressing climate impacts to be managed, and be developed in close collaboration with stakeholders. The study will apply mainly qualitative methods, including policy document analysis, in-depth interviews, participant observation and action research.

Besides the overall adaptation planning in the form of Copenhagen’s adaptation strategy, two specific climate adaptation strategies are currently being investigated as part of the same Copenhagen case study. Namely the cloud burst management strategy and the storm surge strategy. Whereas the former is already formulated, but still in the process of being implemented, the latter is under development, where the Danish Board of Technology are taking part of this process.

Mardrid case study

The case study aims to explore adaptation strategies to climate change in the Madrid region in sectors in which water plays an important role. The study analyzes impacts on water resources taking into account changes in global and local climate, stress over systems and induced effects over different sectors. Adaptation measures will be explored with the help of a selected group of stakeholders though a series of different research actions such as focus groups, expert meetings, and surveys. Further analysis will include quantitative and qualitative economic evaluation for the different adaptation actions identified.The case will contribute to the BASE project by providing an integrated perspective of adaptation measures in water related sector with an urban perspective.

2.6 Adaptation, biodiversity and ecosystem services

By: David Vačkář (CZEG), Zuzana Harmáčková (CZEG), Eliška Lorencová (CZEG), Blanka Loučková (CZEG), André Vizinho (FFCUL)

2.6.1 Introduction

The aim of this section is to bring a review of climate change adaptation approaches related to biodiversity and ecosystem services. While biodiversity and ecosystem services cover broad area closely associated also with agriculture, forestry or water management, we are focusing on the question what is the state of the art in the area of nature-based adaptation measures from the perspective of climate change impacts on ecosystem services and biodiversity. The related topic is how to analyse ecosystem-based adaptation measures designed to provide multiple benefits for both nature and society.

2.6.2 Biodiversity, ecosystem services and climate change adaptation

People obtain valuable services and benefits from the natural environment. These include provisioning services, such as food, biofuel and water; regulating services, such as climate regulation, natural hazard mitigation, erosion control and water purification; and cultural services, such as recreational, aesthetic and other nonmaterial benefits. Approximately 60% of all ecosystem services are being degraded or used unsustainably (MA, 2005). The increasing demand for economic goods and services supported by shrinking ecosystems and predicted climate change manifested by the increase in frequency of extreme events and climate-related disasters, such as floods, fires and droughts, will probably lead to the increasing pressures on natural ecosystems and services derived from them.

Climate change presents one of the most important drivers influencing natural ecosystems and biodiversity (IPCC, 2007b). Despite many remaining uncertainties (Parmesan and Yohe, 2003), the ecological impacts of climate change are observable in all types of environments, ranging from polar to tropical and from terrestrial to marine ecosystems, and on various scales (Walther et al., 2002). There are available several extensive assessments and reviews of climate change impacts on biodiversity and ecosystem services (see for example Campbell et al. (2009) and Staudinger et al. (2012)).

The issues of climate change adaptation and ecosystem services have been addressed only recently (Boyd, 2010, Jones et al., 2012, Munang et al., 2013b, Munang et al., 2013a). The sustainable management of ecosystems and the maintenance of ecosystem resilience are supposed to provide cost-effective alternatives to technologically based measures. Especially regulating ecosystem services have been recognized as critically important for climate change mitigation and disaster risk reduction (Munang et al., 2013a). As our abilities to quantify, value, map and model ecosystem services is relatively rapidly improving (Kareiva et al., 2011), this brings novel opportunities for envisioning future ecosystem services trade-offs in the light of climate change and climate change adaptation.

Ecosystem-based approaches to adaptation have been recently put forward as a useful approach to buffering the impacts of climate change while sustaining ecosystems and biodiversity (Jones et al., 2012). Three scales of adaptation to global changes have been recognized - global, intermediate (the level of ecosystems) and local (the scale of individual populations and species). Biodiversity has been recognized as an indispensable component supporting the delivery of ecosystem services. The diversity of service-providing units gives basis for the stability of ecosystem service supply and leads to an ecological insurance, including insurance to climate change impacts. Biodiversity has been proposed as an important factor controlling resilience, resistance and performance of ecosystems (Mooney et al., 2009, Proença and Pereira, 2013). Therefore, biodiversity conservation and ecosystem-based restoration has been suggested as cost-effective measures of adaptation to climate change.

2.6.3 State-of-the-art approaches: Valuation of climate change impacts on ecosystem services and biodiversity

Although literature on ecosystem service assessments and valuations is rapidly expanding, these studies usually do not address valuation of climate change impacts and adaptation measures on the ecosystem services and biodiversity. The studies of climate change effects can be differentiated according to the climate change aspect they address into 3 major groups:

1. Valuation studies of climate change impacts on ecosystem services and biodiversity;
2. Studies valuing the impacts of mitigation on ecosystems and biodiversity;
3. Studies assessing and valuing impacts of adaptation on ecosystem services and biodiversity.

In following sections, we review illustrative examples of particular studies.

Impacts of climate change on ecosystem services and biodiversity

An example of integrated study of climate change impacts on ecosystem services and biodiversity is the California assessment (Shaw et al., 2009). In this quantitative study, the climate change impacts on different ecosystem services and their economic value have been modelled. The study is linking climate change to ecosystem function, production, and resilience and analyses how changes in ecosystems can affect the economic wellbeing and the creation of economic activity (Shaw et al., 2009). Ecosystem services assessed include carbon sequestration, forage production, water use, snow recreation, salmon fisheries and biodiversity change. Besides the biodiversity change, study is also economically valuing the climate change impacts on ecosystem services.

Climate change impacts include direct market impacts on provisioning ecosystem services. An example is explicit assessment of climate-driven impacts on the profits of cattle ranching in California. Under a variety of scenarios, the climate change could result in economic losses to the cattle industry of between 14 million USD and 191 million USD by year 2035 and between 22 million USD and 312 million USD for the period 2070–2099. Other examples of direct market impacts related to ecosystems include snow skiing and the recreational and commercial harvest of salmon.

In addition to direct market impacts, climate change will incur non-market costs. These include the social cost of carbon emissions and recreational services related to skiing and angling. The study estimate that the non-market value associated with snow skiing could exceed 174 million USD annually and that of recreational salmon angling could reach 20 million USD each year (Shaw et al., 2009).

Concerning the social cost of global climate regulation/carbon sequestration ecosystem service, models predict that California terrestrial ecosystems could increase in their carbon sequestering capabilities and could generate additional value to the world's economy of over to 300 million USD annually in the near future and as much as 18 billion USD annually by 2070. Other models of climate change, however, are predicting negative social costs from climate change of -650 million USD to more than -5 billion USD annually for the period 2005–2034 to as high as -62 billion USD annually by the period 2070–2099.

A smaller-scale case study was conducted by Feagin et al. (2010), who simulated the impacts of climate-change induced sea level rise on the migration of coastal salt marsh ecosystems towards higher elevation. Subsequently, the economic value of ecosystem services and the value of private property lost by sea level rise were calculated, including recreational value, carbon sequestration and storm protection. Sea level rise (according to three IPCC scenarios for 2095) resulted in both positive and negative development of marsh area and the levels of related ecosystem services; however, the impact on private property area was always negative. Therefore, the total financial benefit of low-rise scenario was 890,000 USD/year, while for the high-rise scenario, total financial loss reached almost -440,000 USD/year.

Another case study by Grêt-Regamey et al. (2008) from Swiss Alps introduced a GIS-based modelling approach to assess additional value of ecosystem services (habitat services, avalanche protection) provided under a climate change scenario, supposing a rise in temperatures of 2.4 °C by 2050. Since the increasing temperatures resulted in densification and expansion of the forest cover at higher altitudes, the values of all ecosystem services grew by 45,300-111,700 CHF for habitat services and by 8,034,700-16,159,000 CHF for avalanche protection in comparison with 2000. These assets were considerably higher than estimated costs of forest maintenance (140,000 CHF).

By using GIS-based benefit transfer techniques, Brander et al. (2012) assessed the total economic value of European wetlands lost as a consequence of climate change at more than 1 billion USD/year between 2000-2050. The values of ecosystem services provided by wetlands were derived from observations carried out in the US and Europe and their site-specificity was determined by spatial variables on wetland size and abundance, GDP per capita and population in the proximity of wetlands. The study covered number of ecosystem services, e.g. flood control, groundwater supply, water quality improvement, hunting and fishing, recreation, or habitat services.

Impacts of climate mitigation on ecosystems and biodiversity

Carlsson et al. (2010) designed a multi-country contingent valuation survey with the aim to detect a willingness to pay for mitigating impacts from increasing CO_2 emissions. The effects described to respondents included reduction of harvest, increased flooding and storms and increasing threat to ecosystems and species. Therefore, the WTP to reduce emissions by 30%, 60% and 85% can be interpreted as WTP to mitigate climate change impacts from increasing emissions. The average WTP (in PPP US Dollars) for three alternatives was in the range 21.70 – 54.24 in Sweden, 17.27 – 36.43 in the US and 4.99 – 11.18 in China, with the share of income between 0.004-0.016.

Another approach has been demonstrated by Riera et al. (2007) who analysed willingness to pay for mitigating impacts of climate change on Mediterranean shrublands. They designed a contingent valuation survey consisting of several alternatives including ecosystem attributes (plant cover, fire risk, soil erosion) at different level of impact. Common aspect of mitigation measures is the carbon stored in ecosystems. Ding et al. (2011) estimated the economic value of carbon stored in European ecosystems according to IPCC scenarios. Rajmis et al. (2009) designed a choice experiment to value carbon sequestered by forest ecosystem based on afforestation and subsequent additional carbon sequestration. Results showed that mean willingness to pay for additional tonne of carbon sequestered was 7.34 EUR yr^{-1} t C^{-1}.

Impacts of climate adaptation measures on ecosystem services

In their recent study, Verburg et al. (2012) examined the impact of climate change adaptation measures aimed at flood risk reduction on the provision of ecosystem services. Since many climate change adaptation measures are related to changes in land use, the authors used a series of models to estimate the impact of such land-use-based measures on flood risk, carbon sequestration, habitat connectivity and biodiversity. Analyses were performed for two scenarios, "business as usual" and "alternative policy" scenario, which took a wide range of potential measures aimed at adaptation and flood risk regulation into account. The results showed that although the impact of adaptation activities on the provision of ecosystem services was positive at the location where they were implemented, considerable trade-offs occurred in more distant areas as a consequence. In conclusion, adaptation measures may have both positive and negative effect on ecosystem services and cause number of trade-offs when examined on larger spatial scales; therefore, an evaluation of potential impacts should precede the implementation of land-use-based climate change adaptations.

An example of ecosystem service or value, which is only scarcely accounted in adaptation studies, is the insurance value of ecosystems. This framework follows the experimental research on biodiversity and ecosystem functioning (BEF) which brings an evidence that more divers ecosystems buffer environmental disturbances and therefore can provide more stable delivery of ecosystem services in longer time periods (Naeem et al., 2009) A choice experiment was conducted by Rajmis et al. (2009) in Hainich National Park, Germany, to estimate willingness to pay for climate change adaptation. Climate change adaptation measures consisted of increasing forest resistance and resilience to pests and storms. Values obtained for adaptation measures were 27.54 EUR yr^{-1} for insect pests and storms and 16.83 EUR yr^{-1} for overall forest resilience to environmental stressors.

An example of a sectoral adaptation strategy for biodiversity is the BioAdaPT project (Portugese Climate Change Adaptation Strategy for Biodiversity) carried out by the Centre for Climate Change Impacts Adaptation and Modelling and the National Biodiversity Institute. The main aim of this project (2012-2013) is to collect data and information on vulnerability of biodiversity toward changing climate and altogether with experts and stakeholders develop specific adaptation measures and strategies.

2.6.4 Costs and Benefits of ecosystem-based adaptations

The global cost of adaptation has been estimated in the range 49 – 171 billion USD annually (Jones et al., 2012) The only estimate of the value of global ecosystem services is an order of magnitude higher, reaching 16 -54 trillion USD per year (Costanza et al., 1997). The investments into adaptation of natural ecosystems are estimated at 12 – 22 billion USD (Parry et al., 2009), forming 12 – 25% of global adaptation costs. However, these estimates do not reflect the full costs of EBA and are probably underestimated. Values and benefits associated with ecosystem services have been recently synthesised in a global ecosystem service valuation database associated with the Ecosystem Services Partnership platform (de Groot et al., 2012). Nevertheless, the cost of adaptation to climate change is likely to vary among countries significantly and the global assessments of costs may be misleading (Lange et al., 2010).

Concerning individual EBA projects, the overall assessments of costs and benefits are scarce. Even in the cases when cost-benefit analysis is available, the benefits are largely expressed only in qualitative terms (e.g. habitat protection, recreational opportunities etc.). This indicates that detailed valuation studies at the project level are needed. On the other hand, current evidence indicates that majority of projects using EBA seem to be beneficial from the economic point of view, provided that their long-term social and ecological benefits are taken into consideration. EBA are considered to be more cost-effective than traditional engineered approaches in this respect (IPCC, 2007b).

Generally, the costs of implementing EBA can be divided into two classes comprising financial and opportunity costs. While financial costs represent the value of resources deployed in the development of EBA components, including the costs of labour, materials, energy, etc., the opportunity costs are defined as the value of economic opportunities foregone as a result of EBA, e.g. foregone development, restrictions in resource use and loss of economically utilizable land. Within the financial costs, one-off costs and recurrent costs undertaken to implement certain EBA measure can be distinguished. The one-off costs are necessary e.g. to establish management bodies, conduct surveys and research, or purchase land intended for ecosystem restoration. The recurrent costs are required to run the administrative bodies, maintain and restore ecosystems, monitor the changes of ecosystems, etc. The benefit side of EBA projects comprises primary and secondary benefits. Primary benefits usually include environmental enhancements in the form of ecosystem services provision, e.g. enhanced carbon storage, habitat creation and water purification and regulation. Secondary benefits are perceived as socio-economic, e.g. effects on employment and tourism opportunities, quality of life and health improvements (Lange et al., 2010). Moreover, EBA can bring economic, social and environmental co-benefits that are both marketable (e.g. livestock and fish production) and non-marketable (cultural preservation, biodiversity maintenance) ecosystem services (Jones et al., 2012).

Although comparing the costs and benefits of EBA to engineered adaptation approaches (e.g. the construction of traditional flood prevention systems) is difficult, the evidence based on several European case studies shows that the costs of EBA are not necessarily higher than in the case of traditional approaches. Moreover, the additional ecological and socio-economic benefits are likely to outweigh the benefits of traditional adaptation measures (Naumann et al., 2011). However, there is a need for novel studies as the literature on valuation of ecosystem services and biodiversity is not always directly applicable to climate change adaptation (Krupnick and Mclaughlin, 2012).

2.6.5 Ecosystem-based adaptation approaches and examples

Considering the overall impact of climate change on ecosystems, biodiversity and human society, effort to reduce the risk of adverse environmental outcomes by developing adaptation strategies and measures has become a matter of great concern among both researchers and policy-makers recently (Campbell et al., 2009). Both developed and less-developed countries have embarked on decreasing their vulnerability towards changing climatic conditions through activities ranging from institutional and regulatory measures to technical improvements (Smit and Wandel, 2006, IPCC, 2007b). However, the efficiency of many of these actions remains unclear, demanding future research and discovering new adaptation options (Ford et al., 2011).

A promising group of feasible adaptation solutions is represented by Ecosystem-based Adaptation (EBA), defined as “the use of biodiversity and ecosystem services as the part of an overall adaptation strategy against the adverse effects of climate change” (Doswald and Osti, 2011). Although current adaptation strategies tend to focus on technical, structural, social and economic developments, ecosystems and biodiversity can play a significant role in societal adaptation to climate change. Although ecosystems and biodiversity are threatened by climate change, they pose an option to adapt at the same time, as they provide a wide range of services decreasing the climatic impact, e.g. carbon sequestration, flood protection and the prevention of soil erosion (Campbell et al., 2009).

EBA has been proposed as a “natural” solution to adaptation to climate change (Jones et al., 2012) and is supposed to enhance the adaptation capacity of human society through the sustainable management and restoration of ecosystem services, while providing multiple benefits to human society. EBA surpasses other adaptation approaches by delivering multiple co-benefits and avoiding maladaptation (Munang et al., 2013b). The examples of EBA measures with related benefits are given in Table 6. Other examples of EBA actions include alien species management and enhancing genetic diversity (USGCRP, 2008, Naumann et al., 2011).

Table 6 Benefits resulting from EBA

Ecosystem-based Adaptation	**Benefits**
Restoring fragmented or degraded natural areas	Enhances critical ecosystem services, such as water flow or food and fisheries provision
Protected groundwater recharge zones or restoration of floodplains	Secures water resources so that entire communities can cope with drought and flooding
Connecting expanses of forests, grasslands, reefs or other habitats	Enables people and biodiversity to move better to more viable habitats as the climate changes
Protecting or restoring natural infrastructure such as barrier beaches, mangroves, coral reefs and forests	Buffers human communities from natural hazards, erosion and flooding

Source: Sandwith and Suarez (2009)

The overarching aim of EBA is to enhance the ecosystem resilience to climate change. In this connection, there is an array of adaptation approaches, which may form the basis for successful adaptation measures. First, management should focus on key ecosystem features, e.g. structural characteristics, organisms or areas, to secure the stability of the whole ecosystem. Second, the reduction of localized anthropogenic stresses, such as pollution or fragmentation, is important to minimize potential synergies between these stressors and climate change. Third, the variety of species and ecosystems should be preserved in a number sufficient for restoration, following future disturbances. Fourth, the availability of refugia, defined as areas less affected by climate change, is vital to provide recovery destinations for climate-sensitive species. Finally, a human-facilitated relocation of organisms to bypass barriers may be necessary to prevent isolation of populations (USGCRP, 2008).

In order to ensure the success of EBA, it proves essential to precede the implementation of EBA activities by estimating current baselines, identifying change thresholds and modelling the range of possible climate change impacts and system responses, together with assessing the level of uncertainty assigned to various future impacts of selected measures. The implementation of EBA measures should be followed by monitoring and evaluation of the changes. The success of EBA is also conditioned by collaboration among ecosystem managers and organisations, which is necessary in order to broaden the spatial and ecological scope of potential adaptation measures and to enhance research capacities (USGCRP, 2008).

Regarding experience gained during realized EBA projects, a number of case studies conducted in several European countries were examined in a study by Doswald and Osti (2011). In total, the dataset contained 49 EBA case studies, 33 % of which were coming from the United Kingdom. The aim of the study was to analyse the good practice examples of EBA and the experience gained, which are summarized in Figure 8. In addition, the authors emphasize the importance of stakeholder engagement and communication, which prevents the projects from being disapproved or made impossible by the public or local organisations.

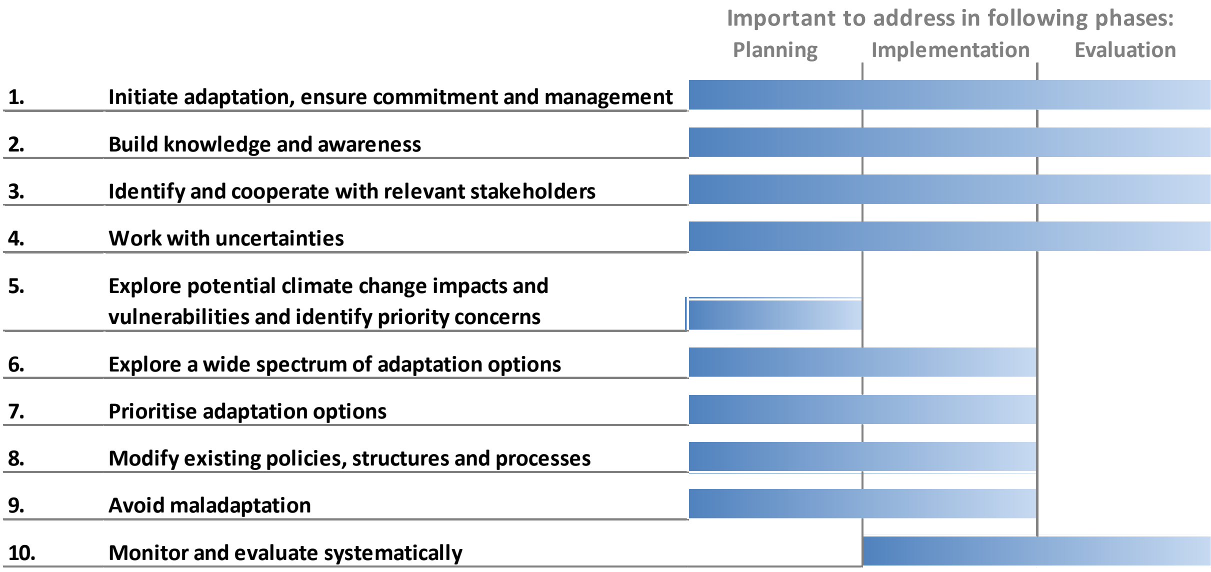


Figure 8: List of guiding principles in context with the stages of the adaptation process
Source: (Prutsch et al., 2010)

The key problem common to most of the studies lied in the fact that most of the case studies did not provide any evidence of how effective the activities have been in terms of adaptation, which made the evaluation of the projects' results impossible (Doswald and Osti, 2011). One of the scarce examples of modelling the effects of EBA on ecosystem services is given in (Verburg et al., 2012), where the authors combined dynamic and indicator models to calculate the effects of flood-related adaptation policies on selected ecosystem services.

Despite the lack of evidence for the results of EBA projects, the assessment of socio-economic impacts of adaptation measures is essential to enhance the information basis for future adaptation activities. Communicating the efficiency of EBA measures in financial terms is also necessary for most ecosystem managers and decision-makers. Therefore, future economic assessments of EBA efficiency are required as a means of advocating the future use of ecosystem-based approaches, while cost-benefit analysis seems to be one of the most suitable options (IPCC, 2007b).

Green Roof case study: InVEST modelling tools

One of the main aims of the “Green Roof” case study is to propose several adaptation scenarios for Šumava National Park and evaluate their impact on local ecosystem service provision. Since potential ecosystem-based adaptation measures in the study area will encompass land-use/land-cover (LULC) changes, it is vital to assess the actual impact of these measures on the future levels of ecosystem services. To achieve this objective within the “Green Roof“ case study, the InVEST modelling tools (Integrated Valuation of Ecosystem Services and Tradeoffs) will be utilized.

Description

InVEST represent a suite of models developed by Natural Capital Project initiative at Stanford University (http://www.naturalcapitalproject.org/InVEST.html), focused on ecosystem service assessment and evaluation on various landscape scales. This suite of models is a free ArcGIS extension available on the web page of the initiative and has been utilized for ecosystem service evaluation in various research projects worldwide, especially in order to compare different alternatives of potential future landscape development (Kareiva et al., 2011, Goldstein et al., 2012, Isely et al., 2010, Nelson et al., 2009, Tallis and Polasky, 2009).

InVEST presents a group of spatially explicit modelling tools, based on current land-use maps and future landscape scenarios. During the creation of scenarios, participation of local stakeholders is preferred and including their opinions and preferences about future landscape features (e.g. ecosystem-based adaptive measures) is recommended. In addition, the results of the modelling tools are presented as spatially explicit maps of future ecosystem service levels and can serve as the basis for following discussions with the stakeholders. Therefore, the application of InVEST in the “Green Roof“ case study will provide useful outcomes, additionally contributing to local adaptive governance and decision-making.

Data needs

In the present case study, various ecosystem services will be evaluated, with an emphasis on regulating and provisioning services, which may be influenced by LULC-based adaptive measures to a large extent. Individual InVEST tools aimed at these types of services will be thus utilized, e.g. Carbon sequestration, Biodiversity of Timber provision tools.

The basic data inputs, common for all the above mentioned tools, are current land use maps and future scenarios, the development of which can be based on the collaboration with local stakeholders. The expected sources of LULC maps are CORINE Land Cover data sets; however, InVEST tools can be run even with LULC maps with finer resolution.

Subsequent data needs depend on the individual tools utilized. In general, various ecological and socio-economic parameters of the study location, mainly in the form of raster maps and table databases, are required. The data will be gained from national-scale and localized studies, performed by Czech and European research and academic institutions.

2.6.6 Linkages with the agricultural and coastal case studies

Case study: South Devon Coast, England

The South West's long coastline attracts ca. 21 million tourists a year and is home to more 50% of the Marine Conservation Society's designated best United Kingdom beaches. This case study investigates the key climate impacts affecting biodiversity and ecosystem services in the South West of England as well as adaptation challenges and barriers. This case study will also explore what is currently being done to promote adaptation and what type of knowledge is being used to support adaptation (and by whom).

Case study: Adaptation to Drought in Alentejo (Portugal)

In this case study different projects/organizations/communities/farms have planned or already implemented Ecosystem Based Adaptation measures such as "restoring fragmented or degraded natural areas" and "protect groundwater recharge zones or restoration floodplains", like the community of Tamera, the project Aldeia das Amoreiras Sustentável, or the farm of Herdade do Freixo do Meio. The effectiveness of these measures will be evaluated as well as the participatory process.

Case studies: Adaptation to sea level rise and storms in Cascais and Vagueira (Portugal)

In Cascais and Vagueira (both coastal case studies), the sea level rise and frequent storms have generated the need for adaptation plans. In Cascais the adaptation plan has already included several Ecosystem Based Adaptation measures. In Vagueira (prospective case study) the research will facilitate the participatory assessment and planning of the adaptation pathways, where ecosystems services will be certainly on the discussion rounds due to their big importance in the Aveiro delta, in the territory where is this case study located.

General objectives of the case studies

Case studies will investigate different aspects of particular examples of Ecosystem Based Adaptation measures in Europe.

Objective of the Green Roof" case study is to, based on the scenario workshop, propose several adaptation scenarios for Šumava National Park and evaluate their impact on local ecosystem service provision.

As biodiversity and ecosystem services sub-group overlaps with agricultural and partly coastal sub-group, there are synergies with case studies. For instance, adaptation to drought in Alentejo and adaptation to sea level rise and storms in Cascais (Portugal) investigate already implemented Ecosystem Based Adaptation measures, assess and evaluate effectiveness of these adaptation measures.

2.7 Adaptation and human health

By: Tim Taylor (EU) and Aline Chiabai (BC3)

2.7.1 Existing analysis of health impacts of climate change in Europe

In order to design effective adaptation measures in public health, there is a need to first understand the current health risks related to climate and the risks which might arise in the future for expected changes in climate. Table 7 reports the results from some key European projects (PESETA, ClimateCost, cCASHh) and the main related literature on the impacts of climate change on health.

Table 7 Health impacts related to climate change in Europe

	Expected impacts			
Health impacts (mortality and morbidity)	**PESETA project (Watkiss and Hunt, 2012, Watkiss et al., 2009)**	**ClimateCost project (Kovats et al., 2011)**	**cCASHh project (Menne and Ebi, 2006, EEA, 2012a)**	**Geographical distribution**
Heat stresses	Small increase in 2011-2040 to significant increase in 2071-2100. By 2020 expected increase by 25,000 deaths per year. By 2080 expected increase by 60,000-165,000 deaths without adaptation and physiological acclimatisation.	Increase of 26,000 deaths per year in 2011-2040, to 127,000 deaths per year in 2071-2100 (A1B), with no adaptation. Under E1 scenario 69,000 additional deaths per year by 2080.	Heat waves are projected to become more frequent and more intense over the 21st century. Estimates of relative risks available from comparative risk assessment (McMichael et al., 2004).	Most affected Mediterranean and Southern Europe and Central-Eastern countries.
Cold stresses	Small decrease in 2011-2040 to significant decrease in 2071-2100. By 2080 expected decrease by 60,000-250,000 deaths.	–	–	Most affected Northern Europe.
Air pollution and ozone related mortality and disease	–	–	Quantification of future ground-level ozone is uncertain due to complexity. Estimates on humans? Synergistic effects between high temperature and air pollution (PM10 and ozone) observed during hot weather.	Increased average summer ozone concentrations in Southern Europe and decreased levels in northern Europe and Alps.
Flood-related deaths and injuries	Significant increase by 2080 (650 additional deaths per year in A1B, and 185 in E1 mitigation scenario), though reductions with coastal adaptation.	Increase of 130 deaths per year by 2050 and 650 by 2080 in A1B. In the E1 the increase is of 100 deaths per year by 2050 and 185 by 2080.	–	Most affected northern Mediterranean, and northern and western Europe. According to ClimateCost 2/3 of projected deaths expected in Western Europe.
Mental	Significant increase in number of cases in		Flooding associated with increased rate of anxiety	Most affected northern

stresses	high sea level rise scenario (A2) by the period 2071-2100 (5 million additional cases per year), though important reduction with adaptation.	–	and depression (Bennet, 1970; Sartorius, 1990). The persistence of the health impacts is directly related to the intensity of the flood.	Mediterranean, and northern and western Europe.
Vector-borne diseases				
Mosquito-borne diseases	Unlikely to expect substantial increase due to appropriate public health care. Many cases of malaria occur in travellers, while small number of dengue and yellow fever. Re-establishment of malaria in Europe not expected.	–	The Asian tiger mosquito important vector in EU, transmitting dengue and chikungunya. Climate-related increase in population of this mosquito could lead to a small increase of dengue in Europe, but further modelling is required. Risk of chikungunya may increase. Malaria vectors present in Europe, few cases of local transmission occur annually. Re-establishment of malaria in Europe not expected.	Not endemic in Europe. Climatic suitability for Asian tiger mosquito projected to increase in central and western Europe and to decrease in southern Europe.
Hantavirus	Unclear the risk under climate change, but not considered high.	–	Projected to shift up to higher latitudes and altitudes, unless vaccination programs are put in place.	Projected to increase in northern and central Europe and decrease in southern Europe.
Leishmaniasis	Some potential increase with climate change but very low.	–	Projected to slightly increase, expansion constrained however by the limited migration of sand-flies. The distribution of the vector could extend to higher altitudes. In places where the climate will be too hot and dry the disease might disappear.	Central Europe might become more suitable for the vector, while the risk of transmission may decrease in southern Europe. Cases reported from Albania, Bosnia and Herzegovina, Bulgaria, Croatia, France, Greece, Hungary, Italy, Malta, Monaco, Portugal, Romania, Spain and Serbia and Montenegro.
Lyme borreliosis	Lyme could increase slightly with climate change and human behaviour for increased contact with ticks in leisure time.	–	–	Endemic in Europe. Highest incidence in central Europe.
Tick-borne	Endemic areas could			Endemic in Europe,

encephalitis	extend to higher altitudes and latitudes with climate change.	–	–	mostly common in Northern and Central countries.
Water and food-borne diseases				
Salmonellosis	Increase of 20,000 cases per year by 2020 and 40,000 per year by 2080, A2. By 2071-2100 50% more cases than would be expected just due to population change.	Increase of 7,000 cases per year in EU27 by 2020, 13,000 by 2050, and 17,000 by 2080 in A1B. Increase of 6-7,000 cases per year by 2050 and 2080, baseline decline.	Floods and heavy rainfall may disrupt water treatment and sewage systems and contribute therefore to increase exposure to salmonellosis.	Largest increase in UK, France, Switzerland and Baltic countries.
Campylobacter	–	–	Use of rainwater might increase during droughts and campylobacter in untreated run-off water might contribute to increase the disease in animals and humans.	Northern Europe more exposed with the projected increase in heavy rainfall and risk of groundwater contamination (rural areas more prone).
Cryptosporium	–	–	Increase in rainfall (and preceding dry weather) is predicted to increase cryptosporidiosis, due to infiltration of drinking water reservoirs from springs and lakes.	–
Norovirus	–	–	Heavy rainfall and floods might cause wastewater overflow with risk of contamination of shellfish farming, and increased risk of norovirus infections.	–
Vibrio	–	–	The infection is linked with the increase of summer water temperatures and extended summer seasons, but the disease is projected to increase only modestly due to the current low incidence.	Baltic sea.

Source: results from PESETA (Watkiss and Hunt, 2012, Watkiss et al., 2009); ClimateCost (Kovats et al., 2011); cCASHh projects (Menne and Ebi, 2006, EEA, 2012a).

Similar estimates are provided by national assessments such as the UK government report on climate change risk assessment (CCRA), which includes also the risk of increased marine pathogens and algae blooms due to higher sea temperatures, which can cause different negative impacts on human health.

2.7.2 Planning adaptation

Informed decision-making can only be taken by knowing the financial resources needed for adaptation in the health sector, their cost-effectiveness, the cost of inaction and the damages which could be avoided if proper adaptation plans are put in place (Markandya and Chiabai, 2009).

A number of key steps have been proposed for planning adaptation in the health context (adapted from (Füssel et al., 2006)), which should be, in principle, analysed with relevant stakeholders who will be in charge of implementation.

As a first step, the scope of the assessment has to be defined, including decisions about geographical scope, time period of reference, types and levels of stakeholders. Second, the risk assessment has the objective to estimate the risk of adverse health impacts on populations exposed to the climate variation in a specific geographical region. A third step includes the analysis of the adaptation baseline, which refers to the interventions already existing in a specific region to prevent and reduce impacts. Fourth, health impacts/risks are projected under future scenarios for specific geographical areas and time periods, based on changes in climatic and socio-economic variables. Projections should include an analysis of uncertainty. Projected impacts can be expressed in physical or monetary units (cost of inaction). The fifth step consists of identifying the adaptation measures to reduce future expected impacts, based on the analysis of the adaptation baseline (current adaptation might need to be strengthened or additional measures might be required). The assessment of the measures helps in prioritizing goals, based on some pre-defined criteria, such as cost-effectiveness, cost-benefit or multi-criteria analysis. Benefits represent the avoided damages and residual damages should also be assessed. Costs and benefits should be intended as social costs and benefits. Other criteria might also be taken into account by decision-makers (equity, distributional impacts among vulnerable populations, development goals, etc.). The prioritization of measures should also reflect the appropriate timing of adaptation, as is discussed in the next section. Finally, the measures are implemented and their effectiveness is monitored and assessed. The latter is crucial and should be taken in an early stage of the planning as it affects the prioritization of actions. WHO (2013) proposes an economic valuation tool to help in the assessment of costs and benefits in the health sector, and namely the assessment of health damage costs (inaction), the health adaptation costs and the measure efficiency (avoided cost).

2.7.3 Existing studies on health adaptation in Europe

In order to assess the adaptation costs in the health sector, it is necessary to estimate the excess cases and deaths, for different health outcomes, due to climate change, to project future population, and to calculate the number of people at risk in the future (multiplying future population with the incidence ratio). The costs are calculated by multiplying the number of people at risk with the cost of health measures on a per capita basis.

As for the benefits of adaptation, these are the avoided impacts, so that it is necessary first to calculate the impacts and then how much these impacts could be reduced by adaptation measures. Ciscar and Soria (2009) calculated that in 2020 the health impacts of climate change could range from 13 to 30 billion € (2005 prices). By 2100, the impacts would rise up to 50 to 180 billion € (2005 prices) without acclimatization. The IPCC (2007) estimated a loss of life between 6 and 88 billion USD (1990 prices).

In the context of adaptation costs, one of the first studies to mention is that of Ebi (2008) who estimated the costs of adaptation for malaria, diarrhoea and malnutrition between year 2000 and 2030, due to climate change. Three exposure scenarios are considered: unmitigated scenario, stabilization at 750 ppm CO_2 equivalent by 2210 and stabilization at 550 ppm CO2 equivalent by 2170. Costs are provided for geographical regions including Africa, America, Sout-East Asia, Europe, Eastern Mediterranean and Western Pacific. For each health

outcome, specific measures have been identified: for diarrhoea, immunization programs and improvement in water supply and sanitation; for malaria, impregnated bed nets, indoor spraying, and preventive treatment in pregnancy; for malnutrition, costs of nutritional programs and monitoring.
Total costs for the year 2030 are given in Table 8, ranging from a minimum of 3,300 to 18,000 million US$ (2000), annually and globally. Table 9 provides adaptation costs for the same health outcomes, disentangled by macro geographical regions and differentiating between developing and developed countries, with some information about Europe as well (Markandya and Chiabai, 2009). Developing countries are expected to support the highest cost.

Table 8 Global annual costs of health adaptation to climate change between 2000-2030 (US$ Million, 2000)

Cost/Scenario	Unmitigated	Stabilization at 750ppm	Stabilization at 550ppm
Malaria	3,100 to 8,800	1,900 to 5,600	1,600 to 4,500
Diarrhea	2,731 to 9,010	1,983 to 6,814	1,706 to 6,024
Malnutrition	62 to 166	81 to 216	54 to 150
All Costs	5,900 to 18,000	4,000 to 12,600	3,300 to 10,700

Source: based on cost estimates from Ebi (2008)

Table 9 Additional Annual Costs of Health Adaptation in Alternative Climate Change Scenarios per Geographical World Region 2000-2030 (Million US$, 2000).

REGION	**Climate Scenario**					
	S550	**S750**	**UE**	**S550**	**S750**	**UE**
	Diarrhea			**Malaria**		
Developing countries						
Africa	633-1,334	756-1,646	954-2,026	1,283-3,718	1,567-4,595	2,508-7,222
Americas (Central/South)	22-372	22-442	22-582	23-65	29-76	43-121
Eastern Mediterranean	87-713	87-765	131-1,122	230-626	284-772	434-1,231
South East Asia	952-2,198	1,106-2,542	1,428-3,231	0-8	6-9	6-17
Western Pacific (A)	0-1,109	0-1,109	185-1,664	37-98	43-120	68-188
Subtotal	*1,694-5,726*	*1,971-6,504*	*2,719-8,625*	1,573-4,514	*1,928-5,572*	*3,059-8,780*
Developed countries						
North America	0-70	0-70	0-94	0	0	0
Europe	12-205	12-217	12-260	0	0	0
Western Pacific (B)	0-23	0-23	0-32	0.136-0.370	0.177-0.494	0.265-0.741
Subtotal	*12-298*	*12-310*	*12-385*	*0.253*	*0.335*	*0.503*
WORLD	*1,706-6,024*	*1,983-6,814*	*2,731-9,010*	*1,573-4,515*	*1,928-5,573*	*3,059-8,781*

Source: adapted from Markandya and Chiabai (2009), based on cost estimates from Ebi (2008).

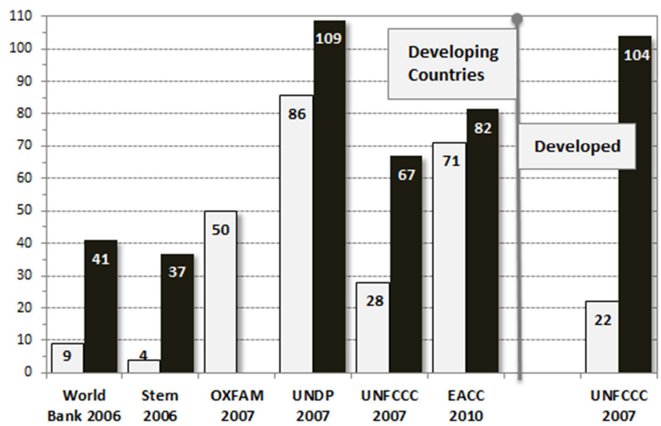
Note: S550 implies stabilization of emissions of GHGs at 550 ppm by 2210. S750 implies stabilization of emissions at 750 ppm by 2170 and UE implies unmitigated emissions.

Another study on the cost of adaptation in the health context is from Van Rensburg and Blignaut (2002) who estimated the costs for adaptation in year 2025 in Southern Africa, related to an increase in the incidence of malaria. Total annual costs for preventive and reactive measures (treatment) are estimated to be US$ 3,800 million in 2025 (2000 US$) or 3% of GDP per capita. These figures are more conservative but still comparable with the results of Ebi (2008).

In some studies the cost adaptation is estimated by investment and financial flows in terms of percentage of GDP and foreign investments and aid sensitive to climate, with a mark-up factor applied for climate proofing investments (UNFCCC, 2007). These studies usually focus on global estimates and broad sectors ((Stern, 2006, UNFCCC, 2007, Oxfam, 2007, UNDP, 2007) (Figure 9). These studies provide some figures for the health sector as well, but the methodology suffers from some critical limitations, attributable to the calculation of the mark-up factors (Parry et al, 2009). Furthermore, the estimates are not available by health outcomes and by geographical regions, adding to the uncertainties in the estimation process. Finally, as adaptation costs in health are expected to be supported mainly in developing countries, these approaches do not include an estimate of these costs for the developed countries, resulting in a serious lack of data in this context. However, the latter will be also affected, even if in a smaller scale, and data are needed to have an approximation of the expected expenses needed for health adaptation (see Ciscar and Soria, 2009; IPCC, 2012; Figure 9).

In this respect, it is worth mentioning the project CLIMATECOST that assessed potential impacts and costs of a number of health outcomes judged to be the most relevant for Europe. These include mortality related to heat stresses and flooding, and morbidity due to food borne diseases. As for heat, it is estimated that 26,000 additional deaths per year are expected by year in the period 2011-2040, 89,000 in 2041-2070, and 127,000 in 2071-2100, under scenario of high emission (A1B), no mitigation and adaptation. As for flooding, 130 additional deaths per year have been estimated by 2050s, and 650 by 2080s, under scenario A1B (two third expected in Western Europe). As for food borne diseases, salmonellosis is expected to increase in Europe, with 7,000 additional cases per year by 2020s in A1B, 13,000 by 2050s and 17,000 by 2080s. Similar estimates are provided by the project PESETA, with some higher predictions, as it can be seen from Table 7.

As highlighted in CLIMATECOST, there is very limited information about the costs of adaptation in health. Some estimates exist on heat warning systems but only for specific locations (and very difficult to be up-scaled or re-calculated at a larger scale) (Ebi et al., 2004), while changes in infrastructures are more expensive and quite complex to estimate. There is therefore a strong and urgent need to fill this research gap.



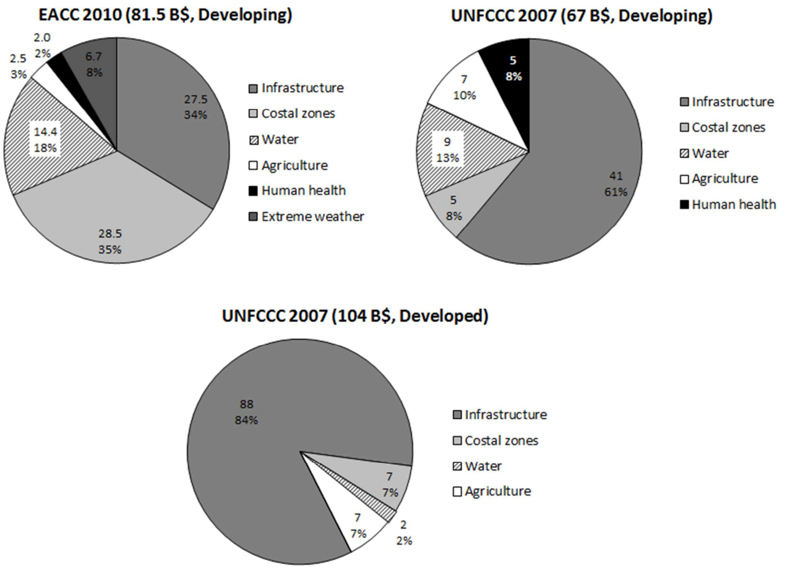


Figure 9 Annual estimates of adaptation costs to climate change (billion USD per year)

Source: Chiabai and Spadaro (2014 forthcoming)

Note: UNDP estimates include costs for disaster response systems (2 B$) and poverty reduction programs (40 B$)

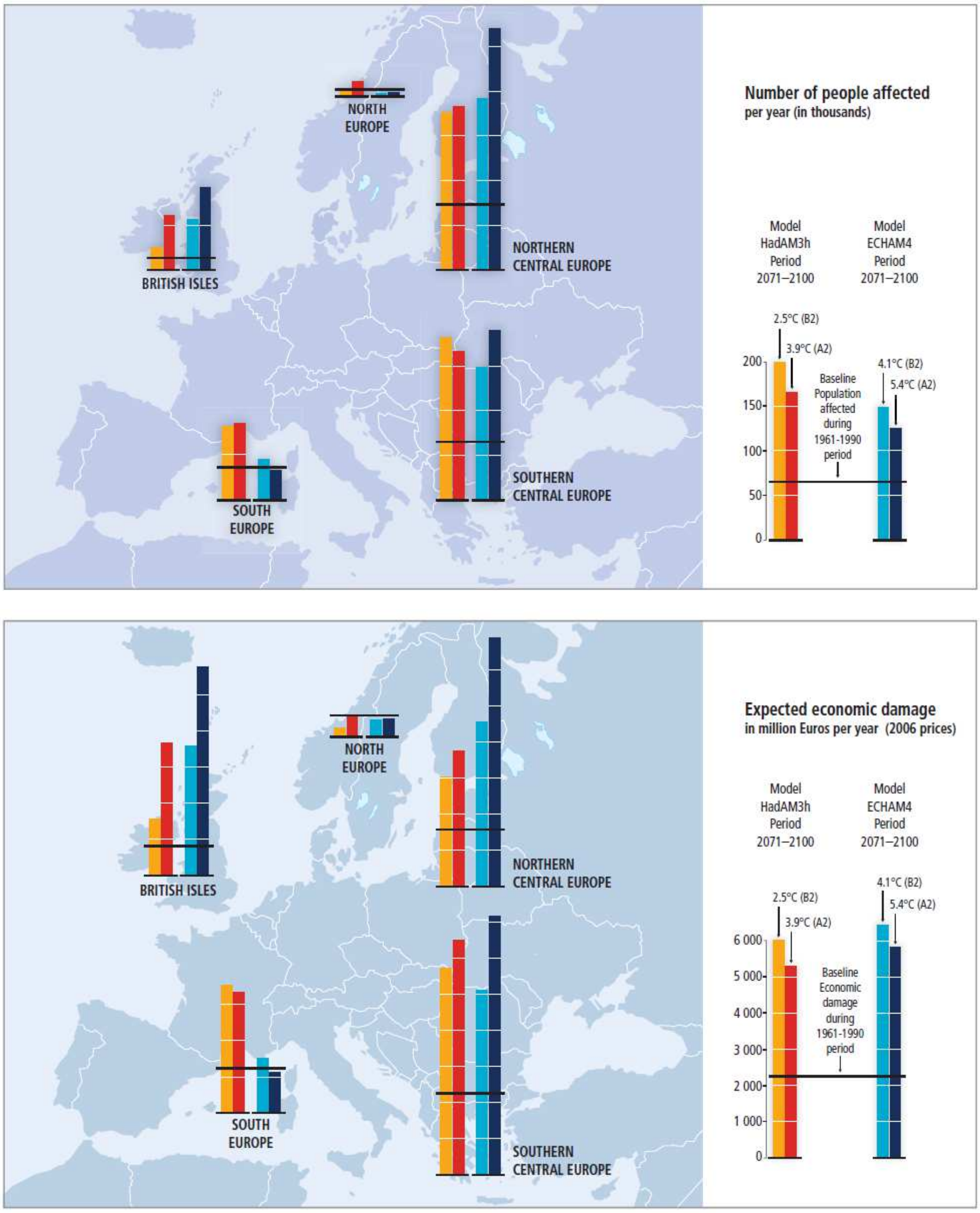


Figure 10 People affected and economic damage from natural disaster in Europe ($2009), 2000-08

Source: IPCC (2012)

2.7.4 Towards adaptation pathways for health

Adaptation in the health sector can be classified using the conventional categories applied in public health according to timing, and namely primary, secondary and tertiary interventions (Markandya and Chiabai, 2009, McMichael et al., 2003)(e.g. warning systems, water and sanitation programs). Primary interventions are usually implemented before the damage has occurred in order to minimize the exposure, by removing the risk or by increasing individuals' resistance (Davis and Shipp, 2009). Traditionally, public health interventions have been focused on primary prevention, which is more cost-effective than reactive measures.

Secondary interventions aim to prevent the disease before it becomes manifest, such as the case of screening tests to detect blood pressure and prevent heart attacks (Davis and Shipp, 2009). In the context of adaptation, these measures correspond for example to the monitoring and surveillance programs which are put in place once the impact has occurred but before the disease is established. Tertiary interventions are applicable once the impacts had occurred in order to minimize the damage and avoid complications, and they correspond to the curative treatments. Table 10 provides an attempt to group adaptation measures into the three categories used in public health.

Table 10 Adaptation measures

	Adaptation measures		
Health impacts	**Primary**	**Secondary**	**Tertiary**
Heat stresses	Building and technical solutions. Urban planning (reforestation, green roofs, etc). Heat health warning systems (preventive). Educational campaign.	-	Heat health warning systems (reactive). Emergency plans and medical services.
Extreme weather events related deaths, injuries, mental health effects	Healthy ecosystems around systems to provide natural barriers to flooding. Structural measures to reduce flooding (dykes, walls, etc). Land-use and urban planning (flood-resistant). Early warning systems and real-time forecasting.	Disease surveillance and monitoring	Emergency and evacuation plans.
Vector-borne diseases	Healthy ecosystems (including biodiversity) Vector control (vector habitat destruction, bed nets, etc.). Information and health education.	Disease surveillance and monitoring. Vaccination.	Diagnosis and treatment (early detection)
Food-borne diseases	Food sanitation and hygiene (refrigeration, ozone treatment of drinking water, chlorination of drinking water, etc.). Food safety education.	Disease surveillance and monitoring. Zoonosis program to control disease in animals (salmonella). Microbiological risk assessment.	Diagnosis and treatment (early detection)
Water-borne diseases	Regenerate ecosystems and biodiversity e.g. wetland restoration. Improved river water quality e.g. through improved water and sanitation systems Information and health education.	Disease surveillance and monitoring.	Diagnosis and treatment (early detection).

This categorization could be integrated within the concept of adaptation pathways (Haasnoot et al., 2013, Haasnoot et al., 2012a), where policy interventions are placed in a sequence providing a set of possible paths taking into account different criteria such as severity and frequency of impacts, urgency, flexibility and uncertainty. The timing of each measure becomes crucial based on threshold effects or adaptation tipping points. The planning and set-up of the three types of interventions mentioned follow different routes according to the health outcome considered and the geographical area of interest.

2.7.5 Assessing the effectiveness of adaptation

Different methods are used by economists to evaluate if the cost of a measure is justified in terms of the results obtained. Public health has usually used cost-effectiveness analysis (CEA), which estimates the cost of achieving a certain health impact, measured as number of deaths, cases or DALY avoided. The method is used to identify the measure with the highest cost-effectiveness. Cost-benefit analysis (CBA), on the other hand, estimates and compares costs and benefits in monetary terms, in order to identify the measure with the highest net benefit. Both methods focus on the social costs of implementation, defined as the aggregated opportunity costs incurred by the society if the measure is put in place. The costs of a measure are those associated to the direct implementation of the measure, to the effort needed to improve adaptive capacity (institutional costs such as those related to infrastructures, training, information) and to the resource reallocation, these latter being usually not included as difficult to estimate. An alternative method which could be used is the multi-criteria analysis (MCA) which takes into account different criteria for identifying priorities (UNFCCC, 2009). The monetary values are just one of the criteria, while it is able to account for equity and distributional effects.

It is also important to consider the multiple benefits or co-benefits which can be generated by adaptation (Figure 11). For example, the improvement of food safety and quality will provide important health benefits in terms of reduced number of cases, but it will also contribute to the European Sustainable Development Strategy. The construction of a flood protection structure will provide important benefits in terms of avoided damages to buildings and health benefits, while it will have little contribution to development. Such a distinction is crucial when estimating the costs of health adaptation in order to delineate priorities among sectors and to identify other related impacts in a common framework of analysis (Markandya and Chiabai, 2009).

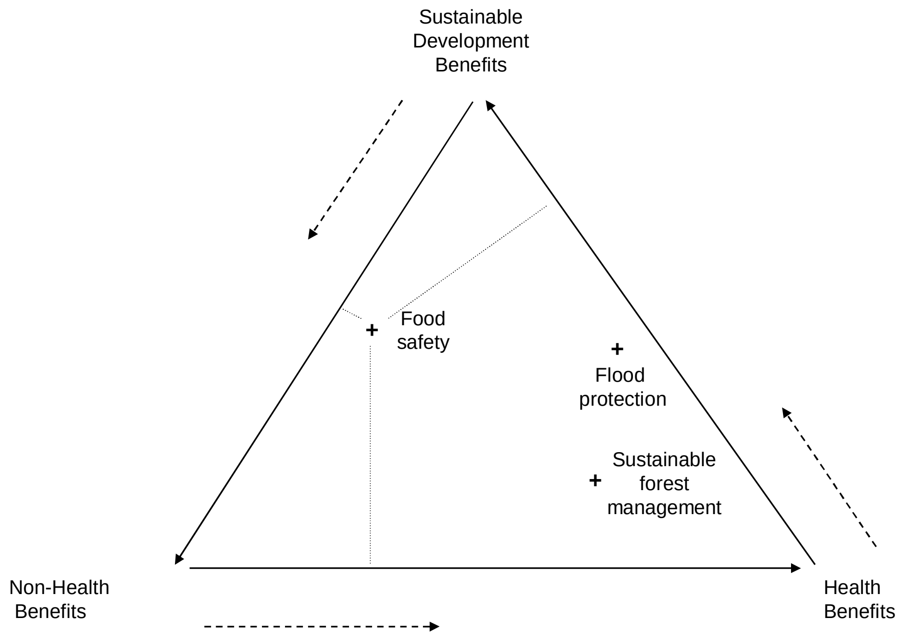


Figure 11 Measures with co-benefits

Source: adapted from Markandya and Chiabai (2009)

2.7.6 Costs and Benefits of Adaptation: Health

The quantification and valuation of the health benefits and costs of adaptation strategies raises particular issues for policy analysis. Human health is perhaps one of the more controversial issues to place value on, as shown by previous debates around climate policy assessment around health values in the Second Assessment Report of the IPCC. This section gives an overview of key issues in assessing the health impacts, starting with issues in quantification, before discussing valuation and decision support tools.

Quantification

The quantification of health endpoints is complicated by the many different forms of both mortality and morbidity risks associated with climate change. These affect the measure of benefit in physical terms and the method for monetary valuation. An overview of the different mortality and morbidity risks associated with climate change is given in Table 11.

Table 11 Overview of mortality and morbidity risks

Type of health impact	**Definition**
Mortality	
Accidental mortality	Sudden death due to an accident.

Acute mortality	Sudden death due to exposure to an infection or another environmental hazard such as air pollution.
Chronic mortality	Death following exposure to an environmental hazard (or infection), with an intervening period of deteriorating health.
Latent mortality	A special case of chronic mortality in which death follows exposure to an environmental hazard, with an intervening period during which health does not deteriorate.
Morbidity	
Accidental morbidity	Injury due to an accident.
Acute morbidity	Sudden deterioration in state of health due to exposure to an infection or another environmental hazard such as air pollution.
Chronic morbidity	Deteriorating heath following exposure to an environmental hazard or infection.

Source: Based on Metroeconomica (2004)

The key issues in the quantification of the impact on health include:

a. The nature of the impact on health – does increased mortality affect only the sick (who may have limited life expectancy) or the general population?
b. The latency of impact – i.e. when does the impact occur in relation to the climate event;
c. The distributional nature of the impact – are particularly vulnerable groups affected? Is the impact on children or the elderly?

The impacts on life expectancy may lead to different measures of mortality being used for different health impacts. Sudden deaths of members of the general population may need to be separated from forms of mortality that reduce life expectancy for those who are likely to have short life expectancy. The measures of *statistical lives* and *life years lost* are commonly used.

Quality Adjusted Life Years (QALYs) or *Disability Adjusted Life Years* (DALYs) are also common measures of health outcomes. These are particularly important for morbidity outcomes and for chronic mortality, as they can also encompass elements of loss of quality of life as well as life expectancy. These measures thus aim to incorporate both mortality and morbidity in one single indicator, which is particularly useful to assess programs having impacts on more than one indicator (e.g. life years saved and reduction of symptoms).The main problem is related with age, as the elderly would have, for example, fewer QALYs than the younger .In terms of latency, identifying when the impact is likely to occur may lead to discounting of future life years lost/saved in physical terms. Note care needs to be taken to avoid double discounting in this case if cost-benefit analysis is used.

Valuation

Valuation methods

A number of methods have been used to assess the value of impacts on health, including both monetary and non-monetary measures. It is important to note that different metrics may be appropriate for different audiences and for different policy contexts

- Quality Adjusted Life Years (QALYs) – ranking based on surveys about different conditions. This allows for a non-monetary assessment of the “value” of changes in health state;
- Monetary valuation of willingness to pay to reduce health risks. E.g. value of mortality based on value of a statistical life or value of a year lost, drawing on contingent valuation, choice experiments or hedonic wage risk studies;
- Cost of illness approaches; and
- Monetary assessment of social value of a QALY using choice experiments.

The need to avoid double counting should be noted – as some elements of cost-of-illness may be captured by willingness to pay measures in certain cases.

It is to be noted that few studies have used monetary methods to value mental health impacts – some have looked at major depression (e.g. Morey et al. (2007); Herbild et al. (2008)).

Some argue existing methods do not properly account for public benefits of health. For example, Hausman (2010) argues that private evaluation of health states is not a good measure of public evaluation. This is reflected in the difference between preferences of individuals and the value of health states – with an example being the choice to take medication compared to productivity for those with manic depression. Hausman argues that judgments of value require information, experience and time and that the public value of health is not an aggregation of personal values e.g. coping with disability may lead to good QoL values for the individuals involved. Deliberative monetary valuation may fill a gap – but this has a number of weaknesses including the difficulty of comparing results from different groups.

Valuation issues of specific health endpoints

Some issues in the valuation of specific endpoints are given in Table 12.

Table 12 Key issues

Health Endpoint	**Key issues in valuation**
Heat stresses	Key issue is determining the appropriate unit for quantification. In UK Climate Change Risk Assessment, sensitivity analysis was used around different assumptions for health impact.
Cold stresses	While heat stresses are assumed to increase in urban contexts, cold stresses can be expected in both rural and urban areas, which should be taken into account in assessments.
Air pollution and ozone	Valuation can be based on VLYL for mortality – and probably appropriate to draw lessons from CAFÉ cost-benefit analysis/HEIMTSA project
Flood related deaths and injuries	Valuation should be based on VSL for mortality
Mental stress	Few studies assess WTP for avoiding mental stress, cost-of-illness may be appropriate route
Vector borne disease	

Mosquito borne disease	Valuation becomes an issue here if vaccination possible – some may see as an adaptation cost, others an impact. DALY used for malaria (WHO), assumptions needed about value of one year of life to calculate benefit cost ratio.
Hantavirus	
Leishmaniasis	Values available for DALY (WHO).
Lyme borreliosis	
Tick-borne encephalitis	Study on benefits of vaccination for TBE for French troops in Balkans
Food borne disease	
Salmonellosis	Key issue is assumption of non-reported disease in quantification.
Water borne disease	
Campylobacter	WTP may need to be based on e.g. gastroenteritis for morbidity.
Cryptosporium	WTP may need to be based on e.g. gastroenteritis for morbidity.
Norovirus	WTP may need to be based on e.g. gastroenteritis for morbidity.
Vibrio	WTP may need to be based on e.g. gastroenteritis for morbidity.

Benefit Transfer

The appropriate use of benefit transfer methods - to take studies from one context and apply in another - is important, as it is unlikely in most cases that primary valuation studies can be conducted. Databases of previous studies may prove useful for identifying studies for particular endpoints. An example is the HEIMTSA project, which valued a number of health endpoints. Table 13 gives an overview of the values used in that project.

A key issue in benefit transfer is the degree to which appropriate adjustments are made. The adjustment for differing income across nations is common - with income elasticity of demand also being taken into account through sensitivity analysis. The question of whether it is appropriate to value a statistical life in Romania and a statistical life in the UK differently will depend on the decision maker.

Adjustment over time is also common – with changes in price levels being factored in. A useful spread sheet tool to facilitate this is the Currency Conversion Tool on the ExternE website (http://www.externe.info/externe_d7/?q=node/2).

Table 13 Monetary Values in HEIMTSA project

Health End-Point	Low	Central	High	Unit (2010) per case	Reference
Sleep disturbance	480	1,240	1,570	Euro/year	Godet-Cayré et al. (2006); Ozminkowski et al. (2007)
Hypertension	880	950	1,110	Euro/year	Ramsey et al. (1997); Berto et al. (2002)
Acute myocardial infarction	4,675	86,200	436,200	Euro	Moïse et Jacobzone, 2003; Yasunga et al. (2006)
Increased mortality risk (infants)	1,120,000	2,475,000	11,200,000	Euro	Holland et. al. (2004)
Chronic bronchitis	43,000	60,000	100,000	Euro	Krupnick and Cropper (1992)
Severe COPD	70,000	120,000	260,000	Euro	Maca et al. (2011)
Increased mortality risk - Value Of Life Years acute	60,820	89,715	220,000	Euro	Alberini et. al. (2006)
Increased mortality risk - Value of Prevented Fatality acute	1,120,000	1,650,000	5,600,000	Euro	Alberini et. al. (2006)
Life expectancy reduction - Value of Life Years chronic	37,500	60,000	215,000	Euro	Alberini et. al. (2006); Desaigues et. al. (2011)
Respiratory hospital admissions	2,990	2,990	8,074	Euro	Navrud (2001); Holland et. al. (2004)
Cardiac hospital admissions	2,990	2,990	8,074	Euro	Navrud (2001); Holland et. al. (2004)
Work loss days (WLD)	441	441	441	Euro	Navrud (2001); Holland et. al. (2004)
Restricted activity days (RADs)	194	194	194	Euro	Navrud (2001); Holland et. al. (2004)
Minor restricted activity days (MRAD)	57	57	57	Euro	Navrud (2001); Holland et. al. (2004)
Lower respiratory symptoms	57	57	57	Euro	Navrud (2001); Holland et. al. (2004)
LRS excluding cough	57	57	57	Euro	Navrud (2001); Holland et. al. (2004)
Cough days	57	57	57	Euro	Navrud (2001); Holland et. al. (2004)
Medication use / bronchodilator use	74	80	96	Euro	Maca et al. (2011)
Lung cancer	70,000	720,000	4,200,000	Euro	Weissflog et al. (2001); Serup-Hansen et al. (2003); Scasny (2008); Jeanrenaud and Priez (1999); Aimola (1998)
Leukaemia	2,050,000	4,000,000	7,000,000	Euro	Aimola (1998)
Neuro-development disorders	4,500	15,000	33,000	Euro/year	Ščasný et. al. (2008)
Skin cancer	11,000	14,000	27,000	Euro	Aimola (1998)
Osteoporosis	3,000	5,700	8,100	Euro	Kudrna and Krška (2005); Werner and Vered (2002)
Renal dysfunction	23,000	30,400	41,000	Euro	Bartaskova et al (2005); Sun-Mi et al. (2006)
Anaemia	750	750	750	Euro	Ossa et. al. (2007)

Source: Hunt et al. (2011)

Valuing Children's Health

Children may be at particular risk from climate change in terms of certain health endpoints – e.g. risk of death through flooding. The valuation of children's health is particularly contentious. The debate is still open on whether children's health endpoints should be valued differently to adults. A number of studies have found that willingness to pay for health risks in children is approximately twice that of adults, but the underlying cause of the value difference is not that well studied (Hoffman and Krupnick, 2004). OECD (2006) discusses differences in risks and exposure, as well as differences in valuation, and associated issues for transferring measures from adults to children.

Decision Support Tools

Cost-effectiveness analysis is probably the most common form of decision support in the health sector - with the cost per Quality Adjusted Life Year (or QALY) being used as the denominator on many such appraisals. Recent work in Europe has called into question the methods of application of QALYs, but it is still probably the most accessible form of decision support for policymakers in health.

Cost-benefit analysis is far less used in the health sector – though it has been used significantly in other arenas with significant environmental health aspects. For example, the setting of standards for air pollution emission from transport – which has significant health implications – has been appraised using cost-benefit methods.

Multicriteria decision analysis is in its relative infancy in the health sector, though some would argue that decision making bodies such at the National Institute for Clinical Evidence in the UK uses a form of MCDA in deciding on granting the use of drugs.

2.7.7 Health case studies in BASE

In BASE the following cases studies are expected to have significant focus on health:

- Iberian case study on water and adaptation: different locations will be chosen to address the problems related to water and climate change in Spain and specifically:
    - Heat waves and droughts: co-benefits in health and water systems. Area: Madrid urban and possibly peri-urban area.
    - Flooding: health and a number of sectors selected among those more affected.
- Mental health and climate in the UK
- Adaptation costs of health care in Cornwall, UK to meet climate change – building on an existing adaptation strategy.

In addition, other case studies in e.g. the Urban and Water Resources groups may have health elements.

Iberian case study:

a) Heat waves and droughts

The case study will develop a methodological framework to assess costs and benefits of cross-sectoral adaptation strategies to reduce the impacts of heat waves and droughts in the area of Madrid. The analysis will focus on the co-benefits of a set of adaptation measures in different sectors. The area of Madrid has been chosen as a case study due to its multiple vulnerabilities due to climate change, its large size and population, its drought-prone climate and its use of trans-boundary water. The study will identify measures with co-benefits on water and health, assess their costs and benefits, and develop collaboration with relevant stakeholders in the Tajo river basin.

b) Flooding

The objective of the flood case study is to balance the costs of flood risk prevention measures with their benefits. The tangible impacts such as the economic impacts and the intangible impacts such like health impacts (death, injuries, post-traumatic stress) of floods in local Spanish case studies will be reviewed. A review of the measures in place and the potential measures of prevention will be a prerequisite to assess the avoided damage and their costs. Local case studies are elicited with the participation of local authorities (water agencies, river basin agency, etc): in the Basque Autonomous Country with the city of Bilbao and/or in the Ebro river basin with the city of Zaragoza.

Case study on mental health in UK

Spatial data on prescriptions, medical diagnosis and hospital admissions will be analysed to assess the extent to which climatic variation affects the risks of mental health. Adaptation options will be identified in consultation with stakeholders, and costs and benefits will be identified where possible.

Case study on health care in Cornwall, UK

Analysis will be conducted of the health adaptation options in the county of Cornwall, UK. The county has recently developed a health adaptation strategy document, and we will work with stakeholders to identify adaptation options. This considers a broad range of climate impacts – including flooding, food- and tick-borne disease. Cost-benefit analysis of options will follow, where possible augmented by MCDA.

2.8 Conclusion

The review results indicate that BASE case studies can make a substantial contribution by extending the evidence base on adaptation and that focusing on providing evidence on costs, benefits, effectiveness and implementation of climate change adaptation would help BASE to make a particularly strong contribution to the EU state of the art.

2.9 Appendix

Some projects and literature which might be of relevance for BASE agricultural case studies.

A.1 Other projects which might be relevant for BASE agricultural case studies

Climate Adapt

EU's Climate Adapt database contains 15 research projects with case studies within the category 'agriculture and forestry'. These 15 projects are briefly described below. Additionally, two case studies are registered as 'financial' (i. ClimaBiz and ii. Bioenergy and fire prevention (the last one is registered among the agricultural case studies too)) and could be of relevance. Furthermore, we have added some other projects to the list. Finally, case studies regarding water resources and water management might be of relevance – we expect, however, that these case studies are considered by the water subgroup.

Adaptation and Prevention Measures – ES (Case study)

A study defines different potential climate scenarios for the Spanish Ebro Delta. The case study was part of the database OURCOAST on integrated coastal zone management. Objectives of the case study: "The specific objectives of the project were (1) defining different potential climate scenarios for the Ebro Delta; (2) analysing the vulnerability at the ecological, economical and social levels; (3) defining the impacts and potential risks for the different components: coast, wetlands, dune systems, habitats, endangered species, health, agriculture, population and other socio-economic components; and (4) designing an action plan for climate change adaptation in each scenario. The timescale associated with implementation and goal achievement was 1 year (Dec. 2007-Dec. 2008). The case study might be of interest to the BASE agricultural subgroup, but it has not been possible to identify the detailed data on this case study.

CLIMFORISK – Climate change induced drought effects on forests

The project is centred on developing scenarios of how forest growth could change in the future by compiling existing data and models.

SOILCONS-Web

The aim of this current project (running until Dec 2014) is to develop, test and implement a tool to support the decisions of stakeholders on soil and landscape conservation issues. Currently (April 2013), there does not seem to be relevant documents for BASE in this project.

SOILPRO

Is apparently more a tool than a case study: "The SOILPRO project has the overall objective of halting soil degradation in EU Member States within the Thematic Strategy for Soil. It will do this by encouraging co-operation between local authorities and research institutes within a transnational environment, as this can promote the development of spatial methodologies for monitoring and managing soil degradation". One element in the project is to develop a web-based application tool that can support authorities in their efforts to monitor, identify and assess areas at risk.

AdaptFor – Adaptation of forest management to climate change in Greece

This project seems to primarily be centred around an assessment of the effects of *climate change* on selected forest ecosystems in Greece.

Adapt2Change - Adapt agricultural production to climate change and limited water supply

The project seems to be oriented towards technical solutions: "The overall objective of the project is to demonstrate adaptation of agricultural production to climate change and limited water supply. Specifically, it aims to minimise agricultural water use by introducing a water-recycling method in a closed, fully automated, hydroponic greenhouse system". Four prototypes are developed in Greece and Cyprus.

BIOTAGENE – Elaboration of novel metagenomic method for environmental monitoring

Project about a new method for environmental monitoring.

CALCHAS

Through pilot studies in Greece and Cyprus this project aims at improving knowledge and skills on spatial planning, evacuation planning and increase the effectiveness and readiness of fire brigades, citizens etc.

ENSAT - Enhancement of Soil Aquifer Treatment to Improve the Quality of Recharge Water in the Llobregat River Delta Aquifer

Project oriented toward technical solutions: “The project’s overall aim is to demonstrate the application of a well-established technology for aquifer remediation such as the use of reactive barriers to enhance the degradation of recalcitrant compounds, but in an innovative way”.

Green Deserts: new planting techniques for tree cultivation in desertified environments

Also oriented towards technical solutions: “The project’s main objective is to demonstrate the feasibility and effectiveness of new tree planting techniques in desertified, poor and/or rocky areas”.

RESILFOR - Restoration of beech and silver fir forests in the Toscan Marches Appennines

Another project focused on technical solutions for forestry: “The general objective of the project is to safeguard mountain habitats with beech-silver fir Apennine forest and beech-yew forest, through restoration of the forest ecosystems by low impact techniques, focusing on sites where temperature increases and rainfall reduction problems are not foreseen in the short run”

AQUAVAL - Sustainable Urban Water Management Plans, promoting SUDS

Case study of two Spanish municipalities having problems with sewer overflow which discharges directly into the local rivers, deteriorating water quality and threatening the river’s ecological status. The rivers are very important in the region for agri-tourism. The principal aim of the AQUAVAL project is to introduce the use of sustainable urban drainage systems (SUDS) to both municipalities. A project which seems to be oriented towards technical solutions. If the project for instance contains data on effects on agri-tourism it might be interesting for BASE.

GAIA

Project about urban forestation.

Bioenergy and fire prevention

The main objective of this project is to improve the Enguera’s (Spanish municipality) capacity to protect its forest resource from fire and demonstrate new win-win rural employment opportunities that provide environmental benefits. New forest management tools and approaches will be developed to minimise fire risks. The potential of biomass as a source of renewal energy and rural employment will also be tested and evaluated.

ClimaBiz - Financial Institutions: Preparing the Market for adapting to Climate Change

Among the project aims of this project is to: i) ‘Identify the physical, regulatory and reputational risks in south-eastern Europe arising from climate change, and prioritise risks and opportunities to be managed by Piraeus Bank’; ii) Quantify climate change risks and opportunities, and put a price on climate adaptation solutions for companies.

INFORM - Building a structured, indicator based knowledge system for sustainable forest policy and management

This project's general objective is to “establish a knowledge base for national forest policy development and implementation, based on MCPFE criteria and indicator estimates, including impact assessments on forests related to climate change”. This project might contain relevant data for forestry modelling.

ACLIMAS - Adaptation to Climate Change of the Mediterranean Agricultural System

The project's overall objective is "to bring a durable improvement of the agricultural water management and a broader socio-economic development of target areas in the context of adaptation to climate change, increasing water scarcity, and desertification risks". The project promotes multidisciplinary approach integrating local technical adaptation measures with socio-economic and environmental aspects of water management.

Motive - Models for Adaptive forest Management

The project focuses on a wide range of European forest types under different intensities of forest management and investigates adaptive management strategies that address climate change. Specific attention is given to uncertainties and risks and how they can be considered in improved decision support tools. This 4-year project ends 30th April 2013.

ForeStClim - Transnational Forestry Management Strategies

An environmental project concerned with forests and climate change with the general objective to develop adaptation strategies in forest management for the future to preserve the present forest diversity in the face of the expected climate change scenarios. The project ended 31st December 2012.

CLIMSAVE - Climate Change Integrated Assessment Methodology for Cross-Sectoral Adaptation and Vulnerability in Europe

The project's main objective is to deliver an integrated methodology to assess cross-sectoral climate change impacts and to provide a platform for an improved integrated assessment of climate change impacts, vulnerability and related cost-effective adaptation measures covering key sectors in Europe. An interactive web-based tool will allow stakeholders to assess climate change impacts and vulnerabilities for a range of sectors, including agriculture, forests, biodiversity, coasts, water resources and urban development.

ACQWA (ASSESSING CLIMATE IMPACTS ON THE QUANTITY AND QUALITY OF WATER)

The goal of the project is to use modelling techniques to quantify the influence of climatic change on the major determinants of river discharge at various time and space scales, and analyse their impact on society and economy (e.g. supplying irrigated agriculture).

ILMASOPU - Adaptation to climate changes of agriculture and food industries

The ILMASOPU project aims at projecting comprehensive, regional future estimates of Finnish field and horticulture production, competitiveness and environmental effects in changing climate and global markets. This information will serve decision-making, business and anticipating actions.

KLIMZUG – Managing climate change in the regions for the future

This research programme is funded by the Federal Ministry of Education and Research in Germany (BMBF). The objective of KLIMZUG is the development of innovative strategies for adaptation to climate change and related weather extremes in regions. The anticipated changes in climate shall be integrated in processes of regional planning and development. Under KLIMZUG a number of projects are funded, some of them related to agriculture. For example, ”dynaklim – Dynamic Adaptation to the Effects of Climate Change in the Emscher-Lippe Region (Ruhr Basin)” is a networking and research project that carries out multi-disciplinary research on ‘dynamic’ adaption to the effects of climate change. The project focuses on the potential impacts on the regional water balance and the possible options to adapt for population, economy and environment.

A.2 Some peer reviewed research papers of relevance for BASE agricultural case studies

Arbuckle et al. (2013)

The study revealed beliefs of US farmers about climate change and their attitudes toward adaptive and mitigative action. Results show that the relationships between farmers’ beliefs and attitudes toward adaptive and mitigative action differ in systematic ways - farmers who believed that climate change is occurring due to human activity were significantly more likely to support adaptive action. Farmers who attributed climate change to natural causes, were uncertain or did not believe that climate change is occurring were less likely to support adaptation and mitigation strategies.

Asplund et al. (2013)

Analyse climate framing in two specialized farming magazines in Sweden 2000-2009 and the interpretation of the farmers. This aspect is relevant when analysing information flow to farmers in BASE.

Blom-Zandstra et al. (2009)

Explores the conflicting and synergistic properties of different climate adaptation strategies for agricultural and natural environments in the Netherlands. Might be of relevance for the analysis of WP2-WP7 questions.

Brouwer et al. (2013)

Analyses to what degree climate adaptation considerations are mainstreamed in the implementation of the EU Water Framework Directive through case studies in different European countries. Among the conclusions are that there is a huge variation in the degree of integration. Timely incentives and clear guidance is necessary to ensure progress, but “the adaptation agenda is open to abuse by those seeking to rationalise failures to fully implement the WFD has put a brake on the mainstreaming agenda”.

Bussey et al. (2012)

An Australian case study focuses on adaptive capacity in 33 historical case studies. It is demonstrated that adaptive capacity varies with context and is affected by the complexity, technology, leadership, institutions and imaginative resources inherent to the social system examined. Might be of relevance for BASE – in particular in the comparison of cases.

Ciscar et al (2011)

Focus in this study is on the economic damages of climate change. The article quantifies the potential consequences of climate change in Europe in four market impact categories (agriculture, river floods, coastal areas, and tourism) and one non-market impact – human health. A set of coherent high-resolution climate change projections and physical models are incorporated into an economic modelling framework. A welfare loss is estimated. The modelling can be used to prioritise adaptation strategies. The study might be of relevance in BASE.

Crane et al. (2011)

This study claims to be a counterbalance to modelling analyses of climate adaptation. It highlights how adaptive processes and technologies are more than simple technical responses to biophysical conditions. Methodologically, agriculture is considered as ‘performance’. Focus is on climate adaptation as a dynamic process which is socially embedded, in contrast to modelling studies of climate adaptation. Two case studies in Mali and USA are presented. The study might be of relevance when analysing BASE’ WP2-WP7-questions.

Farmer (2011)

Explores cross-scale governance between the EU and member states arising from the identification of key policy priorities by stakeholders in six river basins across Europe. One focus area is climate adaptation. The analysis identifies a number of information transmissions between the different governance levels. The study might be of relevance when trying to analyse BASE’ WP2-WP7-questions.

Frank et al. (2011)

Like Crane et al. (2011) this study tries to counterweight the modelling analyses of climate adaptation through use of motivation theory. It is proposed to add ‘social identity’ to the climate adaptation models. In-depth interviews with Mexican farmers showed that social identity mediates between risk perception and adaptation through its influence on motivation. Might be of relevance to BASE.

Gbetibouo et al. (2010)

The study analyses climate adaptation strategies of farmers in South Africa. Most important elements for farmers’ adaptive capacity were assessed. Might be of relevance to BASE.

Grothman et al. (2005)

Draws on literature from psychology and behavioural economics and develops a socio-cognitive Model of Private Proactive Adaptation to Climate Change, which separates the psychological steps to take action. Case studies in urban Germany and rural Zimbabwe are given.

Iglesias et al. (2012)

Iglesias et al. (2012) contains e.g. a qualitative evaluation of potential costs and benefits of a range of adaptation measures and rank them (low, medium, high).

Leclère et al. (2013)

A modelling study aiming to examine the intertwining processes in agriculture and nature across scales, from the global scale to farm level – by quantifying the effect of farm-scale autonomous adaptations in response to changes in climate. The modelling framework couples a crop model with the AROPAj microeconomic model of European agricultural supply. This study provides a first estimate of the role of such adaptations. It shows that farm-scale autonomous adaptations significantly alter the impact of climate change over Europe, by widely alleviating negative impacts on crop yields and gross margins. However, they also have an important and heterogeneous impact on irrigation water withdrawals.

Lewis et al. (2012)

Lewis et al. identify key positive/negative impacts of climate change on agricultural commodities like wheat and barley, but seem to be more focused on climate change effects than climate adaptation.

Logar and Bergh (2013)

The paper examines available methods for assessing all types of drought costs, including both damage costs (direct, indirect, non-market) and costs arising from adopting policy measures to encourage and adaptation to droughts and mitigation of droughts. The study also considers potential policies for drought mitigation and adaptation and different cost types associated with them. Authors suggest recommendations for good practices regarding the use of methods as well as drought mitigation and adaptation policies.

Mertz et al. (2009)

Case study of farmers in Rural Sahel (Senegal) which through focus group interviews and a household survey analyses the perceptions of climate change and the strategies for coping and adaptation among farmers. Among the conclusions are, that change in land use and livelihood strategies is driven by adaptation to a range of factors of which climate does not seem to be the most important.

Næss et al. (2005)

The article examines the role of institutions in climate adaptation in Norway – specifically towards flooding. Examples from two Norwegian municipalities are used.

O’Neill et al. (2011)

A study focused on agricultural water security. Six broad areas where agricultural research, education and extension can impact water management to achieve agricultural water security are presented.

Urwin and Jordan (2008)

The study focuses on UK case study adopting both a top-down and a bottom-up perspective. Analyses how other sector policies support or undermine potential adaptive responses. The top-down analysis is based on official documents and interviews with decision-makers. The bottom-up approach recognises the importance of other actors in implementation and interviews actors in three different sectors. One conclusion is, that neither of the approaches offers a complete picture of enabling and constraining effects, but together they offer a new perspective.

Ogden et al. (2008)

This study focuses on, how forestry plans are incorporating climate change in Southern Yukon, Canada. Among the conclusions are, that “neither of the plans available for the southern Yukon explicitly identifies climate change vulnerabilities and actions that will be taken to reduce those vulnerabilities and manage risks. However, both plans have incorporated some examples of 'best management practices' for sustainable forest management that are also consistent with appropriate climate adaptation responses”.

A.3 Research reports/books relevant for BASE agricultural case studies

Mickwitz et al. (2009)

This report analyses climate policy integration in six European countries through case studies. The analysis is focused on both mitigation and adaptation.

Swart et al. (2009)

A top-down analysis of national adaptation strategies in six European countries is presented. This report is structured around six key themes:

- Motivating and facilitating factors for climate adaptation strategy development
- Science-policy interactions and the place of research
- The role of communicating adaptation
- Multi-level governance in shaping and delivering National Adaptation Strategies
- The integration of adaptation into sectoral policies
- The role of policy monitoring, review and enforcement

Parry et al. (2009)

An evaluation of estimates of the costs of adaptation within different sectors made by the United Nations Framework Convention on Climate Change (UNFCCC) in 2007 and by some preceding studies.

Kerr et al. (2008)

A report presents a summary and review of past research on the economic effects of climate on agriculture in New Zealand. These estimated effects are compared with some new-collected data and used to build scenarios.

3 Policy solutions, coherence and analysis

By Anne Jensen (AU), Helle Ørsted Nielsen (AU)

Policy analysis has in the BASE case studies two main objectives; 1) to place the analysis of adaptation in a wider policy context in order to understand how more general policies facilitate or hinder adaptation in specific settings; and 2) to provide input for the wider analysis on adaptation policy conducted in WP2 and WP7. This chapter will address these two objectives and provide the theoretical basis for working with analyses of adaptation from a policy perspective. It should be noted that economic analysis and analysis of participation are not specifically targeted here as these are at the centre of other WPs and other chapters.

3.1 Introduction

The policy dimension of adaptation to climate change concerns governmental and other public measures taken to counteract the adverse impacts of a changing climate. In BASE, we will analyse these initiatives in particular cases of climate adaptation from multiple perspectives, including an economic CBA perspective, a perspective on proactive participation and an adaptive capacity perspective. The cases cover a range of examples of climate adaptation at different stages of maturity, at different scales and they furthermore address different types of impacts and different sectors. It is therefore essential that the case study analyses are very clear as to what a case is a case *of* (adaptation in a specific sector; adaptation success/barriers, drivers; adaptation actors; etc.).

After this introduction, adaptation to climate changes is discussed as an issue of multi-level policy making, followed by a discussion of adaptive capacity of national and local governance institutions, stressing the significance of climate policy integration. The next section assembles this perspective on policy analysis of climate adaptation in key issues that must be addressed which in chapter 6 leads to the formulation of key questions that can assist the individual case studies. Through addressing questions, i.e. one or more, within each key issue, each case study will provide insights and produce the data needed for WP2 and WP7.

3.2 Objectives of the policy dimension of the BASE case studies

The aim of the policy perspective is for the case studies of BASE to be able to identify the drivers of appropriate adaptive actions implemented by policy institutions, specific to each case study as well as aggregated across case studies, done through examination of the adaptive capacity. The case studies therefore generate an overview of factors and conditions that have prompted policy actions to manage the impacts of climate change and upon which future actions can be built. To investigate the policy dimension, we need to specify the theoretical framework for understanding the role of policy. Moreover, we need to specify what the cases represent in light of the policy framework in order to be able to address specific questions to the case study methodologies and data (in other words: why were these cases and not others chosen? How will these cases help us understand the role and the determinants of climate adaptation policies)?

Crucially, the questions for policy analysis found in Chapter 6.3 should be seen as research questions supporting the analyst in searching for meaningful answers on the adaptation observed in the case. This also means that analysts can and often should adapt the questions in a way that best suits their case study approach.

However, when answering the questions the analysts must make clear the type of data (qualitative/quantitative, primary/secondary) and methods (e.g. interviews, documentary analysis, participant observation) that were used. This requirement is crucial in order for the case analysis findings to be used in the best way by other parts of the BASE project especially for comparison of the case studies to ensure that the studies jointly produce scientifically valid knowledge. Also some of the questions – as is indicated in chapter 6.3 below – are more suited to retrospective case studies, others are more suited to on-going/prospective case studies, while others are suited to both. Each case study is, as noted, not expected to address all the relevant questions; however it is expected that all case studies address all of the headline questions to in some way and as many of the questions to be answered as possible.

The approach argued below takes the literature on multilevel governance – more specifically recent work on climate policy integration (Adelle and Russel, 2013) - as point of departure and uses this to formulate the framework of adaptive capacity, on the basis of which core areas to include in the policy analysis of the case studies are identified. Textboxes suggest questions for the investigation of each area. Moreover, a textbox suggests feasible methods for the policy analysis of adaptive capacity of governance institutions. The questions that relate to CBA and participation are mainly addressed in Chapter 4 and 5, respectively. In this chapter, participation will only be included to the extent that it connects to adaptive capacity.

3.3 Adaptation actions and multi-level governance

The impacts of current and predicted climate changes present challenges for societies that in scope reaches beyond most policies, and adapting to these requires on the one hand consideration of the policy context of adaptive policy-making (Urwin and Jordan, 2008) and on the other a rethinking of policy making and the development of novel policy practices. Adaptation takes place in the interaction between policy/governance institutions, social actors, including business, citizens and other stakeholders, and the physical and natural environment. Hence, multiple actors with different interests and objectives are involved in the development and the implementation of adaptive policy actions. In addition, analysing climate adaptation policies and strategies, we confront an inherently complex policy area which furthermore is marked by strong uncertainty and high urgency; the former not to be understood as uncertainty of the knowledge it-self but rather in the lifespan of the knowledge that concerns the actual impacts of climate changes at a global level as well as in localized areas.

Furthermore, adapting social systems to the impacts of a changing climate involves governance across multiple levels of policy making, from European policies to local scale. Authors stress that policies made at European, national or regional scale may enhance as well as impede adaptive policy actions at local scale (Næss et al., 2005, Urwin and Jordan, 2008). The relationship between different levels of government thus needs to be considered in relation to adaptation policy. This is especially the case with research on the European Union (EU) as it is widely considered to be a multi-level system of government (Benson and Jordan, 2007) with decision making occurring from the council of ministers right down to the localised neighbourhood levels. Generally speaking, multi-level governance characterises two interrelated processes: ‘multi-level’ refers to the increased interdependence of governments operating at different territorial levels (Marks and Hooghe, 2004); ‘governance’ broadly refers to the patterns, activities and process of social, business, political and administrative actors to steer society (see Jordan, 2008). Thus, multi-level governance presents a patchwork of actors operating at different tiers of the political system, in this case the EU. Why does this matter in the context of adaptation?

First, adaptation is an emerging area of EU policy activity and hence there is a patchwork of adaptation strategies in Member States and the regions, with some member states not even having a concrete strategy. Even with the emergence of the EU strategy, there will still be a diversity of approaches employed across the EU as climate adaptation is only an emerging area of EU policy competence. Second, the EU adaptation strategy is primarily geared towards influencing EU level policy in relevant sectors (e.g. water, agriculture, marine and coasts, biodiversity). In these sectors the EU has policy competency which means that EU-wide policies must be followed. Crucially, these sectoral EU policies can both facilitate and constrain what can be done to adapt nationally and locally. For example, Brouwer et al. (2013) suggest that local level adaption in the water sector is in part hampered by inconsistencies on the issue adaptation in the

Water Framework and the failure of EU agricultural policy to address the intensive water use practices of the sector. Likewise, national policies can bind local-level actions. Third, multi-level governance implies that a range of actors need to be engaged with adaption strategies at all levels of government. Drawing on the principles of multi-level governance therefore, a critical question for the case studies is: "**How is climate adaptation understood by different actors at different governance scales ?**(see Chapter 6.2).

In addition to the interaction between different levels of governance, the level of climate governance has individual relevance for adaptation policy and mitigation policy. The distinction between climate mitigation policies as collective action problems which must be addressed at super- and supra-national level through international negotiations and agreements, and climate adaptation policies which are implemented locally as part of land use, water management, infrastructure provision, etc. has led to that authors often delegate main mitigative policy actions to the national or super-national level while adaptive policy actions have been allocated to local or regional levels (Mickwitz et al., 2009). Likewise, adaptation is an issue of a range of interrelated sectors and policy areas (Kok and de Coninck, 2007), bringing policy integration, spill-over effects as well as direct impacts into focus (Urwin and Jordan, 2008). Mainstreaming of adaptation issues into sectorial development may offer synergies while there also exists a risk for mal-adjustment, impeding adaptation policy (Kok and de Coninck, 2007).

Policy actions that address the impacts of climate change involve to varying extent these issues related to multilevel governance and multi-sector policies, and are furthermore embedded in existing policy institutions and policy areas. In this chapter, the basic premise is that drivers of policy action are fundamentally linked to the ability of policy institutions to address the core challenges of a changing climate and develop apt policy responses. Considering that management of the impacts of climate change takes place in a context of complexity and diversity, and considering that our case studies and case study research teams include rather diverse approaches, a general framework to address the analysis of adaptive policies of the included cases is to examine ***adaptive capacity*** in the cases.

3.4 Adaptive capacity of local governance

Adaptive capacity is based on notions of resilience and adaptation, and the analysis of adaptive capacity specifies conditions that potentially reduce vulnerability to climate impacts (determinants of adaptive capacity). To apply adaptive capacity in the analysis of adaptation policies provide a dynamic perspective on issues also discussed in terms of vulnerability (Yohe and Tol, 2001) and resilience (Davoudi et al., 2012) (Dodman and Satterthwaite, 2008) (Heazle et al., 2013). Managing climate change is conditioned by the ability of governance institutions to cope and manage the challenges posed by climate change impacts, or in other words, the adaptive capacity of policy institutions at multiple levels of governance. IPCC understands adaptive capacity to comprise the 'ability of a human-environmental system to adjust to climate change, moderate potential damages, take advantage of opportunities, and/or cope with consequences' (IPCC, 2001). Also Ivey et al. (2004) conceptualise adaptive capacity to denote a flexible systemic character which exists and develops in the interaction with external properties and processes. They thus understand adaptive capacity broadly to be 'the potential or ability of a system, region, or community to adapt to the effects or impacts of climate change' (Ivey et al., 2004 :3566).

Adaptive capacity thus encompasses a *potential* which is realize in particular actions and situations, often when the governance institution is under stress (Yohe and Tol, 2001). This potential to adapt concerns different time-frames, ranging from short to long term, and may include adaptation and adaptive actions at and across multiple scales. As an ability to carry out means that reduce vulnerability to (future) impacts of climate change, adaptive capacity is embedded in the system and equally an adjustable character, that impact on how well suited process of climate adaptation policy making and implementation of these, and the outcome/output of climate adaptation policy processes are to address the challenges of counteracting the impacts of a changing climate. Tinch et al. (2012) identify three areas that are included in adaptive capacity; Absorb and recover from stresses; Alter exposure to climate change risks, and; Acknowledge and take advantage of new opportunities.

Furthermore, adaptive capacity is dynamic and stresses the *flexibility and learning* of governance systems or institutions in situations of stress or crisis or when faced with novel challenges (Pelling et al., 2008). Not surprisingly, adaptive capacity is therefore linked to the character of **existing governance institutions**, where features of good governance are especially significant; decentralisation and autonomy, transparency and accountability, responsiveness and flexibility (Dodman and Satterthwaite, 2008). Moreover, examination of adaptive capacity is based on thorough knowledge of the case. We must further include an additional step of assessing what is implemented or achieved by particular adaptive initiatives or adaption approaches/strategies.

Significantly, adaptive capacity is responds to changes in economic, social, institutional and political environments over time (Yohe and Tol, 2001), emphasising learning as a central aspect of adaptive capacity, i.e. social and policy learning is intrinsic to building, maintaining, utilising and benefiting from a governance system's ability to adapt to the impacts of climate change. Events originating in the economic, social, institutional and political environments may lead to a narrower coping range. Also, cumulative effects of increased frequency of events that are not met by adequate changes in the adaptive responses may lead to a situation for example where a city or the sector goes beyond the threshold for adaptation, catalysing major changes. Furthermore, unforeseen side-effects may impede adaptive capacity, just as determinants of adaptive capacities intertwine across scales. Thus, it is important to recognize that successful climate change adaptation and vulnerability reduction are rarely undertaken with respect to climate change alone, and vulnerability reduction appears to be most effective if undertaken in combination with other strategies and plans at various levels (Smit and Wandel, 2006 : 289).

Moreover, the dynamic character of adaptive capacity means that the analysis should also address **institutional perceptions of climate adaptation**, i.e. the ways in which climate change and possible measures to adapt to its impacts are understood, conceptualised and integrated into the norms and practices of climate policy making/planning (Adelle and Russel, 2013, Burch, 2010, Smit and Wandel, 2006, Yohe and Tol, 2001, Jensen et al., 2013). For example, studies of the adaptive capacity of particular governance institutions stress the role of knowledge as vital for understanding and improving the adaptive capacity of especially local and regional governance institutions (Nilsson and Persson, 2003). A fuller understanding of the position and role of knowledge and forms of knowledge as open for amendments and re-conceptualisations, as for example when CBA, risk analysis and innovative clean tech networks becomes central in climate adaptation policies or new approaches to engaging citizens in implementing adaptation policies are integrated in adaptation policy making, adds to a solid conceptualisation of adaptive capacity.

In addition, while climate change already appears to cause catastrophic events, the larger consequences of climate change are often framed with a view to 2050 or even the end of the century. Combining with the uncertainty about how, when and where climate change will show presents a challenge for bringing climate adaptation to the forefront of crowded policy agendas (Næss et al., 2005), which brings a focus. At the same time the complexity of climate change underscores a need for bringing climate adaptation out of the isolated position as one among many pressing environmental policy areas, and engage measures and decision making across a range of sectors and levels of policy. This places the concept of climate policy integration at the core of policy analysis and policy formulation while a robust, elaborate and operationalized conceptualization of climate policy integration is only emerging (Adelle and Russel, 2013).

In linking climate adaptation strategy to the concept of CPI the underlying premise is that climate impacts are far reaching with cross-sectoral implications. Moreover, sectoral responses to potential impacts can by undermined by conflicts with policy existing within a sector, or negative policy spillovers between sectors. For example with the former, an oft quoted example is that of biodiversity policy where objectives to maintain a rare habitat *in situ* conflicts with the adaptation strategy of allowing habitats to migrate northwards in response to warmer temperatures. An example of a between sector conflict might be seen with water policy where efforts to adapt to reduced water availability may be undermined by consumer protection policy which seeks to drive down water prices and thus provide little incentive for domestic water conservation. CPI is a strategy which seeks to identify such conflicts as well as to identify policy synergies to encourage a more coherent cross-sector approach to climate change adaptation (Adelle and Russel, 2013).

Mickwitz et al. (2009) define climate policy integration (CPI) on the basis of the classic definitions provided by e.g. Lafferty and Hovden (2003). In this conception, CPI concerns ‘the incorporation of the aims of climate change mitigation and adaptation into all stages of policy-making in other policy sectors; complemented by an attempt to aggregate expected consequences for climate change mitigation and adaptation into an overall evaluation of policy, and a commitment to minimize contradictions between climate policies and other policies’ (Mickwitz et al., 2009). They stress that CPI can be measured through the extent to which specific criteria are met (Jordan and Lenschow, 2010).

However, Adelle and Russell advance a more process-oriented perspective on CPI which is more aligned with our approach. They differ between ‘traditional environmental/climate policy to include ‘command and control’ type regulation and environmental/climate policy integration to consist of ‘softer’ modes of governance such as strategies, policy appraisal, budgetary tools and voluntary instruments’ (Adelle and Russel, 2013:2). The basic point of departure for the authors is that ’the concept [of CPI] clearly implies a relatively strong revision of the traditional hierarchy of policy objectives’ (Adelle and Russel, 2013: 5-6), thereby implying both theoretical and practical (i.e. policy relevant) basic defining feature; that the challenges of climate change are so fundamental and severe that their management implies a rethinking of policy and the way policy institutions work. Adopting Jordan and Lenschow (2010)’s framework for conceptualizing *environmental* policy integration, three dimensions are applied to narrow down CPI; CPI as an understanding of and a commitment to include climate policy objectives in policy making across sectors, as a process of governing or as an outcome of policy.

CPI as a basic understanding underpinning policy making directly refers to the vital aspects of forms of knowledge in framing and processes of policy learning which condition the field of policy options (Jensen et al., 2013). In the case studies, it entails examining how adaptation is **framed in strategies and understood by different actors** and particular in relation to the **underlying philosophy of the adaptation approaches** followed (see policy questions in 6.2).

The second dimension for approaching CPI as a continued process of governing includes the logic of intervention of climate policies, involving both institutional mechanisms for coordination as well as policy learning through interaction and knowledge exchange (Jordan and Schout, 2006) as a latent but entrenched part of governing. In this respect, integration of new policy framings or re-framing processes across policy sectors inherently involve policy learning, enhancing or building sector capacities for addressing or managing climate policy issues. Crucially, knowledge use and exchange underpins this integration process by identifying within and between sector policy conflicts, impacts and spillovers through which learning, cooperation and reframing can occur (Jordan and Schout, 2006). Without such knowledge policy integration could not occur in a systematic manner as decision makers would not know what the key inter-sector and cross–sector impacts and integration concerns are. Thus dialogue and learning between officials and stakeholders would be limited. Crucially, knowledge use and exchange underpins this integration process by identifying within and between sector policy conflicts, impacts and spillovers through which learning, cooperation and reframing can occur (Jordan and Schout, 2006). Without such knowledge policy integration could not occur in a systematic manner as decision makers would not know what the key inter-sector and cross–sector impacts and integration concerns are. Thus dialogue and learning between officials and stakeholders would be limited.

While climate mitigation studies repeatedly point at the urgent need for not only adjustments and incremental policy learning but for fundamental social, economic and political transitions, it is however en open question whether climate adaptation issues can be managed through a re-articulation of policy-making with inclusion or repositioning of other forms of knowledge than were previously dominating, i.e. a reframing of policy making. It is thus important for case studies to examine **how knowledge is used** (see Chapter 6.2). Crucially, knowledge exchange also requires that suitable institutional structures (e.g. leadership and commitment), mechanisms (e.g. inter-sector committees) and tools (e.g. impact assessment) are in place to facilitate learning, knowledge exchange and reframing around adaptation.

Integration of climate adaptation requires that such structures, mechanisms and tools help decision makers prioritise climate adaptation (and climate mitigation), facilitate both coordination across and within sectors, and encourage learning around forms of knowledge that link climate issues to other policy issues. For this reason it is important that the case studies consider questions around different types of **leadership** occurring, the **institutional environment** in which adaptation occurs and processes in place for **steering adaptation sustainably.**

Jordan and Lenschow (2010) note that the third component, assessing EPI as a policy outcome, is largely lacking in the literature. But they do point to evaluation criteria such as creation of administrative capacities or evaluation bodies, which may also be applied to the BASE studies of CPI. But standards for measuring the degree or character of CPI are underdeveloped in the literature. In BASE we suggest using adaptive capacity as ameasure of CPI.

Practices, i.e. routinized ways of doing things, and tradition for participation, including who is involved in decision making in the different phases of adaptive policy making and with respect to which type of decisions, are included in political culture and framework, and for our purpose it is helpful to include question on the **engagement of stakeholders**, including citizens, NGO's and business, as an additional focus area for the case studies.

This overview of the literature of adaptive capacity, climate policy integration and multilevel governance can be summarized in the following key factors that determine adaptive capacity. Of course, it goes without saying that the determinants and their relative influence are interdependent, and factors are interacting and not mutually exclusive. At a very general level, these comprise a cocktail of (Smit and Wandel, 2006 :287, Adger and Vincent, 2005, Yohe and Tol, 2001).

- Perception of and experience with adaptation/climate change impacts
- Extent and form of climate policy integration
- Available knowledge and the use and integration of knowledge,
- Institutional environment, including robustness of institutions, climate adaptation policy institutions at other policy levels, political system
- Managerial ability, including leadership and formal institutions
- Political culture and framework, e.g. flat or hierarchical, trust, tradition for participation
- Engagement with stakeholders/the public, including citizens, business, communities, associations, other local governance actors
- Networks (professional and governance) and, for adaptive capacity at household level, in particular also kinship and social networks
- Financial resources, including budgets, allocation of funding
- Technology resources and innovation,
- Infrastructure, including surface/waste water, but also communication, transport and energy

In addition, the importance of the individual factors is dependent on the ways in which they are applied, i.e. case specific ways that information/knowledge, technology, policy cultures, legal frameworks, institutional capacities, infrastructures, networks, etc. are activated and included in strategies and initiatives to adapt to climate impacts.

Adaptations are manifestations of adaptive capacity and it is perhaps instructive for evaluation of adaptive capacity to classify **adaptive actions** along five dimensions (Smit and Wandel, 2006 : 288) timing relative to climate impacts: anticipatory, concurrent, reactive;

- Timing relative to climate impacts: anticipatory, concurrent, reactive
- Intent: autonomous or planned;
- Spatial scope: local, regional, national, European;
- Form: behavioural, informational, institutional, technological; and
- Degree of adjustment: from minor alterations to abandonment of activity.

3.5 Key Governance and policy issues to address in case studies

Based on the above overview of the adaptation governance and policy literature, three *overarching questions* guide the policy related analyses in the case studies:

- What seems to determine the adaptive capacity (and vulnerability) in the case?
- How successful are the cases in advancing adaptation (adaptive capacity/reduction of vulnerability)?
- Which factors should one pay attention to in efforts to increase adaptive capacity?

Case analyses that respond to these overarching questions will provide knowledge for WP2 and WP7 that both have a main focus on the role of policies and policy implementation, as this leads to considerations of the policy implications of specific sorts of policies (i.e. how should policies be designed?), institutions, administrative mechanisms and tools (i.e. what institutions/mechanisms/tools seem necessary/how should they operate?), resources (i.e. what resources are critical?) and how can success be determined.

The basic level of questions concerns the process and is formulated to allow, as far as possible, unambiguous responses with the documentation of “evidence” of the adaptation process. The questions aim to help the cases formulate a narrative of “what is going on” in order to provide a wider context for how policies contribute to (or hinder) the adaptation processes and actions at the case level. The overview of the adaptation governance and policy literature is summarized in following the key factors, addressing the determinants of adaptive capacity, and should guide the case-specific design of the case data production and analysis

- Basic description
- Understanding of climate adaptation (perception of climate adaptation/ /knowledge):
- Institutional environment (networks/policy culture)
- Leadership (managerial ability):
- Managing and steering adaptation sustainably
- General philosophy/underlying approach/strategy in the adaptation planning/action in the case
- Knowledge
- Engagement of the public (stakeholders and citizens)
- What is the impact/effect of studied case? (All)

A set of questions relating to the above key factors for determining adaptive capacity is formulated in Chapter 6.2. Again, it is important to stress that the relative weight of the different questions is determined by the nature of the individual case study. The extent to which each case study engages with the individual questions in each group varies and depends on the case study cluster, i.e. what is central issues for one cluster may be less apt for another; the nature of the case *per se,* i.e. the scale and extent of policy intervention and the progress of policy initiatives to manage climate impacts; and on the design of the individual case study, i.e. what are stakeholders and case owners engaged with in the case and what is of particular relevance for the individual case study. However, all cases should respond to each group of questions at some level.

4 Guidance for economic evaluation of adaptation options in the case studies

By: Volker Meyer (UFZ), Oliver Gebhardt (UFZ), Jenny Tröltzsch (EI), Aline Chiabai (BC3), Anil Markandya (BC3), Filipe Alves (FFCUL), Timothy Taylor (EU), Nina Becker (UFZ), Clemens Heuson (UFZ)

4.1 Introduction

The main objective of this chapter is to provide guidance for the BASE case studies on economic evaluation of adaptation measures which is one of the main aims of BASE. The case studies are highly diverse in terms of the climate change impacts they are facing, affected sectors, potential adaptation measures, data availability on costs and benefits, and so on. Therefore, a complete harmonisation of the economic evaluation approach in all case studies is neither possible nor desirable. Instead, at least a common stepwise procedure is recommended, to ensure as much comparability and transparency as possible.

This stepwise procedure was originally developed by UFZ (Gebhardt et al., 2012, BMVBS, 2013) as guidance for German municipalities to evaluate adaptation options. As such, it aims to be quite simple to apply, accounting for a great diversity in data availability and uncertainties. It does not recommend one evaluation method but gives room for several ones, such as cost-benefit analysis, cost-effectiveness analysis and multi-criteria analysis.

The procedure is adjusted for BASE with the help of several BASE partners. Apart from giving guidance to each case study and ensuring at least some degree of comparability it should furthermore ensure that data is provided which is required by the models from WP3 applied in WP6 for a large-scale evaluation of adaptation pathways. The stepwise evaluation procedure is briefly illustrated in section 4.1.1. Each step is then described in the following sections, illustrated by a case study example. A further case study example is described in section 4.7.

As this guidance aims at supporting ongoing decision making processes in the various BASE case studies it is primarily addressing ex ante cases. Nevertheless, it can also be applied in retrospective case studies for analysing the efficiency of adaptation measures and stakeholder preferences from an ex post perspective.

Although there is no explicit discussion of participatory methods in this chapter (for details in this regard see chapter **Error! Reference source not found.**), it is assumed that there is some kind of stakeholder and/or decision maker involvement at the various stages of the evaluation process. The extent of the involvement depends on the specific decision making context as well as on the evaluation method chosen. In general it can be assumed that multi-criteria analysis offers the greatest variety of options for this kind of involvement. Despite this focus, the use of participatory methods in the decision making process is not a prerequisite for applying this guidance. The only constraint for non-participatory ex ante or ex post case studies is that if a multi-criteria analysis is to be carried out assumptions regarding the preferences of the stakeholder(s) and/or decision maker(s) have to been made.

4.1.1 Stepwise procedure for the economic valuation and prioritization of adaptation measures

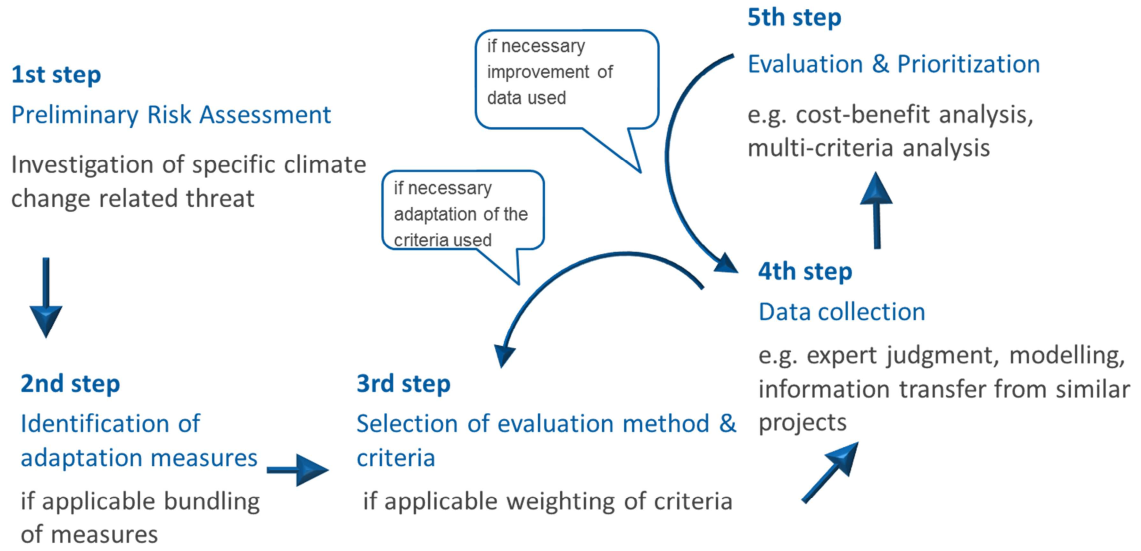


Figure 12 steps of the economic evaluation process

- Figure 9 shows the five steps of the evaluation process. These steps will be described in the following and illustrated by a case study example.
- Depending on data availability, flexible adjustments of the process are possible:

1. Adjustment of evaluation criteria (feedback loop step 4 to step 3)
2. Improvement of data basis, e. g. by reducing uncertainties, if prioritization results are ambiguous (feedback loop step 5 to step 4).

4.1.2 Example: heat in the city – Short introduction

- Redevelopment of a central urban square (‚Eichplatz‘) in Jena, Germany
- Centrally located square in the city centre of Jena with a total area of 1.6 ha
- Currently mostly black asphalt sealed surface area (parking area) with a low share in green areas

Figure 13 Present parking area on the 'Eichplatz' square

- Measures to reduce heat stress are to be integrated in the redevelopment of the area.Objective: Comparison of potential measures regarding various aspects which are of relevance to local decision makers.

4.2 Step 1: Preliminary risk assessment

Problem definition

For problem definition the following questions should be answered:

- Which problems already exist, what is/are the current risk/s? Does your case study have a single or multi impact focus?
- What is at risk? Which assets are of relevance within the geographic context of our study?

- This includes land values, buildings, infrastructures, natural capital, and social capital. How has the value of those assets evolved in the past and why?
- Which areas are affected? If possible provide maps and sectoral disaggregation of impacts.
- Which sectors are affected? Does your case study have a single or multiple sector focus?

- How do these risks presumably change due to climate and socio-economic change?
  How do asset at risk and their value evolve with these changes? Why? Compare with surrounding environment and take into consideration the new climate change and socio economic scenarios.
    - For ex-post case studies: describe climate scenarios and socio-economic change scenarios used as well as expected impacts.
    - For on-going and prospective case studies: use new scenarios for climate and socio-economic change provided by WP3 (CMCC).

- What timeframes are considered in the cases and how do they relate to the timeframes proposed by WP3&6: short-term 2015-2030, mid-term 2030-2050, long-term 2050 to 2100?

How to do this

- Existing problems: analysis of past events

  Current risk situation: Refer to existing risk or vulnerability studies
- Assets at risk, including areas and sectors: asset definition and asset mapping
    - Identify assets which already do exist within the geographic context of your study. This includes land, buildings, infrastructures, natural capital, and social capital. Depending on the nature of the assets (private, public) all information should be available in companies' financial reports, public assets reports, and land value estimations, e.g. by banks. If data regarding natural and social capital is not available simple mapping might be sufficient.
    - Identify key assets for the economic, natural and social resilience of the community and key stakeholders who are legally responsible and/or have vested interests with regard to the respective area. This can be done through inquiries to the local community.
- Expected changes in risk due to climate change and thus assets at risk:

  Refer to existing studies on climate change impacts and vulnerabilities; plus new IPCC AR5 climate scenarios (downscaled data can be provided by CMCC), and socio-economic scenarios.

  If such studies are not available:
    - Can WP3-models provide results for your case studies?
      According to the data exchange plan from WP3&6 it is planned that each WP3 model is applied in at least one case study.
    - Own modelling/risk assessment, if possible.
    - Interviews with experts on expected climate change impacts.

Example, step 1

Preliminary risk assessment

- Jena is particularly exposed to heat stress and flooding due to its geographic location in the Saale valley surrounded by shell limestone slopes.

- Highest level of thermal stress experienced in the city centre during the summer months.
- Increase of mean annual temperature of 1,2K over the past 100 years.
- Heat stress is expected to increase on the basis of climate projections:
    - Projected increase in mean annual temperature.
    - Projected increase in number of days with temperature$_{max}$ ≥ 30°C from 10-12 days/year to 19-20 days/year until 2050 (STAR, WETTREG2010)

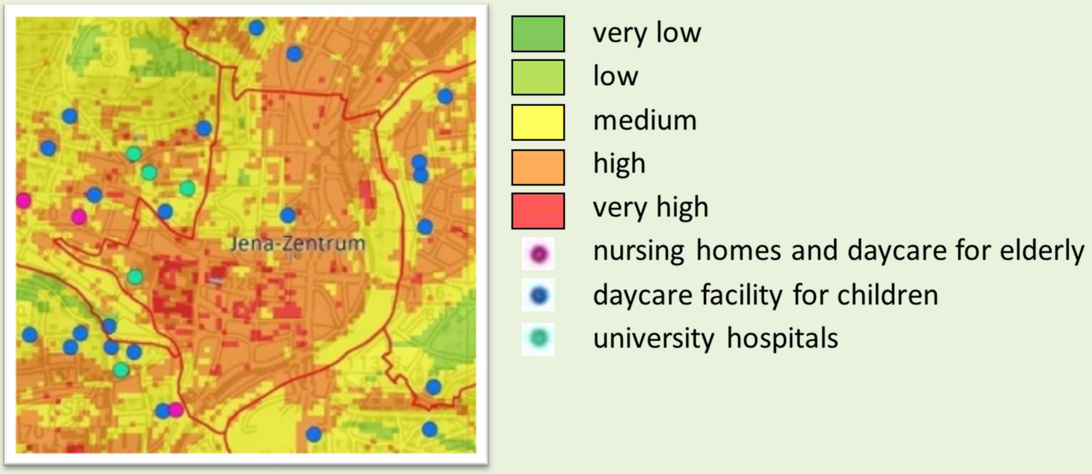


Figure 14 Risk of heat stress in the city area of Jena based on the degree of sealed surface, building structure, global radiation, local and regional wind system

Source: ThINK (2011)

4.3 Step 2: Identification of adaptation measures (and pathways)

Objectives of measures

- Before designing specific measures the objectives of adaptation in the case study should be described:
    - What is the primary objective of adaptation?
      (e.g. flood risk reduction, heat stress reduction, …)
    - Are there other objectives to be considered?
    - The different objectives are the basis for the development of evaluation criteria (cf. step 3a)

Potential measures

- To gather important potential measures the following questions should be considered:
    - Which measures could fulfil the objective(s) (short-term, long-term measures)?
    - Are there adaptation measures already in place?

- o Are there already other measures from distinct planning procedures in place which could implicitly contribute to the adaptation objective(s)?
- o Which measures may provide benefits also in the absence of climate change or climate variability? Distinguish no regret, low regret and regret options.
- o Which measures may result in co-benefits that are only indirectly linked with the primary adaptation objective? What co-benefits could be achieved?

- Appropriate measures should be selected in close cooperation with experts from the different sectoral planning bodies, such as: department of city/regional administration, etc.
- Measures should be described in detail and clearly distinguished from alternative options.
- If possible, displaying the measures on a map helps to better describe the measures and to show if measures are mutually exclusive.

Baseline option

- In particular for cost-benefit analysis (see step 3), a baseline option needs to be defined. All other measures are compared to that baseline option, i.e. benefits and costs are always related to this baseline option.
- The typical baseline option is “business-as-usual”, i.e. it is assumed that e.g. the current protection level is maintained for the evaluation timeframe.

Bundles of measures

- Depending on the problem and measures selected it can be reasonable to build bundles of complementary measures. Bundles should consist of complementing measures which can belong to the same sector, but can also consist of measures of different sectors. Furthermore, the measures can have the same adaptation target, e.g. reducing soil erosion in agriculture by intercropping and buffer strips. But if quite general adaptation targets exist such as increasing the climate resilience of a city, the bundle of measure can also focus on different adaptation targets.

Adaptation pathways

- See dynamic adaptive pathways approach by Haasnoot et al. (2013), requires the definition of adaptation tipping points and “sell-by” dates of measures.
- There will be guidance on the dynamic adaptation pathways approach provided by Deltares.

Example, step 2

Objectives of the measures

- Overall objective: Increase wellbeing at Jena´s central square
- Main objective: Heat stress reduction within the context of the redevelopment of a central urban square in Jena (‘Eichplatz’)
- Further objectives:
  - o Attractive design of the square
  - o Consideration of other aspects, such as great durability, synergies with other adaptation measures etc.

Possible measures

- Greening, in particular:
    - Roof greening
    - Facade greening
    - Bucket-grown plants
- Shading, particularly by the use of:
    - Trees
    - Excess length of roofs
    - Awnings
- Expanse of water:
    - Fountain
- Reflectance of surfaces:
    - Light-coloured pavement

Bundles of measures

- Not applied in this case study

Adaptation pathways

- Not (yet) applied in this case study

4.4 Step 3: Selection of evaluation criteria & evaluation method

4.4.1 Step 3a: Selection of evaluation criteria

- Which positive and negative aspects should be considered in the evaluation of measures?
- Evaluation criteria should reflect all relevant positive effects (benefits) but also the negative effects (costs) measures could have.
- Already at this stage it is reasonable to define in which unit/ on which scale each criteria should be measured, i.e.
    - Monetary units
    - Other quantitative units
    - Qualitative statements, ordinal scale

Potential benefit criteria

Different benefit components can be:

- Avoided damages (at buildings, yields, insured persons, environment)
- Change of recreational function, tourism
- Change of potential for development
- Change of biodiversity and ecosystem services

- Change of values of goods or land
- …

- All benefit criteria can be expressed in terms of:
  - Annual average damage avoided economic, environmental and social risks avoided); if benefit component spreads a lot between different years (large gap between implementation and effect of the measure): discounted value of benefits should be used (see annex 1 on cost-benefit analysis)
  - Or percentage of target achievement
  - Or effectiveness in qualitative terms

Potential cost criteria

Different cost components can be:

- Investment costs
- Re-investment costs
- Running costs, operation and maintenance costs
- Transaction costs, i.e. costs associated with the design and implementation of measures, e.g. effort for participation and communication, negotiations, solving conflicts and other administrative costs (often not or not easily measurable in monetary terms)
- Other negative side-effects, such as negative environmental and social effects of the measures. I.e. building a dike reduces flood risk but could also have negative impacts on floodplain ecosystems.
- …
- All monetary costs criteria can be aggregated to the net present value of costs (discounted value of costs, see annex 1 of this chapter on cost-benefit analysis)

Potential further evaluation criteria:

- Urgency:
  - Timescale: At what timescale does action need to be taken?
  - Time until measure becomes effective (time-lag between implementation and effect of the measure)
  - Lifetime of a measure (usually the measure with the longest lifetime determines the evaluation period)
- Benefits in the absence of climate change or climate variability (no regret, low regret and regret options)
- Synergies or conflicts with other measures
- Co-benefits in other areas (not determined as primary objective(s): economic, *(e.g. effect on employment),* environmental *(e.g. climate mitigation)*, social *(e.g. distributional impacts, quality of life)*)
- Relevance of the measure: How important is the climate change threat addressed by the measure? (What economic values, ecosystem functions and socio-cultural values are at stake, and to what

extent are they affected by climate change impacts? Is there an indication of overriding public interest, e.g. critical infrastructures, public health?)

- Windfall profit: Would or at which part would private stakeholders implement the measure autonomously?
- Dynamic incentive: Does the measure initiate further activities for adaptation to climate change?
- Acceptance: Is the measure accepted by the society and policy makers (see also transaction costs)?
- Robustness: Is the measure effective under different climate scenarios and different socio-economic scenarios?
- Flexibility: Can the measure be adjusted according to changing conditions

Example, step 3a

Definition of evaluation criteria: costs and benefits

Determination of appropriate evaluation criteria and categories of the characteristic attributes in agreement with local stakeholders

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Measure: ....

Description					
....					
Criteria	**Criteria values**				
Lifetime	.... years				
	very high	high	moderate	low	very low
Technical effort	very low	low	moderate	high	very high
Time required for implementation	up to 1 month	up to 1 year	up to 5 years	more than 5 years	
Investment costs Re-investment costs (100 years) Running costs	..........€ ....€ ....€ p.a.				
Cost bearer(s)					
Effectiveness regarding decrease of thermal load	very high	high	moderate	low	very low
Time span for measure to be effective	less than 1 year	up to 1 year	up to 5 years	up to 10 years	more than 10 years
Dependency of benefit on climate change	no-regret	low-regret	regret		
Synergies with other measures	highly synergetic	synergetic	no synergies		
Conflicts with other measures	non-conflicting	conflicting	highly conflicting		
Co-benefits	high	moderate	low	no	
Assessment of feasibility by					
Local politicians	desired	no rejections	controversial		
Citizens	desired	no rejections	controversial		
Authorities	desired	no rejections	controversial		

Table 14 Evaluation form for individual measures

- Present value of costs (considering a 3% p.a. discounting rate of investment and maintenance costs over a period of 100 years)
- Transaction costs: qualitative evaluation of planning and implementation efforts (including potential resistance of interest groups)
- Qualitative evaluation of the effectiveness of an individual measure for reducing heat stress, of the time until the effect takes place, and of likely synergies and conflicts with other adaptation measures

4.4.2 Step 3b: Selection of evaluation method(s)

- The selection of an appropriate evaluation method(s) should be based on
  - Type of evaluation criteria
  - Data availability
- Accordingly, the following questions should be answered to find an appropriate approach:

- Is it possible to express all relevant cost and benefit criteria in monetary terms?
  - ➢ **Suggested method: Cost-benefit analysis** (see annex 1 for a detailed description)
  - Comparison of all monetary costs and benefits for each measure
  - The annual average damage avoided by the measure is usually the main benefit-related criteria.
  - Decision rule: the measure with the highest net present value (net present benefits minus net present costs) is selected.
- Is it possible to express the positive effect (objective) by a single non-monetary indicator?
  - ➢ **Suggested method: Cost-effectiveness analysis** (see annex 1 of this chapter)
  - Monetary costs are related to the percentage of target achievement ('effectiveness')
  - The method can only be used if measures for the same concrete target will be compared, like reduction of 1°K of heat stress in a house/neighbourhood, reduction of certain amount of substance concentration in water.
  - Decision rule: the measure is selected which achieves the target with lowest costs (or with the best relation of degree of target achievement to costs)
- Are there are several relevant objectives (or criteria) which include also criteria which cannot be (or cannot be easily) expressed in monetary terms?
  - ➢ **Suggested method: Multi-criteria analysis** (see annex 1 of this chapter)
  - Aggregation of criteria with different units (EUR, cm, % etc.)
  - Multi-criteria analysis usually requires a weighting of criteria (see step 3c)
  - Decision rule: depending on the multi-criteria approach chosen (typical approaches are e.g. weighted sum approach, MAUT, Outranking approaches such as PROMETHEE

A brief guidance for each method can be found in annex 1 of this chapter.

Example, step 3b

Choice of evaluation method

- No monetary damage estimates for heat stress available in the case of Jena ‚Eichplatz'
- A quantitative assessment of the effects of the adaptation options is only available for one of the measures (Predicted Mean Vote (PMV[3] differences for shading by the use of trees)).

[3] PMV values (Predicted Mean Vote) as indicators for heat comfort can be established with the help of microclimate modelling. The PMV values can be ascribed to heat or cold related stress levels.

- ➢ No monetary assessment of the benefits of all considered measures possible
- ➢ Assessment of the values of the qualitative criteria feasible by consultation of experts
- Consideration of multiple target values, therefore:
  - ➢ Application of a multi-criteria analysis (MCA)

4.4.3 Step 3c: Weighting of evaluation criteria

(only required for multi-criteria analysis)

- Main question: Which weight should each of the criteria have in the final evaluation?
- Criteria weights should be determined by the decision makers and/or stakeholders
- Typical weighting procedures are:
  - „Swing-weight" - approach
  - „point allocation" - approach
  - Pairwise comparison (AHP-approach)
  - Ordinal ranking
  - Importance scale
  - Importance-impact range graph

For brief guidance on the Swing-weight approach and the Point-allocation approach see annex 2).

Weighting with several decision makers/stakeholder groups

- If there are more than one decision maker/stakeholder/interest group the weighting procedure can be carried out for each of the different groups to obtain several different weighting sets which express the preferences of each group.
- By conducting the evaluation and prioritization (step 5) for each of these weighting sets the effect of the different preferences on the overall results can be shown.
- ➢ This can be used as a starting point for discussion and search for compromise solutions.
- For approaches for participation of stakeholder or other actors in the evaluation process – see chapter 5 *Participation of citizens and stakeholders*.

Example, step 3c

Weighting of criteria

- Exemplary weighting for three stakeholder groups (based on point allocation procedure, see Annex 2)

Table 15 Hypothetical weighting of evaluation criteria by stakeholders

	Criteria	Weights (%)		
		Stakeholder 1 Urban Planer	Stakeholder 2 Politicians	Stakeholder 3 Citizens
1.	Costs	60	60	35
1.1	Net present costs	45	60	40
1.2	Technical effort	15	5	10
1.3	Time required for implementation	10	10	15
1.4	Assessment feasibility (politicians)	5	10	10
1.5	Assessment feasibility (citizens)	5	10	20
1.6	Assessment feasibility (authorities)	20	5	5
	Sum	*100*	*100*	*100*
2.	Benefits	40	40	65
2.1	Effectiveness regarding decrease of thermal load	40	45	50
2.2	Time span for measure to be	10	15	15
2.3	Lifetime	10	15	10
2.4	Dependency of benefit on climate	5	5	0
2.5	Synergies with other measures	10	5	5
2.6	Conflicts with other measures	10	5	0
2.7	Co-benefits	15	10	20
	Sum	*100*	*100*	*100*

4.5 Step 4: Data collection

- For each selected measure and each evaluation criterion used data needs to be collected, i.e. a decision matrix needs to be filled.
- An example how such a decision matrix could look like is shown in Table 10 (here the matrix is separated into cost and benefit criteria).

Data sources

- Data sources can be highly diverse, depending on the type of risk considered (heat, flood, health, water scarcity, …), the evaluation criteria, type of measures etc.
- Potential sources could be:
  - Damage & impact assessment methods for different sectors
    - → link to WP3 models (health, flood, water scarcity, agriculture, ecological discharge)
    - → link to other existing models (LISFLOOD, etc.)
  - Existing studies on costs and benefits of measures (transferability?)
  - If no relevant data sources exist and own modelling cannot be carried out, expert consultations can be used to derive values for the performance of each alternative measure in each criterion.
- A brief guidance on the evaluation of costs and benefits of health related climate change adaptation can be found in annex 4.

Time frame

- Usually, the alternative measure with the longest lifetime determines the timeframe of the evaluation. E.g. if the lifetime of measure A is 75 years and the lifetime of measure B 25 years, the timeframe of evaluation is 75 years. For measure B re-investment costs after 25 and 50 years have to be considered then (or, in the dynamic pathways approach, a shift to another measure).

Discounting of costs and benefits

- After assessing all costs and benefits in monetary terms, they have to be discounted, i.e. converted into their present value in order to make them comparable (see Annex on cost-benefit analysis for detailed guidance).
- We recommend using the discount rate prescribed by national guidelines for climate change adaptation measures (or other public investments).
- In addition, to show sensitivity of results against different discount rates also a low and high discount rate should be tested (1% and 5%)

Treatment of uncertainties

Uncertainty with regard to impacts and their values is at the heart of any adaptation evaluation. Hence it cannot be treated as an additional issue and has to have a central role in the exercise. Ranges of possible values arise at several stages and form what is sometimes referred to as the uncertainty cascade. This starts with emission scenarios, global models and regional models. If we use the term in a broader climate change adaptation context we should also include uncertainties due to statistical downscaling, systems impacts and socio-economic impacts.

Further uncertainties result from the economic evaluation of costs and benefits:

- If cost or benefit assessments are based on transfers, i.e. transferring the estimates of one country/region from available data sources to other European countries/regions on the basis of some key indicators.
- If assumptions on the effect of a measure have to be included in the estimation. In the case studies such assumptions will be based on past examples and the evaluation of (local) experts and will be discussed with different actors. But if no concrete past examples exist uncertainty remain.

Figure 15 summarizes the different stages at which data might be uncertain.

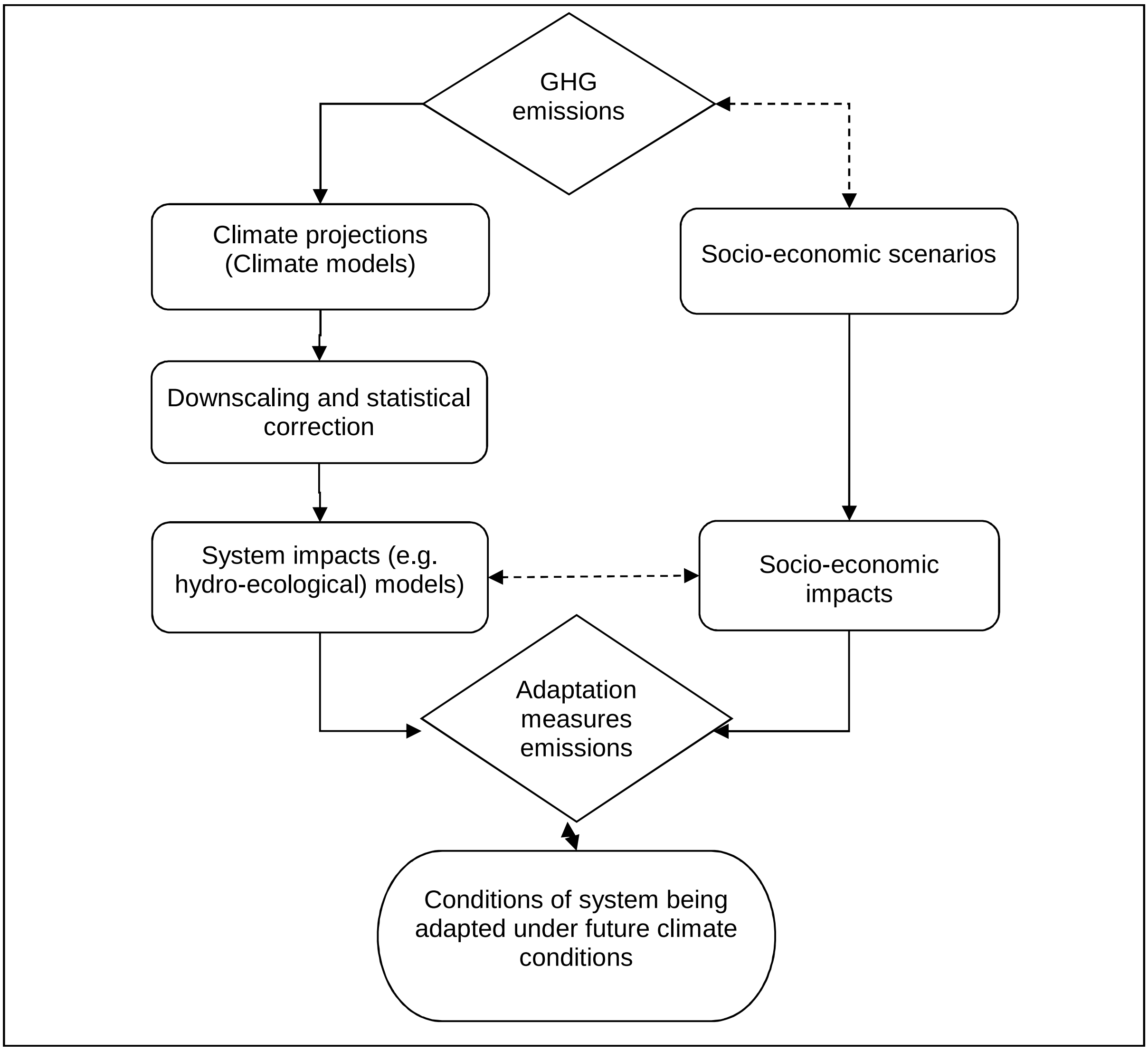


Figure 15 Structural elements in the assessment of climate change impacts and adaptation illustrating the uncertainty cascade

Once the data has been collected it is important to provide the full set to the decision maker. This means that the whole range of values should be made available, not just the average. Furthermore it is useful to indicate what is better determined and what is less well determined (e.g. do we have a narrower range for temperature or for precipitation)?

Once the uncertainty has been properly represented the cascade results in a range of values for the main impacts and possibly in a range of values for the costs of the adaptation measures. The commonest way to handle such ranges at the evaluation stage is to use the mean values (averages). While this is useful it is not enough for choosing the option. The decision-makers need some idea of the uncertainty, which can be represented through a sensitivity analysis. When carrying out the evaluation using economic criteria such as cost benefit analysis or cost effectiveness analysis the sensitivity can take the form of simple calculations of lower and upper bounds based no plausible bounds for the different components of the uncertainty cascade; alternatively it can take the form of a Monte Carlo analysis where ranges for the different elements in the cost and benefit calculation are fed into a model that calculates the implied net benefits or other measure of performance for each option under consideration. Indeed software tools such as ‘Tornado’ or ‘Crystal Ball’ are commercially available to carry out the sensitivity analysis and supporting Monte Carlo exercises.

A project document that does not report the sensitivity of the outcome indicator (e.g. the internal rate of return or net present value) to key parameters such as the costs or other uncertainties would be considered a poor piece of work. Likewise the analysis would be expected to identify the robustness of the chosen option to the dominant uncertainties.

An alternative to handle uncertainty within the framework of a cost benefit or cost effectiveness analysis as described above is to use decision-making tools in which the uncertainty has a central role but which do not involve calculating expected values or averages. A description of rules that have been developed for this purpose is given in Table 16.

Table 16 Options to account for uncertainties in decision processes

Method	Decision Criteria	Assumptions	Comments
Maximin	Each option has a range of outcomes, one for each scenario. The score for each option is the minimum outcome value and the selected option is the one with the highest score.	This is an extreme risk aversion approach. In our example we would always build a sea wall as long as the cost is less than the maximum damage.	Such extreme risk aversion rarely reflects social preferences. It has the advantage that the outcomes need not be quantified on a cardinal scale.
Minimax Regret	For each scenario, substract the outcome of the option that does best in that scenario from the outcomes of other options in that scenario. This gives a regret table. For each option calculate the maximum regret and select the options with the smallest of these.	Rule is applicable when we care about missed opportunities. Generally less pessimistic than Maximin.	Ranking between two options can change if a third option is introduced. Does require outcomes to be quantified on a cardinal scale.
Info-gap Decision Theory for Robustness	Construct a measure of the maximum amount of uncertainty we are exposed to and still ensure that losses do not exceed a given level. The decision maker then specifies an acceptable level of loss and chooses an option that has the lowest uncertainty subject to that loss limit.	Not a formal decision making process and can be expanded to include gains from different options as well (referred to a opportuneness).	Very much an *ad hoc* decision rule, but one that recognizes the limits of simple robustness approaches.
Multi-criteria Analysis (MCA)	Each option is scored against a number of criteria and the option with the highest score is chosen. One of the criteria could be the robustness of outcomes in the face of uncertainty.	Agreement can be reached on the weight to be given to each criteria. This may be difficult.	Some sensitivity of the chosen option to different weights or scoring methods is normally required.

Of the four methods described in the table the one that has most attraction within the BASE community is probably multi-criteria analysis (MCA). One possibility to include the uncertainty dimension in MCA is to add a separate uncertainty criteria, with its own weighting. In the PRIMATE decision support tool it is possibly to directly consider the uncertainties of the alternatives' performance for each criterion (e.g. as a range, a triangular distribution or any other probability distribution). PRIMATE then takes these uncertainties via Monte-Carlo-simulation into account for the ranking of options. I.e. if PRIMATE is used it is not necessary to add a separate uncertainty criterion.

- Following aspects should be documented:
    - Uncertainties in the data:
        - At least use of uncertainty margins (e.g. „300-450 EUR").
        - If possible also information on the distribution function.
    - What is the performance of the measure in the best/the worst case?
    - Different types of uncertainties in the input data can be included in the PRIMATE evaluation tool (margins, triangular distributions, other distribution functions)
    - Is there no data at all available for a certain evaluation criteria?
    - If necessary, refine the criteria catalogue (back to step 3)

Example, step 4

Data collection

- Assessment of data availability and identification of relevant contact persons jointly with the responsible parties of the city planning department

Table 17 Data matrix of alternative measures and cost criteria

Measure								
		Cost-related criteria						
No.	**Denomination**	**Investment costs/ Re-investment costs** in €	**Running costs** in € p.a.	**Technical effort** 1 = very low 2 = low 3 = moderate 4 = high 5 = very high	**Time required for implementation** 1 = up to 1 month 2 = up to 1 year 3 = up to 5 years 4 = more than 5 years	**Assessment of feasibility by local politicians** 1 = desired 2 = no rejections 3 = controversial	**Assessment of feasibility by citizens** 1 = desired 2 = no rejections 3 = controversial	**Assessment of feasibility by authorities** 1 = desired 2 = no rejections 3 = controversial
1.1	Expanse of water: Fountain							
2.1	Greening: Bucket-grown plants							
2.2	Greening: Roof greening							
2.3	Greening: Facade greening							
3.1	Shading: Excess length of roofs							
3.2	Shading: Awning							
3.3	Shading: Trees							
4.1	Reflectance of surfaces: Light-coloured pavement							

Table 18 Data matrix of alternative measures and benefit criteria

Measure		Benefit-related criteria						
No.	**Denomination**	**Effectiveness regarding decrease of thermal load** 1 = very high 2 = high 3 = moderate 4 = low 5 = very low	**Time span for measure to be effective** 1 = less than 1 year 2 = up to 1 year 3 = up to 5 years 4 = up to 10 years 5 = more than 10 years	**Lifetime** 1= very high 2 = high 3 = moderate 4 = low 5 = very low	**Dependency of benefit on climate change** 1 = no-regret 2 = low-regret 3 = regret	**Synergies with other measures** 1 = highly synergetic 2 = synergetic 3 = no synergies	**Conflicts with other measures** 1 = non-conflicting 2 = conflicting 3 = highly conflicting	**Co-benefits** 1 = high 2 = moderate 3 = low 4 = no
1.1	Expanse of water: Fountain							
2.1	Greening: Bucket-grown plants							
2.2	Greening: Roof greening							
2.3	Greening: Facade greening							
3.1	Shading: Excess length of roofs							
3.2	Shading: Awning							
3.3	Shading: Trees							
4.1	Reflectance of surfaces: Light-coloured pavement							

Data sources

- Expert interviews (urban planner, architects, landscape architects, business enterprises, communal service provider)
- Relevant scientific studies etc.

Strategies in dealing with uncertain data

- Collection of maintenance costs based on cost calculations for similar projects.
- Utilization of ranges for monetary and qualitative data.
- Qualitative estimation of transaction costs.

4.6 Step 5: Evaluation and prioritisation

4.6.1 Step 5a: Conducting the evaluation with the selected evaluation method (see step 3)

For the evaluation different evaluation methods exist:

- See brief guidance of evaluation methods (CBA, CEA and MCA) in Annex 1.
- Evaluation software can be used to support the evaluation process. Available software tools which support CBA and/or MCA are e.g. Definite[4], D-Sight[5], SALDO[6], ADx[7], PRIMATE
- PRIMATE can be provided by UFZ and used by BASE partners for the evaluation in their case study

[4] http://www.ivm.vu.nl/en/projects/Projects/spatial-analysis/DEFINITE/index.asp

[5] http://www.d-sight.com/

[6] www.austroclim.at/fileadmin/user_upload/StartClim2010_reports/StCl10_C_bewertungstool_FINALSchutz.xls

[7] http://weadapt.org/knowledge-base/adaptation-decision-making/adaptation-decision-explorer

Example: PRIMATE (can be used for CBA and/or MCA)

- Fill in the decision matrix (see Table. 16):
  - Alternative measures (rows)
  - Evaluation criteria (columns).
  - Determine if criteria should be minimised or maximised.
  - Define uncertainties for each criterion
  - Define indifference and preference thresholds for each criteria
- Fill in data from step 4.
- Determine criteria weights (see step 3).
- Run the evaluation.
- A detailed description of the tool is provided in the PRIMATE handbook[8]

Example, step 5a

Implementation of the Evaluation (Multi-criteria Analysis)

- Data were, as described above, analysed with PRIMATE

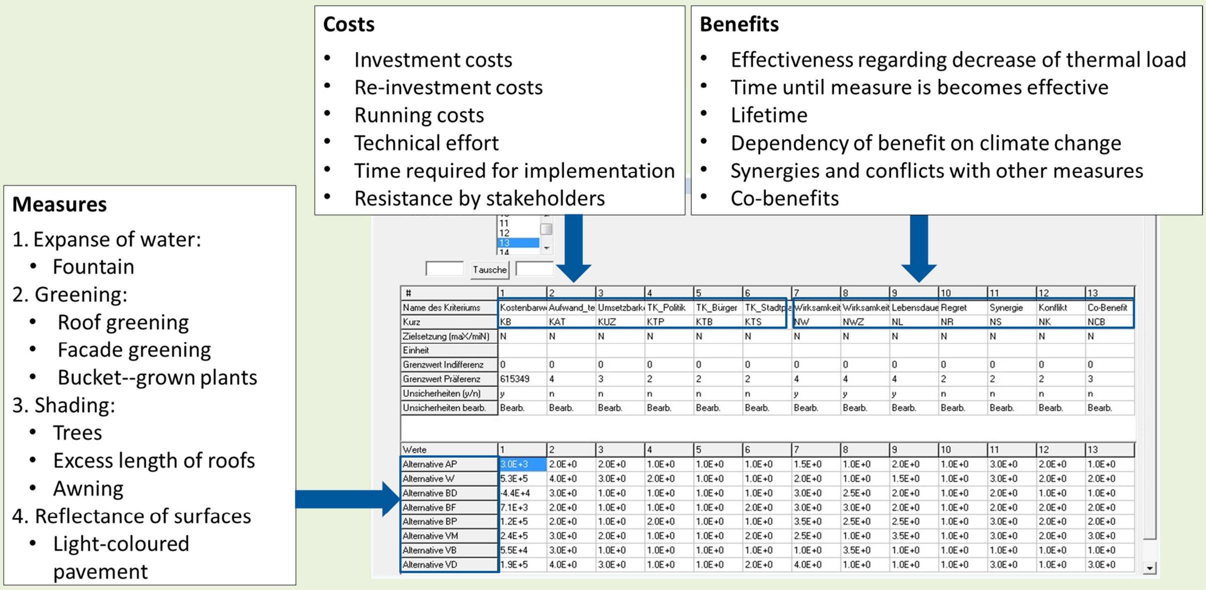


Figure 16 Completed PRIMATE data sheet

- Inserting weights for individual criteria and groups of criteria (costs and benefits) in correspondence with Table 13.

Starting of the evaluation in PRIMATE.

[8] https://emdesk.eu/cms/?p=334&hash=fYWQ7bGF0ZXN0OzIzNzMzZG93bmxv6

4.6.2 Step 5b: Presentation of results

- The different evaluation methods (see step 3 and Annex 1 of this chapter) lead to different outputs, i.e.
    - o CBA: net present value and/or benefit-cost ratio
    - o CEA: costs required for target achievement or effectiveness-cost ratio
    - o MCA: depending on the method
        - ▪ PROMETHEE: net fluxes
        - ▪ Weighted sum, MAUT: normalized values (0-1)
- Depending on the decision rule of each method, a ranking of the measures can be derived.

Communication of uncertainties[9]

- PRIMATE considers the uncertainties in the input values (as well as in the criteria weights) and therefore creates a ranking probability (see Figure 5).
- For net present values or cost-benefit ratios: average values or ratios should be accompanied by the variability of the ratio (min/max-ratios), e.g. benefit-cost-ratio for a measure is: average: 0.16, variability: 0.10-0.20.
- Remaining uncertainties in the results of the evaluation process have to be made transparent.
- Are the uncertainties in the results too high to come to a decision?
    - o Try to improve the data basis (back to step 4).

Example, step 5b

Evaluation results

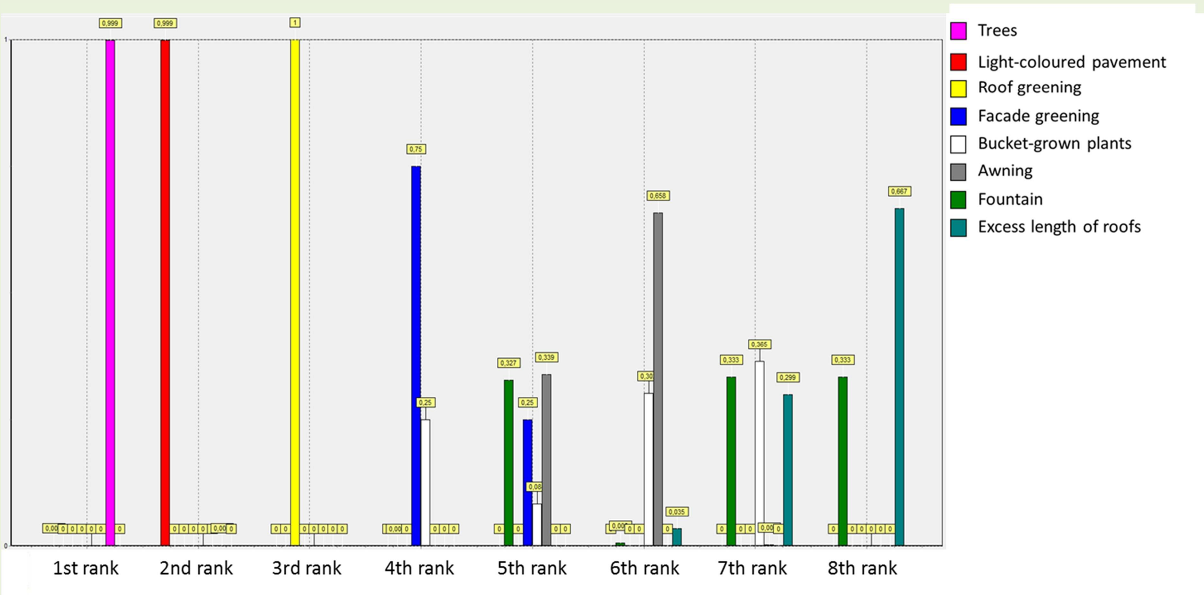


Figure 17 Ranking of evaluated measures

Note: Numbers indicate the probability that is assigned to the concerning rank.

[9] Please also see http://infobase.circle-era.eu/ for links to different adaptation projects dealing with uncertainties.

Results based on the hypothetical weighting:

1. Shading by the use of trees
2. Use of light-coloured pavement
3. Roof greening

The results show the probability being very high that the…

- … measures cultivation of trees, use of light-coloured pavement, roof greening (and facade greening) are most appropriate to reduce heat stress efficiently.
- … measures of compartmentalized greening, as with bucket-grown plants, installation of awnings and excess length of roofs, as well as a fountain are less efficient in reducing heat stress in comparison with the aforementioned measures.

4.7 Example

Example: Restoration of pasture land (Tröltzsch et al., 2012)

Short introduction

- Analysis of a concrete case at the river Elbe in the north of Germany (size of restoration area: 611 ha, potential 13 million m^2 water retention)
- Sector: biodiversity, water (flood protection)
- Urgency: high, because long implementation time and time-lag between implementation and effect

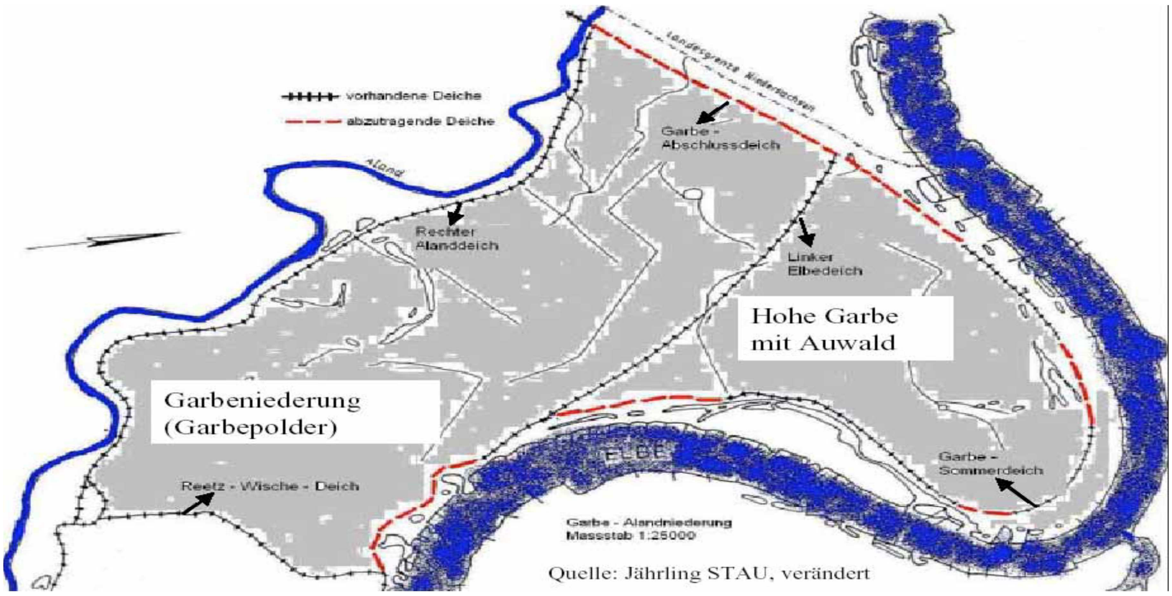


Figure 18 Area for restoration of pasture land.

Source: Zielaskowski (2004)

- Measure: Area is splitted: 1. Area of Hohe Garbe is already indicated as floodplain and protected by a summer dike. There partially pasture land exist. 2. Garbeniederung is behind the Elbe dike and used as agricultural land. For the adaptation measure it is needed to rebuilt the existing dike, e.g. with 4 slots (red) Building of new dike as Elbe winter dike (Western and Southern part). Further floodplains for Elbe: 611 ha, retention of 13 m m^3 of water is possible in case of Elbe floods. The measure would be part of a biotope network.
- Objective: Economic analysis of one measure compared to the baseline option (business as usual): restoration of pasture land in this area.

1: Preliminary risk assessment

- For Germany in general and also the river Elbe an increased probability of flood events is expected. In this region climate scenarios propose a precipitation increase in winter of maximum 38% in 2071-2100 compared to 1961-1990. (COSMO-CLM, REMO, RCAO: Regionaler Klimaatlas Deutschland).
- Different large flood events already occurred in the last years, e.g. 2002, 2013.
- No own risk assessment for the area was conducted. But different studies for similar restoration projects neighbouring the case study area exist. These studies show a flood reduction between 9 and 40 cm for a restoration area of 400 ha. Furthermore effects for cities nearby are expected, e.g. Wittenberge.
- Timeframe: The estimation was prepared for 90 years (2011-2100).

2: Objectives of the measures

- Primary objectives: Decrease the flood damages in the region and protect biodiversity, especially because the measure is part of a biotope network.
- Further objectives: Increase of landscape and recreational value

Possible measures

- Only one measure discussed (see above).

Bundles of measures

- No possibility to apply in the study.

Adaptation pathways

- No possibility to apply in the study.

3a: Definition of evaluation criteria: costs and benefits

Evaluation criteria according to criteria set which was developed in the project:

Table 19 Evaluation criteria for assessing measures for restoration of pasture land

Basic information	Cost/benefit	Evaluation

Sector	Costs: direct costs, further economic costs, external costs	Relevance
Type of measure	Benefits: economic, environmental, socio-economic benefits	Effectiveness
Relevance for public sector	Uncertainty of evaluated costs and benefits	Windfall profits
Urgency, Time-lag between implementation and effect, life-time		Dynamic incentives
		Acceptance
		Interactions with other adaptation measures
		Flexibility (no-regret, scenario-variability)

- Present value of costs and benefits (considering a 1,5% p.a. discounting rate over a period of 90 years)
- Qualitative evaluation of further criteria (basic criteria: descriptive; uncertainty costs/benefits+ evaluation critera: high, medium, low)

3b: Choice of evaluation method

- Objective was to monetarise as many cost and benefit components as possible.
- Further criteria evaluated in qualitative terms.
- Therefore: cost-benefit analysis (for additional criteria also multi-criteria analysis).

3c: Weighting of criteria

- Not applied in the case study.

4: Data collection

- Based on desktop research and interviews.

Data sources

- Information on local case study area
- Studies on pasture land restoration and regional models/calculations of effects on flooding events
- Cost data for restoration of pasture land and further benefits (mainly from regional studies)

Strategies in dealing with uncertain data

- Use of ranges for monetary data and also necessary assumptions are partially done as ranges,
- Comparison of total costs with data estimated by a local planning company

5a: Implementation of the Evaluation

- All cost and benefit components were included in an Excel-sheet, which was also used for discounting the different components.
- Included cost components:
    - Costs to rebuilt dikes and built new dikes
    - Costs to buy land from farmers
    - Lost income of farmers
    - Planting costs for pasture forest
- Included benefit components:
    - Lower maintenance costs for dikes, due to shorter length
    - Avoided damage costs in case of flood event
    - Nutrition retention
    - Evaluation of biodiversity
- Further evaluation qualitative criteria were estimated (see 5b),

5b: Evaluation results

Table 20 Evaluation results: Costs, benefits, benefit-cost-ratio*

	Current situation (assuming no climate change)	**With climate change**	**Main factors**
Costs	10 m €	10 m €	Dike re/building, income losses
Benefits	20-35 m €	30-45 m €	Value for biodiversity conservation
Net present value (NPV)	10-25 m €	20-35 m €	
Benefit-cost ratio	2 - 3.4	3 - 4.5	
Uncertainty of estimation	High		

Note: Discounted costs and benefits until 2100.

Table 21 Evaluation results: Qualitative criteria

Criteria	Evaluation	Further description
Relevance	Need-to-have	Because biodiversity conservation is basis for human livelihood
Effectiveness	High	Restoration would increase adaptive capacity of eco-systems, effect is proofed.
Windfall profits	No	Because nature conservation mainly task of public institutions
Dynamic incentive	Yes	Incentive for nature-oriented flood protection.

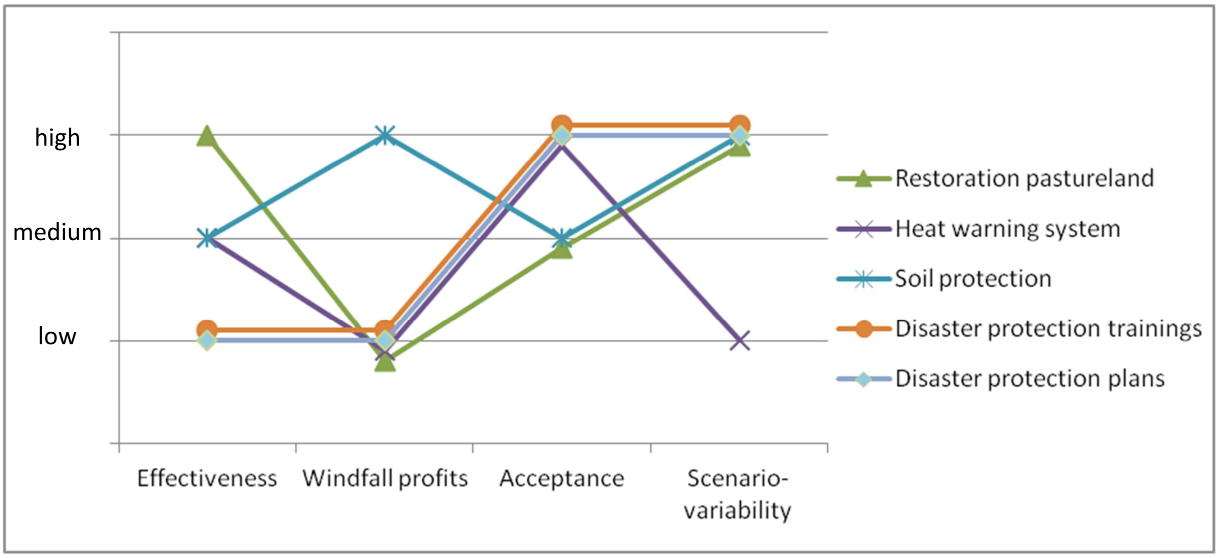


Figure 19 Evaluation results: Comparison of different measures

4.8 Data required by WP 6 for upscaling (see D6.1)

Apart from the economic evaluation of adaptation options *within* the case studies it is also the objective of the bottom-up assessment in the case studies to provide data for the upscaling of costs and benefits in WP6. Many of these data requirements will be already achieved by following the stepwise guidance described above. In order to ensure that all required information is at hand case studies should be able to answer the questions in table 22 (Please also have a look at the D6.1 report on EMDESK).

Table 22 Information requirements by WP 6 for upscaling

Key questions	Auxiliary questions
What is the baseline option? (see above step 2)	As a business as usual strategy (recommended) or, or as a no adaptation strategy?
	• How is this baseline built up? • What is included and what is excluded?
	what is the ambition level of the reference strategy? • maintaining current risk levels or current protection levels (implying with CC risks may increase)? • Is current backlog of investments for adaptation measures included or excluded? • Does it include only planned adaptation or also autonomous, non-planned adaptation?
Which evaluation method is applied? (see above step 3	• CBA? • CEA? • MCA? • Other?
Which cost categories are included? (see above step 3)	• Investment costs, operation & maintenance cost? • Other negative effects (economic, ecological or social)? • Direct, indirect costs? • Tangible, intangible costs?
Which benefit categories are included? (see above step 3)	• Which positive effects are included (economic, ecological or social)? • Direct, indirect costs? • Tangible, intangible costs?
Which discount rate is applied? (see above step 4)	• National discount rate? • Low discount rate (1%)? • High discount rate (5%)?
Which evaluation outcomes are available? (see above step 5)	• CBA: present value of costs, of benefits, net present value, benefit-cost ratio? • CEA: net present value of costs, effectiveness, cost-effectiveness? • MCA: qualitative or quantitative performance of adaptation options in single criteria, overall performance of adaptation options, ranking of options?

4.9 Conclusions

As the two different case study examples show the stepwise procedure described in this section is relatively easy to apply under different context conditions (risks, impacted sectors, data availability, etc.). Depending on the type of evaluation criteria used and data available for analysis different evaluation approaches might be applicable, such as cost-benefit analysis, cost effectiveness analysis and/or multi-criteria analysis.

Furthermore, possibilities to handle uncertainties in the input data in the evaluation process are presented. The decision support tool PRIMATE or alternative tools can support for the various types of economic assessments described above and to include uncertainties in the outcomes of the evaluation process.

By following the guidance and considering the questions raised in section 4.8 it is also ensured that all information required for upscaling of cost and benefits in WP 6 is provided.

4.10 Annex

4.10.1 Annex 1: brief guidance for alternative evaluation approaches

A) Cost-benefit analysis

- Literature: see e.g. Hanley and Spash (1993) and Pearce and Turner (1990)

1. Project definition
    - Selection of alternative option (measures),
    - Determination of the evaluation timeframe

2. Quantification and monetisation of all relevant project impacts

   In principle, all costs and benefits of the alternative options have to be included in monetary terms. These should be estimated for each year of the evaluation timeframe for every single measure (compared to the reference measure = the business as usual or do-nothing option).
   Typically, investment costs occur in year 0 of the evaluation timeframe, while current costs have to be accounted for each year, and potentially re-investment costs may be necessary after a certain amount of time.
   Benefits of climate adaptation measures are usually estimated with the reduction of expected annual damage. Such annual expected damage can be estimated in quantitative terms usually only based on modelling. Where such modelling is not available in terms of existing studies or own modelling resources, only proxies can be identified in close cooperation with stakeholders that can function as an indication for the measures' benefits. In addition, this annual expected damage value and thus the benefit of an alternative measure within the evaluation timeframe is subject to change to due climate change and other socio-economic changes.

3. Discounting

   After assessing all costs and benefits in monetary terms they have to be discounted, i.e. converted into their present value in order to make them comparable. The rationale for this is *time preference* of people: benefits as well as cost are valued higher the sooner they are received or have to be paid, respectively (Hanley & Spash 1993).
   In order to discount future values to their present value a discount rate is used:

$$PV(X_t) = X_t \left[(1+i)^{-t}\right]$$

With $PV(X_t)$: present value of X_t
X_t: cost or benefit received in time t
i: discount rate

Obviously, the choice of the discount rate has a huge influence on the weight given to future costs and benefits: a high discount rate would mean to give only small weight to cost and benefits which occur in the future, whereas a low discount rate gives them a higher weight. There is an on-going debate about a "right" social discount rate, but different authors argue against a straight line discount rate (see e.g. Gowdy (2007) and Turner et al. (2007)) and recommend a declining discount rate. The rationale is that people discount their near future at a higher rate than the distant future. Furthermore, the position of future generations in strengthen by such declining discount rates as future costs and benefits get more influence on the net present value. E.g. the official German methodological guideline for the valuation of environmental damage uses such a declining discount rate by recommending a discount rate of 3% for a timeframe of up to 20 years and a discount rate of 1.5% for impacts occurring after that.[10]

It is recommended to use the discount rate prescribed by national guidelines for climate change adaptation measures (or other public investments). In addition, also a low and high discount rate should be tested to show sensitivity of results against different discount rates (e.g. 1% and 5%).

4. Decision rules:

The usual criterion for the evaluation of projects in a cost-benefit framework is the *Net Present Value test*. The Net present Value (NPV) is defined as the sum of discounted benefits minus the sum of discounted costs over the lifetime of a project (Hanley and Spash, 1993):

$$NPV = \sum_{t=0}^{n} B_t (1+i)^{-t} - \sum_{t=0}^{n} C_t (1+i)^{-t}$$

The first test would be to check if the NPV of a project is positive, i.e. if its benefits exceed its costs. If yes, it could be stated that this project would lead to a gain in social welfare and should be accepted.

However, if there is more than one alternative the second decision rule would be to choose the project with the highest NPV. Ideally the NPV should be maximized in order to meet the Pareto optimum defined at the beginning of this chapter. Generally, it is assumed that with an increasing level of investments in risk reduction, benefits increase with a decreasing rate while costs increase with an increasing rate (Young, 2005); (Weck-Hannemann and Thöni, 2006) see figure 5.5.2)[11]. If this is the case, the Pareto optimal level of risk reduction (R*) would be at that point where marginal benefits equal marginal costs (ebd.).

[10] In contrast, MAFF (1999) prescribe a constant discount rate of 6% for flood alleviation projects. On the other side, the *Stern report*, estimating the economic impacts of climate change, describes discounting as unethical with regard to future generations and applies a discount rate of 0.1% (Stern 2006).

[11] Admittedly, empirical evidence from the UK showed that for the national level costs of flood protection could also increase with an even higher declining rate than the benefits (Pearce & Smale 2005). In this case the NPV of flood protection projects increases the more is invested.

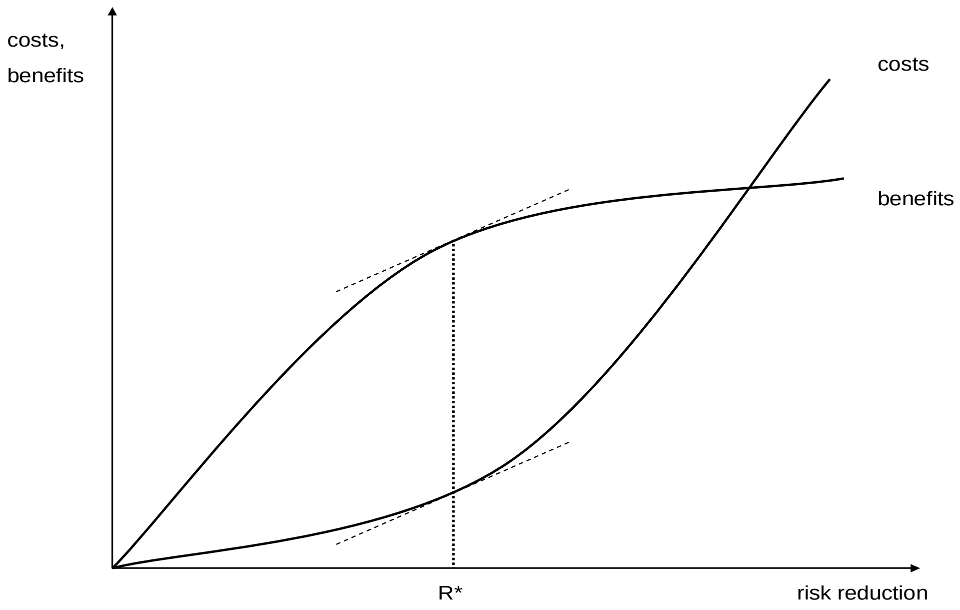


Figure 20 The Pareto optimum of risk reduction

Source: (Young, 2005) and (Weck-Hannemann and Thöni, 2006)

However, like Young (2005) states, CBA in practice is typically not seeking for that optimum solution. Instead, among a set of options the alternative is chosen which comes nearest to the Pareto efficiency. This is true also for the practice of planning flood risk management projects where it would be quite difficult to calculate marginal costs and benefits for all of the variety of different options. Accordingly, the project with the highest NPV should be selected.

An alternative cost-benefit criterion is the benefit-cost ratio (BCR), which is the ratio of discounted benefits to discounted costs:

$$BCR = \frac{\sum_{t=0}^{n} B_t (1+i)^{-t}}{\sum_{t=0}^{n} C_t (1+i)^{-t}}$$

A BCR > 1 indicate a positive impact of the project on social welfare, like an NPV > 0 does. But in contrast to the NPV the BCR does not measure the total impact of the project on social welfare but the relation of its benefits to its costs. E.g., assuming a run of the benefit and cost curve as shown in figure 20, the BCR would be highest for relatively small projects, which have on the other side only a relatively little NPV. Hence, the ranking of alternatives would be different when using the BCR instead of the NPV criterion.

The choice whether the NPV or the BCR should be used depends on the decision situation: If e.g. one project should be chosen among a set of options then the decision rule would be to choose the one with the highest NPV. If, on the other side, capital budget is fixed and several projects should be carried out with this budget the right decision rule would be rank the projects by their BCR and accept them in order of their ranking until the budget is exhausted (Pearce and Smale, 2005).

5. Sensitivity analysis

Sensitivity analyses should be carried out to identify whether variations in the input data (e.g. discount rate) used lead to implications for the final results.

B) Cost-effectiveness analysis

- Literature see e.g. Hanusch (1994)

1. Definition of alternative options or measures, and evaluation timeframes
   Alternative options or measures are to be identified and an evaluation timeframe should be determined. All costs of alternative measures can be assessed in terms of monetary units.

2. Define a non-monetary target indicator
   Stakeholders define a non-monetary indicator for the different utilities of the alternative measures (here effectiveness of a measure can include, for instance, reduction of heat stress, the protection against and up to a 100year flood event, etc.). Such an indicator can be either quantitative (e.g. protection of specific number of people) or qualitative (e.g. low, medium or high protection).

3. Quantify cost and effectiveness of the different options within the evaluation timeframe
   In the same manner as for the CBA, determine the present value of alternative measures and assess the effectiveness regarding the afore determined target indicator of each individual measure.

4. Decision rules
   - Costs to achieve the defined target

     If a defined target that should be achieved (e.g. the protection against and up to a 100 year flood event, or the attainment of good ecological conditions) had been established, the alternative measure is chosen that achieves this objective at the lowest cost.
   - Effectiveness at a given cost level

     If in turn, the cost for the measure is predetermined, that measure is chosen which is the most effective in reaching the determined target.
   - Ratio of effectiveness and costs

     In the case of a fixed budget and non-precluding measures, those measures with the highest cost-effectiveness ratio will be selected until the budget is exhausted.

5. Sensitivity analysis
   Sensitivity analyses should be carried out to identify whether variations in the input data used (e.g. discount rate) lead to implications for the final results.

C) Multi-criteria analysis

- Lots of different MCA-methods exist (see e.g. Zimmermann and Gutsche (1991) an overview (Weighted sum, MAUT, AHP, PROMETHEE, ELECTRE,…)
- In the PRIMATE tool the PROMETHEE approach us used. PROMETHEE (Preference Ranking Organisation Method for Enrichment Evaluations) performs a pairwise comparison of all alternatives across all evaluation criteria counting arguments “in favour” and “against” each option. Uncertainties in the criterion values can be considered by using a Monte Carlo simulation approach (Stochastic PROMETHEE II), i.e. several PROMETHEE analyses are performed for a random sample of criterion values within a range to be defined.
  A detailed description of the Stochastic PROMETHEE approach is given in the PRIMATE handbook.

4.10.2 Annex 2: brief guidance weighting procedures

‘Swing-Weight’-approach
The swing weight approach is a trade-off analysis method which considers the range of each criterion. It is a relatively easy to apply approach which involves three steps (Malczewski, 1999, RPA, 2004):

1. Ranking: the starting point is a hypothetical alternative with all criteria at their lowest level. The decision maker is asked which criteria he would most prefer to have a swing to its highest level – the criteria would be ranked first, the next one second and so on.
2. Relative importance: the criterion ranked first is given a score of 100. The decision maker is asked now about the relative importance of a swing from lowest to highest level in the criterion ranked second compared to a swing in the first one (e.g. 50%). Then the criterion ranked third is compared to the first one (e.g. 10%) and so on.
3. Finally, the scores gathered in 2) are standardised by the sum of all scores:

$$w_1 = \frac{100}{100+50+10} = 0.625$$

$$w_2 = \frac{50}{100+50+10} = 0.313$$

$$w_3 = \frac{10}{100+50+10} = 0.063$$

When making a choice of a weighting procedure, a trade-off between ease of application and accuracy has to be made: Rating and especially ranking require little effort but do not have a theoretical foundation which can lead to inaccurate weights. The swing weight and the pairwise comparison may lead to more precise results but require more effort (Malczewski, 1999)

Point allocation approach
The *point allocation approach* seems to be the approach simplest to apply. Here the decision maker is asked to allocate 100 points among the selected criteria. The rationale of this approach is that the decision situation is quite similar to the financial allocation of a given budget and therefore quite familiar to many

decision makers. Nevertheless, (Malczewski, 1999) mentions the risk within this approach that the criteria are weighted without knowing their specific unit and range. In this case the weights would be meaningless.

Other approaches:

- Ordinal ranking
- Pairwise comparison (from AHP)
- Importance Scale
- Importance-impact range graph

4.10.3 Annex 3: Step by step summary of guidance

Table 23 step by step summary of guidance

Summary of guidance		
General and specific steps	**Approach**	**Output**
Step 1 Preliminary risk assessment		
Determine existing problems	Analysis of past events	
Assess current risk situation	Refer to existing risk or vulnerability studies	
Assess assets at risk	Asset mapping (land, buildings, infrastructures, natural capital, and social capital) based on desktop research and expert interviews. Identify sector(s) and key assets, timeframe	
Determine existing adaptation measures		
Expected changes in risk due to climate change and socio-economic change (areas, sectors and assets)	For ex-post case studies: describe climate scenarios and socio-economic change scenarios used, as well as expected impacts on which affected areas and sectors.	
	For on-going and prospective case studies: use new scenarios for climate and socio-economic change from IPCC AR5 downscaled and adjusted to local economy PPC. Downscaled climate data can be provided by CMCC if needed, spatial resolution and timespan are specified.	
	Refer to existing studies on climate change impacts and vulnerabilities.	
	If unavailable, check if WP3 models might provide results for the case study or carry out own modelling if resources are sufficiently available.	
	Expert interviews on expected climate change impacts on assets at risk, as well as plans and ideas for assets in future.	
Step 2 Identification of adaptation measures and adaptation pathways		
Identify primary and other potential objectives of adaptation		
Determine potential measures to attain primary or other objectives	In close cooperation with stakeholders selection of potential measures which: • fulfil the objective(s) on different timeframes, • already exist but could also benefit adaptation objective(s), • may provide benefits independent of the occurrence of climate change,	

	• provide co-benefits Detailed description and possibly displaying measures based on mapping activities.	
Define baseline option	Determine baseline upon which all costs and benefits are compared to. If you take a business as usual approach, current protection levels are assumed for the evaluation timeframe.	
Bundling of measures	Identify complementary measures to attain the objective(s).	
Adaptation pathways	Identify threshold and adaptation tipping points, including their timing as well as to which objective(s) they relate to.	
	Identify courses of actions	
Step 3a Selection of evaluation criteria		
Identify appropriate evaluation criteria	Determine evaluation criteria that reflect all relevant positive (benefits) and negative (costs) effects, and suitable categories of criteria values consulting relevant stakeholders.	
	Define appropriate units to measure criteria.	
Step 3b Selection of evaluation method(s)		
Identification of appropriate method(s)	Select appropriate method(s) based on type of criteria and data availability (method overview in annex 1).	
Step 3c Weighting of evaluation criteria		
(Applicable only to MCA)		
Identify evaluation weighting method	Choose swing- weight or 100- point allocation method (see overview in annex 1).	
Attach weights to the evaluation criteria (potentially in different groups)	According to method chosen, attach weights with stakeholders. In the case of multiple stakeholder or interest groups, a number of weighting sets can be obtained. These then steps 5 and 6 can be evaluated and prioritized, illustrating the effects on the overall results depending on weighting set chosen.	
Step 4 Data collection		
Data sources for data collection for each criteria selected	Identify potential data sources, including damage & impact assessment methods (link to WP3 and other existing models) or existing CBA studies on adaptation measures.	
	If no relevant data sources are available and modelling cannot be undertaken, identify in cooperation with experts proxies for assessing the performance of measures regarding the respective criterion.	
Evaluation timeframe	Commonly determined by the measure with longest lifespan. For measures with shorter lifespans then either re-investment costs need to be considered or, in the dynamic approach, shifts to other adaptation measures.	
Discounting of costs and benefits	Suggested use of discount rate determined by national guidelines for climate change adaptation measures (or public investments).	
	Application of low and high discount rates in the sensitivity analysis.	
Treatment of data uncertainties	Document uncertainty of data of positive and negative effects.	
	Describe performance of measure for the worst/best case scenario.	

	Evaluation tools may allow for inclusion of types of uncertainties (e.g. PROMETHEE)	
	Refine criteria catalogue if no data is available at all.	
Step 5 Evaluation and prioritization		
Determine whether and which evaluation software tool to be used.	CBA and/or MCA are supported by tools, such as e.g. Definite, D-Sight, SALDO, ADx, PRIMATE (PRIMATE can be provided by UFZ)	
	Analysis with the respective tool, presentation of the results and interpretation.	

5 The participation of citizens and stakeholders in climate adaptation

By: Søren Gram (DBT), Bjørn Bedsted (DBT), André Vizinho (FFCUL), Inês Campos (FFCUL)

It is one of the main objectives of BASE to explore the role of participatory and deliberative methods in improving the integration of knowledge and views of citizens and stakeholders in the design of adaptation strategies, with the aim of improving the design and implementation of such strategies. This will be done in two ways:

1. By collecting and analysing data about the character and level of participation in all BASE case studies.
2. By using participatory methods in some of the BASE case studies in order to contribute to on-going decision-making processes.

The objectives of this are to:

1. Make recommendations for the use of participatory methods in climate adaptation (WP7).
2. Develop and test novel participatory methods for climate adaptation (Task 5.3 and 5.5).

<u>Organisation of work</u>

A Participatory Group of BASE partners will oversee and collaborate about the collection and interpretation of data from all BASE partners (Goldsmith and Eggers, 2004). Furthermore, it will collaborate about the test and development of novel participatory methods. Lead partners in the group are DBT and FFCUL, but strong collaboration between all members of the group will be encouraged and facilitated.

This chapter is divided into a general part including some ethical concerns and a part with practical steps to be followed by BASE partners conducting case studies.

5.1 About participatory methods

Participatory methods are methods for including citizens, stakeholders and different areas of expertise in a decision-making process. In governance studies, such participation is alternately referred to as participatory governance, interactive governance, network governance, and collaborative governance (Goldsmith and Eggers, 2004, Hajer and Wagenaar, 2003, Fung, 2002, Sidaway, 2005). The focus in such studies is most often on the inclusion and collaboration of different institutions and stakeholders in forming policies and shaping decisions. In the field of deliberative democracy, participation is often referred to as a way of including citizens in policymaking as a supplement to established governance procedures in representative democracy (Dryzek, 2000, Steyaert and Lisoir, 2005). Participatory practices have proliferated in various fields and contexts, and specific methods have been developed and applied, for example within the field of participatory technology assessment and Science and Technology policymaking (Joss and Bellucci, 2002).

Participation comes in many forms and shapes and can be assessed in different ways. In her often referred to article from 1969 (Arnstein, 1969), Sherry Arnstein places different modes of participation on a Ladder of Participation, ranging from citizen control at the top of the ladder over consultation and informing to outright manipulation at the bottom. Genuine participation, in this perception, is when control and power is given to those participating (in this case, citizens). Subsequent approaches, while still acknowledging to some extent this hierarchy of participation, tend to be less categorical and find equal value in different kinds of participation (Byrne and Davis, 1998).

For the purpose of BASE, participatory methods can be seen as different modes of contributing to particular steps of a decision-making process by including the knowledge and views of a wider range of societal actors. While the inclusion of different kinds of expertise (less traditional scientific disciplines) is often a target of participatory methods, BASE will mostly focus on the participation of stakeholders and citizens in climate adaptation. Stakeholders will be very broadly defined as 'those with a stake and interest in decisions made, i.e. house owners associations, business organisations and environmental NGO's.

It is now commonly accepted that a better knowledge base for decision-making and the achievement of socially robust results depends on the integration of the knowledge, views and interests of a wide range of societal actors, including researchers, stakeholders and citizens. There are a number of both principal and professional reasons to involve stakeholders and citizens in decision-making processes (Klüver, 2002). In short, the involvement of stakeholders and citizens in decision-making processes gives promise of higher legitimacy and effectiveness(Bedsted and Gram, 2013).

The European Commission has issued a White Paper on Governance in 2001(European Commission, 2001), which "*proposes opening up the policy-making process to get more people and organisations involved in shaping and delivering EU policy*". This ambition is also reflected in Guidance Document 8 to the Water Framework Directive[12], which strongly encourages active involvement, describing it as "a higher level of participation than consultation" (European Commission, 2003) (p11). Although the EU Guidelines on developing adaptation strategies encourage the involvement of stakeholders in the design of such strategies (European Commission, 2013), it is not quite in line with the White Paper on Governance when it comes to public involvement which is treated as a matter of one-way communication and awareness raising, rather than consultation or active involvement.

The United Nations Economic Commission for Europe (UNECE) Convention on Access to Information, Public Participation in Decision-Making and access to Justice in Environmental Matters (also known as the Aarhus Convention) was signed under The Fourth Ministers Conference on the Environment for Europe process in Aarhus, Denmark in 1998. The convention, put into force in October 2001, gives the public several rights with regards to the environment such as: the right to receive information on environmental matters, the right to participate in decision-making on environmental issues and the right to demand re-opening of decision-making processes where decisions that have been made without respecting the public's right to information or right to participate.

Another significant UN agreement, Agenda 21, was made in Rio 1992. This action plan towards global sustainable development addresses local authorities in chapter 28: "As the level of governance closest to the people, they play a vital role in educating, mobilizing and responding to the public to promote sustainable development". The plan calls for local authorities to develop a "local agenda 21" plan in corporation with the local population[13].

Existing case studies on Climate-Adapt do not pay much attention to participatory methods and involvement processes. Most mention "participation" as a keyword for their case study description but hardly write anything about it. Those who do write a little, tend to understand participation as a matter of studying different risk perceptions and about providing information to citizens. Two studies go more in depth: the IMRA and COMRISK projects. In the IMRA project (integrative flood risk governance for improvement of risk awareness and increased public participation) three case studies were carried out in Austria, Italy and Germany all using participatory methods: stakeholder- and public workshops in regards to risk management, risk perception and broad public awareness building as required by the IMRA project. It includes some reflection on- and analysis of the participatory methods used in the case studies, mostly regarding requirements with regards to time, personnel and money. A 12-step guide for decision-makers has been developed, with reflections on things to consider before scoping a participatory process in regards to risk governance. The COMRISK project (common strategies to reduce the risk of storm floods in

[12] Working Group 2.9 – Public Participation (2003): *Guidance Document No 8 - Public Participation in Relation to the Water Framework Directive*, in: Common Implementation Strategy for the Water Framework Directive (2000/60/EC)

[13] http://www.unep.org/Documents.Multilingual/Default.asp?documentid=52

coastal lowlands) has produced a report on public perception of coastal flood defence and participation in coastal flood defence planning. The report analyses the effected peoples feeling of involvement in defence planning and the level of satisfaction with participation procedures in defence planning. The analysis is based on questionnaires distributed in three case studies. Also, a literature review on participatory methods and their use is included, but the 7 case studies included in COMRISK do not carry out any participatory processes.

5.2 Objectives of the participatory analysis

Through a systematic approach to the study of participatory methods and climate adaptation in the BASE case studies, BASE sets out to develop a better understanding of the use and potential of such methods in climate adaptation, thus going beyond the current ‘state of the art’. The objectives for doing so are:

- To better understand how the knowledge and preferences of different experts, stakeholders and citizens can successfully feed into adaptation/planning processes, from a multi-level governance perspective
- To contextualize model-based assessments of costs and benefits by situating them within a planning process
- To produce advice on the use of participatory methods in adaptation/planning processes in connection with policy design and implementation
- To assess how particular participatory methods function in different cultural contexts
- To test and develop new participatory methods through systematizing and building on existing ones
- To further develop comparability, reproducibility and robustness of results from research using this type of methodological framework

5.3 Practical steps to analysing participatory processes

All Case studies (both retrospective and prospective) will answer the following the questions:

<u>General:</u>

- What is the democratic and political tradition for involving experts, stakeholders and citizens in spatial planning in the country, and how is climate adaptation situated within that tradition?
- Is the involvement of experts, stakeholders and citizens in your country and case study based on formal laws, general guiding principles or more informal local initiatives, and how exactly is the framework for this involvement described?
- What guidelines for participation are in place, related to the case, and how clear are they?

<u>Specific:</u>

4 Which participatory methods have been used at which stage of the adaptation/planning process? Who (experts, practitioners, stakeholders, citizens) have been involved at which stages of the decision-making process (from early decision to act, to setting objectives, to identifying measures, and to implementing them)?

5 What have been their roles in this involvement (from being informed, to being asked for feed-back, to co-designing – and have they been asked to contribute with knowledge and/or views)?

6 What has been the distribution of power between the experts, practitioners, stakeholders and citizens, and what influence have they had on the adaptation/planning process?

7 How could the participation of experts, stakeholders and practitioners in the adaptation/planning process be improved?

8 How and at which stages of the adaptation/planning process have economic assessments of adaptation actions been used (and which kind?), and how much influence have they had on the adaptation/planning process?
9 Which experts, stakeholders and citizens have been involved in making the economic assessments and the decision about which kinds of costs and benefits to assess, and how influential have their respective contributions been?

Re 1) “Citizens” refer to a broad category of people (for example the residents in a municipality) who themselves will not directly be affected by climate change (for example flooding of their house) but as a resident (and taxpayer) could have positions or ideas for how to priorities land use and climate change measures in the future.

Re 4) Try to sketch out the different phases of the adaptation process and write who were involved in these phases, for example from where came the initiative to start adaptation planning, who did (and who were actively invited to) contribute with ideas to adaptation measures etc.

Re 5) In the retrospective cases it would be relevant to analyse (for example via interviews) the impact of participation in the adaptation process.

Re 6) Which kind of experts have been involved and what has been their role? Stakeholders are a diverse group of different interests, from big powerful organizations to local informal groups with specific interests. Try to set out the influence of the different groups in relation to the decision making process. Has ordinary (local) citizens without a specific stake been involved (where and how)?

Re 7) For example, were there phases in the decision making process where certain groups were not involved but where the process could have gained if they had? And could the process have been improved with another kind of involvement in certain phases?

Re 9) In retrospective cases you could interview people who have been involved in the case. It would be useful to ask if they found the selected costs and benefits relevant and adequate.

5.3.1 Deadlines

A first draft of your answers and a plan for the rest of the work should be prepared before summer 2014. Members of the participatory group will review the answers from the partners and ask for additional information. Final deadline for answering the above questions is Christmas 2014.

A questionnaire (probably online) will be prepared in order to secure a standardized feed-back for some of the questions, i.e. listings of participants in the different stages of a decision-making process about climate adaptation.

With the information thus collected, analysis of the “width” (the variety of societal actors involved) and the “depth” (the level of influence and responsibility given to the actors involved) of participation can be assessed and useful conclusions possibly made.

5.4 Running participatory processes

Members of the BASE Participatory Group will engage in on-going climate change planning and adaptation processes and thereby tests participatory methods. Furthermore novel participatory methods will be developed and tested by running them in practice. Strong collaboration between the partners will be required in order to deliver the desired results.

Running participatory processes, and thereby interacting with a decision-making process, is very context specific, and it will therefore be impossible to run identical processes, but by collaborating about the use and development of participatory methods, comparisons can be made and experiences gained which will lead to recommendations for the use of existing and novel methods.

Participatory methods, while to some extent standardised, are never used in the exact same way (precisely because they are context sensitive) and are therefore constantly evolving. New methods are often hybrids of existing ones and a matter of using components of one method in others, thereby designing novel participatory approaches to a decision-making process. Novelty is quite often a matter of applying participatory methods used for planning and decision-making processes in one area to new areas, thus taking on new shapes in the meeting with new contexts and purposes. It is from this understanding of the term “novel methods” that BASE will proceed.

5.5 Forms of interactive and action research

S&T studies have consistently emphasized the fact that science and society are closely intertwined and that the production of scientific knowledge is not neutral but always expresses certain values and preferences. Expert methods to support decision-making, such as modelling, scenario building, and foresight exercises, often overlook or simplify complex contextual factors such as policy trends and societal values[14].

It is not possible to draw a clear line between the production of scientific knowledge and a political decision-making process, neither in general nor in relation to climate adaptation (Sarewitz, 2010). This poses the question as to whether the production of climate data informing a climate adaptation strategy should be opened up to more participation. BASE will address this question and possibly propose methods for opening up the data production process, thus improving the uptake of knowledge and preferences of a wider range of societal actors in this part of the decision-making process as well.

Participatory approaches have been widely used within diverse scientific discourses over the past 65 years, making the term evermore confusing and unclear. Strictly speaking participation means “taking part in, or being actively involved in a process” (Brown et al., 2001).

Different levels of participation are possible, from passive involvement and information giving (where information is simply disseminated or received from stakeholders), to interactive participation and self-mobilization (where people share power and co-management of change). Literature refers to a cyclical approach in participation (Brown et al., 2001, Baum et al., 2006, Pimbert and J.N., 1994) wherein a three-step cycle of planning, implementation and evaluation is played and replayed as research proceeds.

Because of its collaborative and participatory nature, these approaches detour from the idea of the ‘outside expert’ coming into a community to examine, theorize and propose solutions. At its higher levels, participation appears in literature as a core component of ‘action research’ being known as participatory action research (PAR). This can be understood as an alternative epistemological view to scientific research, with its own axiology and ontology, understanding that “our world does not consist of separate things but of relationships which we coauthor”(Reason and Bradbury, 2001: 5).

Participatory methodological frameworks have been widely used in a great diversity of research fields, such as medical sciences and development studies. In governance studies and adaptation policy design and implementation, the participatory process is often referred as participatory decision-making or adaptive governance (Tompkins et al., 2008, Vanderlinden et al., 2011). Adaptive governance is linked to the study of socio-ecological systems, where assessing levels of social resilience. Another example is Transition

[14] See: Grunwald, A. (1999): *Technikvolgenabschätzung. Konzeptionen und Kritik.* In: Rationale Technikfolgenbeurteilung. Konzepte und methodische Grundlagen. Springer, Berlin; Jasanoff, S. (1990): *The Fifth Branch. Science Advisors as Policy Makers*. Harvard University Press, and (2004): *State of Knowledge. The Co-Production of Science and the Social Order*. Routledge, London.

Management (Loorbach, 2010), where ‘arenas’ of forerunners are formed to envision future scenarios and sustainable pathways. Other approaches within the multilevel perspective of socio-technical systems theory, such as Strategic Niche Management (Geels et al., 2008), also integrate participation.

Despite critics concerning the limits to its full applicability, participation has been used in broad research scopes, and recently in knowledge domains concerned with sustainability and climate change adaptation and mitigation. Two approaches stand out: participatory integrated assessment (PIA)(Rotmans and Van Asselt, 2002) and integrated sustainability assessment (ISA) (Jäger J. et al., 2008).

In PIA stakeholder participation becomes essential, taking into account people’s knowledge, values and perceptions and it is defined as an “integrated assessment approach in which social stakeholders contribute their knowledge and policy preferences to the assessment of complex policy problems’’ (Schlumpf et al., 1999). Integrated Sustainability Assessment (ISA) is based in PIA, but presents a normative perspective towards sustainability and uses participatory scenario, backcasting and visioning methods as part of an approach designed to initiate transitions towards sustainability (Weaver and Rotmans, 2006). This approach is all but fragmented, instead it takes into account multiple dimensions of persistent problems, such as the environment, the economy, social systems, technology and the perceptions, practices and cultures of various stakeholder groups (Bohunovsky et al., 2011) to find and help implement long term solutions in climate change adaptation and other sustainability challenges. The approach was chiefly tested and applied to case studies in four European funded projects – MATTISSE, ARTEMIS, ALARM and ECOCHANGE.

In conclusion, recent research tends to incorporate participation as an essential component in a methodology for adaptation and sustainability research. BASE offers the stage to develop further similar approaches, as it is a multidisciplinary consortium group analyzing case studies in multiple sectors, stakeholder groups, within a wide geographical distribution, and for multiple impacts and measures. Nevertheless, it seems important that the choice of participatory methods used is narrowed to a limited pool of methods and tools, to allow for higher levels of comparability between cases.

Within BASE, our main focus is not to further develop participatory research as a scientific approach, though this could be an interesting spin-off, but rather to develop participatory tools and methods that can best serve adaptation decision-making processes, and to discuss how resorting to such methods and tools may improve the uptake of local (bottom-up) knowledge and preferences in adaptation planning and implementation within top-down policy design and implementation strategies.

5.6 Ethics of engagement

Discussing the ethics of engagement and participation in adaptation to climate change implies first of all distinguishing the different levels of adaptation actions and measures. The questions that arise while discussing ethics of policy making (Bellamy and Warleigh, 1998) at the European or national levels are different than the ones that arise when discussing local governance or when discussing community-based adaptation (IIED, 2009).

Other aspects of participation and engagement that raise important ethical questions are the ethics of research (Williamson and Prosser, 2002) and the ethics behind the roles, methods and tools used in decision-making processes (Papadakis et al., 1998).

Each of these topics deserve an essay in itself and therefore we will briefly identify some of the questions that arise in each of them, bringing in ideas on how can the answers be found and give space to new, more challenging questions.

5.6.1 Ethics of engagement in policy making and governance

In policy making citizens and stakeholders can be consulted or involved and their opinions can serve different purposes such as: providing more ideas and solutions to the problem; knowing if the citizens oppose a certain proposal and if there is enough public support for its implementation; legally approving a governmental proposal; inviting stakeholders and citizens to contribute with proposals in the first stage of a problem / proposal and accompany the decision makers in all the process, etc.

To discuss ethics it is interesting to see what would be the choice in an ideal world and then evaluate if this choice is possible and if not, what compromises need to be made and to obtain what in return for that compromise.

In an ideal world, the decision makers and all interested citizens and stakeholders can take part in the decision making since the beginning of the visioning process, following to the planning, implementation and evaluation phases of policy making. In an ideal world, all interested people and institutions in a decision making process can listen to the other stakeholders and win-win solutions can be found at all times.

In the present world, involving all interested citizens and stakeholders raises several practical difficulties that tend to result in diminishing and strongly regulating participation in decision making processes.

Arguing for the diminishing and regulation of participation is the difficulty in bringing groups and citizens with opposite world views into working together for the common goal. It is almost impossible to achieve consensus since the stakeholders take strong arguments for their priorities and defend their interests making it very hard for moderators or politicians to harmonize the different views of society. Due to these difficulties in making decisions together, decision-makers feel the need for distance from stakeholders to be able to lower the “noise”, think by them-selves and work on their decisions.

On the other hand, arguing for more participation is the understanding that when participation occurs better decisions and solutions are achieved and normally with less problems and opposition in the phase of implementation. Furthermore, when participants understand that their opinion was valued and useful they feel rewarded and become more active citizens contributing to the common good and goals of society. Like mentioned above, participation promotes more effective and efficient solutions while at the same time bringing legitimacy to the decisions made. When people and stakeholders are affected by a certain decision it is also fair and just that these people are heard in the decision making process and their interests are weighted and balanced together with the other interest at stake.

How are interests of different stakeholders pondered in the decision making process? Is this process transparent for the interested stakeholders? Should this process be transparent? Can it be transparent? What tools can be used to make it transparent?

These questions can be raised in every decision making process and the answer achieved define to a great extent the level of participation and inclusion withheld in the process. BASE will look into case studies where different stakeholders have been involved and will look for the answer to these questions in order to understand how feasible and contextual is the transparent inclusion of stakeholders’ interests in the decision making for climate change adaptation.

5.6.2 Ethics and lobbying

Lobbying is one of the regulated aspects of participation in policy making and its practice influences the final decisions made by politicians whether lobbying is done directly or indirectly (Wilson, 2005).

The Transparency International EU Office states that “lobbying activities at the EU level need to be made more transparent. An estimated 3000 lobbying entities have an office in Brussels and target European institutions to influence legislation, so it is crucial for transparent EU decision-making that their goals and methods are made clear” (Transparency International EU Office, 2012).

The regulation of participation and engagement is therefore essential to ensure transparency in policy for climate change adaptation when potential conflicts may occur.

Ethics are the rules of conduct recognized in respect to a particular class of human actions (Dictionary, 2013). When discussing the rules of conduct in respect to lobbying it is essential to understand that the ethical or moral principles can conflict with the power relations that arise and are reflected in the lobbying practice.

The ethical questions of lobbying can therefore include the issue of how to deal with and regulate the economical and financial power of institutions that have more capital than entire countries. Adapting to climate change and making decisions that respect the interests and ethics of all stakeholders is a challenge that has ethical questions but also practical feasibility issues.

BASE will look in case studies for the direct and indirect lobbying inputs that can provide input to decision making for climate change adaptation and at the same time identify if this input has unbalanced the inclusion of all stakeholders interests and how have decision makers in that context dealt with ethics and lobbying.

Some of the ethical questions that BASE will look for in its case studies are:

- What are the best regulation solutions to allow the participation of strong interest groups and at the same promote the direct participation and engagement of small interest groups namely non-profit institutions, unprivileged citizens, small regions, etc.?
- What are the best decision support tools that improve the use of transparent multi-criteria and participatory decision-making?
- Have all the social actors the same importance (i.e. weight)? Should a socially desirable ranking be obtained on the grounds of the majority principle? Should some veto power be conceded to the minorities? Are income distribution effects important?
- Imagine the common case of building a dam to harvest rainwater in a drought region. Very frequently this dam will submerge an entire village, their cemetery and their history. Would it be ethically more correct to invite this population in a focus group… or ethically compulsory to take into account their choices of life and consider other alternatives? And who represents the population?
- What is the role of lobbying in the whole spectrum of participatory decision making?

5.6.3 Ethics behind the roles, methods and tools used in decision-making processes

Researchers have found (Williamson and Prosser, 2002) that decisions are very affected and determined by the process and by a multitude of contextual, specific and management factors.

Examples of this importance can be:

- If the method of participation only asks participants to consider two alternatives then their opinions will not be known and other, eventually better alternatives will not be considered;
- If the method of participation asks for quantitative evaluation and no qualitative opinions then the richness of opinions will not be heard;
- If the participatory process is too long to achieve results, some stakeholders will prefer a situation of any decision instead of the best solution;
- If people cannot use the internet or a certain *media* then their voice will not be heard in an online public consultation;
- If a public meeting is convened in a *time* when farmers are working in the land then their voice will not be heard in the decision making process;
- If a researcher, politician, moderator or facilitator doesn’t give the right to speak to all people that want to speak in a meeting, then their opinions will not be taken into account;

- If the decision-maker is a person with plenty of power and (s)he is the moderator of the session, people will have difficulty in contradicting the opinion of the powerful person in the room and their opinions will not be heard;
- If the participatory process is not confidential some stakeholders will not feel comfortable to give their personal honest opinion;
- If the participatory process results in proprietary/ commercial information some people will not want to give their input for free.

It is therefore essential that when researchers analyse how solutions were made that all this detailed aspects are taken into account and more specifically, it is important that decision-makers, moderators, facilitators, action-researchers and consultants are aware and trained in group dynamics when supporting strategic decision making processes.

5.6.4 Ethics of research

Kurt Lewin, the first researcher to use the concept of action-research, said that “the best way to understand something is to try to change it”. This phrase opens the debate for the role of the researcher when researching a dynamic and complex process that is occurring in the present. Should researchers consciently interact with the observed in order to better understand the process

- Is it always possible and desirable that the researcher stands as an observer, watching the process occur? And can the researcher fully understand the process without interacting with the stakeholders?
- And to which extent is the observation already an intervention with an impact?
- Can researchers facilitate the opening of people to give their opinions without standing as persons and sharing some of themselves?
- And how can research contribute to solving problems in a bottom-up perspective?
- Is the act of producing knowledge and publishing in scientific journals enough to help problem solving and bottom-up climate adaptation?

What are the ethical principles that going to be used in the BASE project? What ethical principles can be found when reading the Description Of Work (DOW)?

The BASE project will analyse retrospective case studies with participatory and non-participatory methods and in on-going participatory case studies will promote the participatory generation of adaptation strategies and plans, supporting the involvement of stakeholders through novel participatory and co-design techniques[15].

How can these participatory practices inside the BASE project promote the discussion of the ethics in research inside the BASE consortium? And how can these participatory and co-design techniques contribute to raise the value of BASE project to the researched stakeholders and society as a whole?

Ethics is the system of moral principles of a culture and, in this case, of the scientific research community and more specifically of the BASE research consortium. BASE consortium will create some space to answer these questions inside in order to clarify the moral principles that stand behind its the research interests and motivate the consortium into doing its best for science and society.

[15] See BASE Annex I - DOW Description of Work (part A+ B) pages 3, 24, 25, 28, 57

5.7 Conclusion

A Participatory Group of BASE partners will oversee and collaborate about the collection and interpretation of data from all BASE partners. Furthermore, it will collaborate about the test and development of novel participatory methods. Lead partners in the group are DBT and FFCUL, but strong collaboration between all members of the group will be encouraged and facilitated.

The objectives of this are to:

1. Make recommendations for the use of participatory methods in climate adaptation (WP7)
2. Develop novel participatory methods for climate adaptation (Task 5.5)

Participatory methods, while to some extent standardised, are never used in the exact same way (precisely because they are context sensitive) and are therefore constantly evolving. New methods are often hybrids of existing ones and a matter of using components of one method in others, thereby designing novel participatory approaches to a decision-making process. Novelty is quite often a matter of applying participatory methods used for planning and decision-making processes in one area to new areas, thus taking on new shapes in the meeting with new contexts and purposes. It is from this understanding of the term “novel methods” that BASE will proceed.

All Case studies will answer a set of questions midways through WP5. Members of the participatory group will review the narratives and ask for additional information.

With the information thus collected, analysis of the “width” (the variety of societal actors involved) and the “depth” (the level of influence and responsibility given to the actors involved) of participation can be assessed and useful conclusions possibly made.

Within BASE, our main focus is not to further develop participatory research as a scientific approach, though this could be an interesting spin-off.

Ethical and moral principles of decision makers and stakeholders (including researchers) guide the willingness to promote an inclusive and effective decision making process climate change adaptation and BASE will, therefore, be a research consortium that will keep in mind its importance in the whole adaptation process.

6 Common starting points, practices & questions

By: Jouni Paavola (UNILEEDS) and Xin Li (UNILEEDS)

The chapter below outlines the common starting points for BASE case studies, as well as the common and supplementary research questions the BASE case studies will seek to answer. Core research questions are those that all cases will seek to answer, while answering of supplementary questions will depend on the nature of specific case studies and resourcing of the research teams.

6.1 Common starting points

6.1.1 Timeframes and Scenarios

The BASE project aims to provide a common framework on climate and socio-economic scenarios to allow comparability and consistency across the analyses performed by case studies. The common timeframes for scenarios and analyses in BASE case studies are 2015-2030-2050-2100.

The most recent scenario building process developed by the IPCC devises a set of Representative Concentration Pathways (RCPs) corresponding to different greenhouse gas emissions, concentration and radioactive forcing scenarios (van Vuuren et al., 2012). In parallel, Shared Social Economic Pathways (SSPs) are being developed by social scientist (Moss et al., 2011, O'Neil et al, 2012) detailing social economic future development for the world economic system that can be linked to RCPs. The decision of the BASE consortium, to be up to date and policy relevant, is thus to refer to this new information set. The following sections briefly summarize the main features of RCPs and SSPs (See deliverable 3.1 for more information).

Representative Concentration Pathways

Table 24 describes the different CO_2 equivalent concentrations that the four RCPs propose, which range from a minimum of the RCP2.6 to the very high concentration of RCP 8.5.

	Description[a]	Publication—IA Model
RCP8.5	Rising radiative forcing pathway leading to 8.5 W/m^2 (~1370 ppm CO_2 eq) by 2100.	(Riahi et al. 2007)—MESSAGE
RCP6	Stabilization without overshoot pathway to 6 W/m^2 (~850 ppm CO_2 eq) at stabilization after 2100	(Fujino et al. 2006; Hijioka et al. 2008)—AIM
RCP4.5	Stabilization without overshoot pathway to 4.5 W/m^2 (~650 ppm CO_2 eq) at stabilization after 2100	(Clarke et al. 2007; Smith and Wigley 2006; Wise et al. 2009)—GCAM
RCP2.6	Peak in radiative forcing at ~3 W/m^2 (~490 ppm CO_2 eq) before 2100 and then decline (the selected pathway declines to 2.6 W/m^2 by 2100).	(Van Vuuren et al., 2007a; van Vuuren et al. 2006)—IMAGE

[a] Approximate radiative forcing levels were defined as ±5% of the stated level in W/m^2 relative to pre-industrial levels. Radiative forcing values include the net effect of all anthropogenic GHGs and other forcing agents

Table 24 CO2 equivalent concentrations in four RCPs

Source: van Vuuren et al. (2012)

RCPs also provide socio-economic information as in Figure 21 and Figure 22

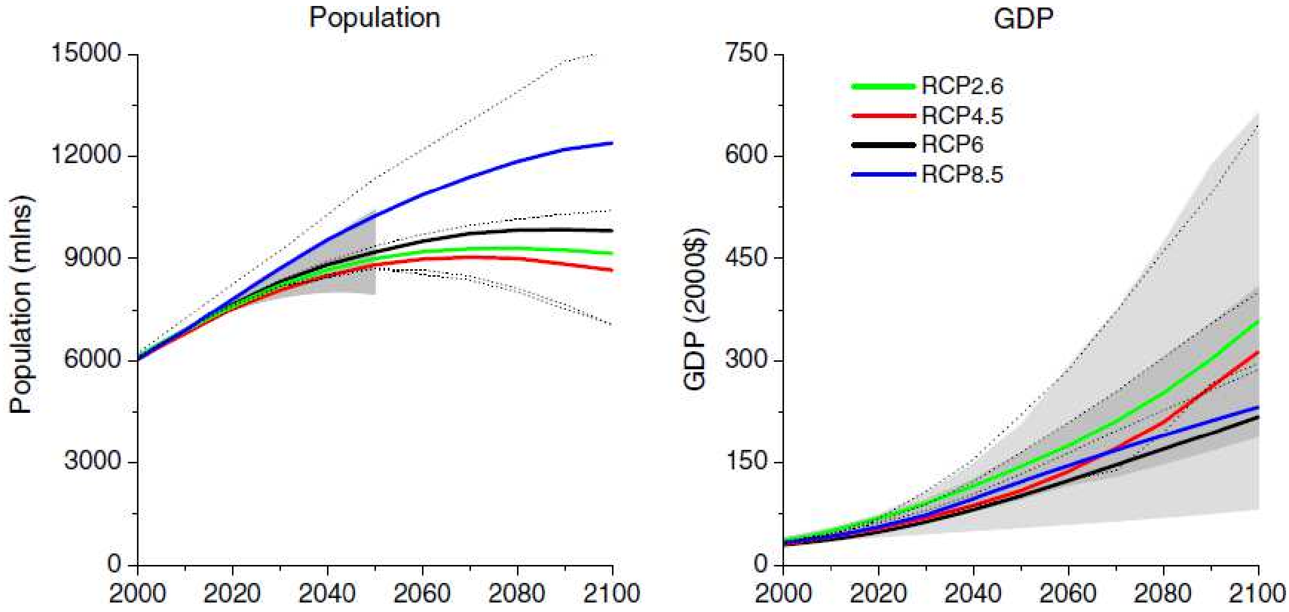


Figure 21 Social economic drivers for RCPs (a)

Source: van Vuuren et al. (2012)

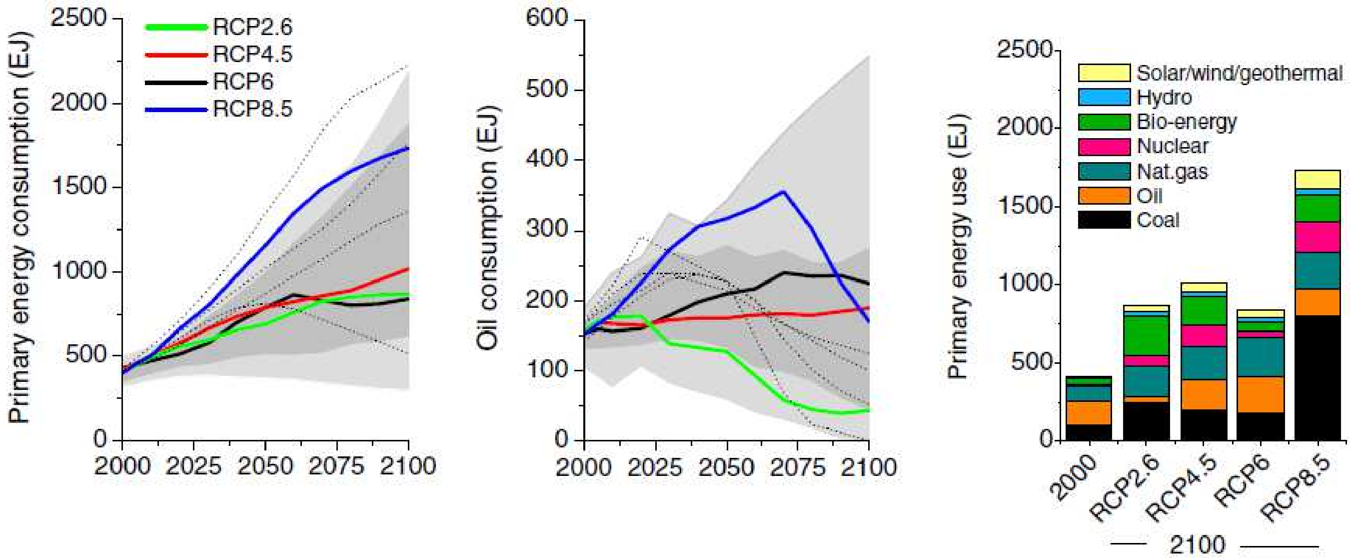


Figure 22 Social economic drivers for RCPs (b)

Source: van Vuuren et al. (2012)

Shared Social Economic Pathways

The SSPs are part of a new framework that the climate change research community has adopted to facilitate the integrated analysis of future climate impacts, vulnerabilities, adaptation, and mitigation. Figure 23 describes the ‘new’ IPCC scenario building process. They are supposed to be either linked, but also independent upon RCPs.

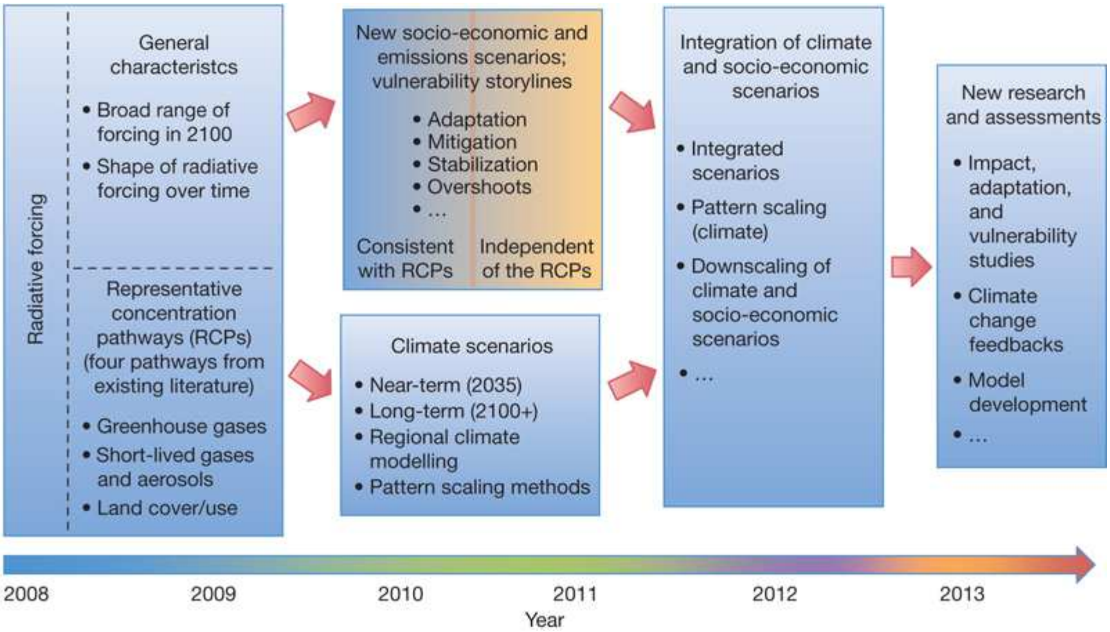


Figure 23 The 'new' IPCC scenario building process

Source: (Moss et al., 2010)

The SSPs framework is built around a matrix that combines climate forcing on one axis (as represented by the Representative Forcing Pathways) and socio-economic conditions on the other. Together, these two axes describe situations in which mitigation, adaptation and residual climate damage can be evaluated. The narratives that describe the main characteristics of the SSPs future development pathways are summarized in deliverable 3.1.

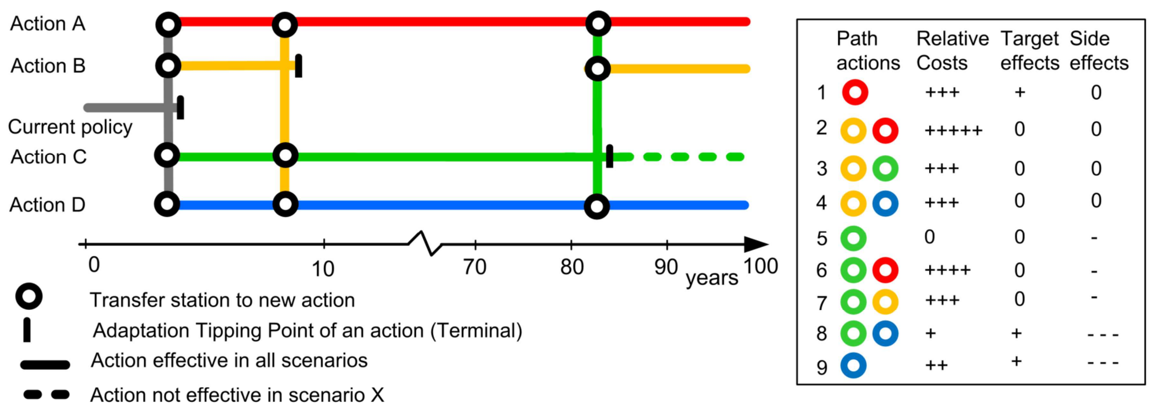
6.1.2 Adaptation baseline, measures and pathways

BASE case studies will examine adaptation measures that have either already been undertaken, or are being considered for implementation sometime in the future. For this reason, there are several possible baselines against which the costs, benefits and effectiveness of adaptation measures can be determined. For the ex post case studies the most obvious point of comparison is that one of "no adaptation": the counter-factual situation within which the adopted adaptation measure is not undertaken. For the forward-looking or ex ante case studies, two different baselines can be considered. Firstly, adaptation measures can be contrasted to a situation of "no (other / further) adaptation". Secondly, the adaptation measures can be contrasted with a "business as usual" scenario where some adaptation will occur irrespective of the studied adaptation measures.

The key analytical practice in case studies should be transparency about the used baseline. For practical purposes, "no adaptation" may be an easier baseline to use in the case studies. Business as usual baseline could include for example "autonomous adaptation", which may be difficult to predict in specific case study settings.

Adaptation to climate change can encompass a myriad of different adaptation measures, which are calculated to help avoid adverse climate change impacts, or to reap the benefits of positive climate change impacts (See Paavola and Adger, 2006). Adaptation can be based on collective choices and action or be a result of private or individual decisions. Adaptation can be undertaken proactively or as an ex post response to adverse climate change impacts after they have been realised. Adaptation can encompass public policies and strategies such as heat wave action plans, burden sharing arrangements such as the provision of insurance, investments in physical infrastructure or goods such as hard flood protection or water storage, provision of public services such as seasonal weather forecasts, or behaviour change such as migration or varied preparedness measures.

One central approach within BASE is to understand adaptation by means of adaptation pathways (Haasnoot et al., 2013, Haasnoot et al., 2012b). ***Adaptation Pathways*** consist of a sequence of adaption ***measures*** (actions) to achieve targets under changing climate and socio-economic conditions. Usually these pathways are used in the context of policy planning, i.e. ***planned adaptation***. Measures, however, may also involve stimulation and enhancement of ***autonomous adaptation*** - the response of individual stakeholders to external changes and (sectoral) policy. Adaptation pathways may be considered as part of an adaptation ***strategy*** in which coping with uncertainty is considered important***.*** Adaptation pathways can be represented through logical pathways maps and scorecards, see figure xx below.



Adaptation Pathways Map **Scorecard pathways**

Figure 24 Graphical depiction of adaptation pathway.

Key elements of the adaptation pathway approach are:

The use of critical thresholds called **adaptation tipping points** (ATP): under what conditions will climate change become a problem for current management and policies (per sector) and is a change of strategy needed? In this way climate impacts can be linked to (sectoral) policy goals.

Consideration of a wide portfolio of options (measures/strategies/actions) for adaptation in case such critical thresholds are near. Distinguish between short-term measures (that might be planned for implementation) and long-term options (what possibilities are there when change is going faster than assumed, or societal perceptions might change?). This means working with multiple time horizons such as 2015-2030-2050-2100.

Consideration of more than one climate and economic **growth scenario** (at least 2, Low emission, High emission coupled to socio-economic growth) to make clear the uncertainty involved from external developments (using the low end scenario will require a lower adaptation effort that the high end) and give some indication of the robustness of different options across scenarios.

Scenarios summarize climate change and socio-economic projections describing a range of plausible external contexts for the system considered in the case studies and model exercises. These scenarios are only very indirectly influenced by adaptation within the considered system and sectors. Scenarios are used within Base as a means to evaluate impacts of climate and socio-economic changes and the performance of adaptation strategies and as a guideline for developing story lines. The choices for using scenarios have been further elaborated in deliverable 3.1.

Storylines are narratives of plausible futures including climate change, socio-economic developments and pathways. Storylines tell the combined logical story of external developments and sectoral responses. Case study teams will develop case-specific adaptation pathways. These will later be up-scaled in consultation with stakeholder panels into wider member state and European adaptation pathways.

6.2 Adaptation Policy and governance: key questions

Based on Chapter 3, each case study must respond to the following questions. The extent to which each case study engages with the different questions varies and depends on the case study cluster, i.e. what is central issues for one cluster may be less apt for another; the nature of the case *per se* i.e. the scale and extent of policy intervention and the progress of policy initiatives to manage climate impacts; and on the design of the individual case study, i.e. what are stakeholders and case owners engaged with in the case. However, all cases must respond to each group of questions at some level.

The three *core questions* guide the analyses of the cases:

- ***What seems to determine the adaptive capacity (and vulnerability) in the case?***
- ***How successful are the cases in advancing adaptation (adaptive capacity/reduction of vulnerability)?***
- ***Which factors should one pay attention to in efforts to increase adaptive capacity?***

Case analyses that respond to these overarching questions will provide knowledge for WP2 and WP7 which both have a main focus on the role of policies and policy implementation in the responses, as this leads to considerations of the policy implications of specific sorts of policies (i.e. how should policies be designed?), institutions, administrative mechanisms and tools (i.e. what institutions/mechanisms/tools seem necessary/how should they operate?), resources (i.e. what resources are critical?) and how can success be determined.

The basic level of questions concerns the process and is formulated to allow, as far as possible, unambiguous responses with the documentation of “evidence” of the adaptation process. The questions aim to help the cases formulate a narrative of “what is going on” in order to provide a wider context for how policies contribute to (or hinder) the adaptation processes and actions at the case level.

Basic description

- History of the case/drivers
- Why was this case chosen?

- Why is adaptation important in the context of the case?
- Is this a prospective, on-going or retrospective case study?
- A brief introduction to the adaptive approach/measures included in the case, e.g. specifying
    - timing relative to climate impacts: anticipatory, concurrent, reactive;
    - intent: autonomous or planned;
    - spatial scope: local, regional, national, European;
    - form: behavioural, informational, institutional, technological; and
    - degree of adjustment: minor alterations to abandonment of activity.
- What is the cultural context of the case study – e.g. urban vs rural; materialist vs. post materialist

For prospective cases:

- What was the role of the analyst in initiating the case?
- Where other actors involved in initiating the case. Who and why?

For on-going and retrospective cases:

- When did the adaptation strategy start taking place?
- Who were the key initiators?
- How far is the implementation of specific adaptive measures?

The following sets of questions are directly related to the above specified determinants of adaptive capacity and should guide the case-specific design of the case data production and analysis. Again, the relative weight of the different questions is determined by the nature of the individual case study.

Understanding of climate adaptation (institutional environment/knowledge):

- Cognitive aspect of policy commitment to climate adaptation and to the principle of integrating policy adaptation into other sectoral policies
    - What is conceptualisation (the understanding) of climate adaptation as a policy problem; what forms of knowledge are included in policy making
- What efforts have been made to provide clear, widely accepted and operational objectives and principles for climate change adaptation among local actors (including institutional ones) ?
- Is the concept of climate adaptation sufficiently clear, agreed upon understood by stakeholders? What is the evidence to support your response, if present?
- How well are the costs and benefits [not necessarily in monetary terms] of adaptation understood by governmental and non-governmental actors in the case?
- What evidence is there that adaptation has been integrated (into "daily" activities and routines), reflecting commitment and awareness? Can you mention in which programmes, plans and budget?
- Has international/national climate change adaptation policy contributed to the understanding, and how has it contributed?
- What factors account for how climate adaptation is understood (e.g. cultural, recognition of the issue, role of powerful actors etc…)
- Do the actors perceive the need for coherence in policy/action? (across sectors/within sectors over levels EU->local)? What coordinating mechanisms exist/are being created. How is co-ordination – organized & institutionalized).
- Are there experiences of conflicting policies and policy measures that affect adaptation?
- Is climate change adaptation an-add on to planning and activities that are in place or progressing in any case, or is it a dominant driver of the activities in the case? Is that part of a larger adaptation strategy (national, regional, local), or part of a policy appraisal tool (such as impact assessment,

strategic environmental assessment, etc…..) ? Or further, an implementation measure from a sectoral policy?
- What is the role of slow trends vs. experienced or feared extreme events, vs. science in driving planning and action for adaptation?
- What role does the context (geography, political history, cultural background,...) play in the initiation and implementation of climate change adaptation?

Institutional environment and focus of adaptive actions (networks/policy culture)

- Presence on institutional policy agendas – is the public sector maintaining a sense of urgency, despite the longer-term nature of the issues related to adaptation and the uncertainty associated with the precise climate impacts? Please provide evidence if possible to back up your answer.
- Which laws/policies are the most important ones? What are the most relevant policy/legal provisions missing from the necessary framework? Do actors experience conflicts or synergies between the laws/policies in the case?
- Policy commitment to climate adaptation and to the principle of integrating policy adaptation into other sectoral policies
    - Institutional aspect: what coordination mechanisms are in place and how is learning organized

Leadership (more for on-going and retrospective) (managerial ability):

- Are all relevant authorities involved? if not, which are missing and why?
- Is there an institutional “catalyst” (authority, select committee etc.) in charge of steering adaptation? Is this institution linked to the authorities that implement the adaptation measures and in which way?
- Is the leadership behind adaptation planning and action manifested formally or informally? Why is this particular type of leadership effective?
- Is leadership expressed through a sequence of priorities over time? Please provide details of how and the different timings.
- Does the current legal framework and existing national or subnational policies provide a sufficient base for effective leadership?
- Has adaptation policy(ies) (at national/regional level?) played a role in creating the drivers for adaptation (at local level) ? How?

Managing and steering adaptation sustainably (more for on-going and retrospective)

- What is the time horizon for action? (Near future, years, decades?)
- Which are the main concerns: short-term risks vs. long term average change; extreme events; adaptation to current conditions?
- Is there a specified baseline reference level for adaptation and how it is determined (acceptability of vulnerability/risk level, culturally constructed, etc.)?
- Is there competition between authorities based on competence/budget/conflicting interests? Why and how does it arise/manifest: is it because of the legal structure or institutional arrangements? What consequences does it have? Whose competences are critical?
- Are sufficient resources available for the planning of adaptation? Which are the most important resources? What resources are lacking?
- Are costs and financing of adaptation action outlined (who will pay, can adaptation become profitable?)
    - Public expenditure (& level-state, local..)
    - Private funding (who: potential victims, entrepreneurs…)
- Business opportunities (recognition of existing, potential)
    - Opportunities for job creation (link to time perspective – immediate vs. long-term change)

- Voluntary action vs. incentives or combinations
- Autonomous & planned adaptation – where are the costs?

General philosophy/underlying approach/strategy in the adaptation planning/action in the case:

- Hard/grey measures (higher dams, concrete based protection…)?
- Reflexive/adaptive adaptation (adaptation thresholds?)
- Structural change to increase resilience to ”any” change with “soft” measures such as green infrastructure, land use planning?
- Why is this approach taken (e.g. lock-in, path dependency, cultural preferences, role of powerful advocates etc…)
- Does adaptation aim for flexibility and reflexivity – i.e. the ability to change as CC and other factors develop? (is the adaptation iterative?)
- Are the nature and role of (potential) obstacles recognized and addressed, including issues related to social acceptance and culture (at the local level; values & practice)? How are they recognized and dealt with.
- What is the position of climate adaptation issues relative to other policy agendas?
  - Is there recognition of wider sustainability issues in adaptation?
  - Resource efficiency
  - Links to mitigation
- Social-cultural conflicts/tensions

Knowledge

- What is counted as relevant knowledge and where does it come from (research, experience, guidance, peers…)? What factors are shaping the hierarchy of knowledge (e.g. institutions, culture, trust, advocacy by powerful groups…)? What kind of knowledge will be more feasibly transferable to policy makers and to other targets across the whole policy cycle?
- What sources of information are important for the planning/implementation of the adaptation action?
- What has been clearly quantified as a base for adaptation and considered a reliable estimate and how?
- Who are considered to be the relevant producers of knowledge for adaptation (different actors – NGO, research...)? Is there a science-policy-practice interface (e.g. knowledge networks, boundary organizations, workshops, etc.)?
- What is the role of knowledge networks? How are such networks created and used at and by different governance levels?
- What tools of planning and management are being used/developed to facilitate “knowledge brokerage” ? What their relative analytical strengths and weaknesses?
- How are different pieces of knowledge used in the case? (Instrumental planning vs. contribution to conceptual understanding vs. political debate vs. symbolic “we are aware (but we are not doing anything).” Why are knowledge used in this way?
- How is the communication between actors & by actors organized?
- How is scientific uncertainty recognized and managed in planning/action?
- Do laws or policies specify processes for the production and use of knowledge (mandatory monitoring, determination of thresholds, appraisal processes, etc.?)

Engagement of the public (stakeholders and citizens)

- Do effective mechanisms exist for informing the public about adaptation? How do they work ?
- Are there clear guidelines on when, with whom, and how inclusion of citizens/stakeholder perspectives should be carried out?

- Are mechanisms in place for the evaluation of and feedback on consultation, and for monitoring the influence of participation on decision-making?
- Is transparency ensured? For example, has restricted information been made the exception, not the rule, both in principle and in practice?
- Are transparency mechanisms being reinforced for key decisions on adaptation?
- Is a framework in place to allow discussions to focus constructively on areas of disagreement, by developing scenarios and options?
- Is stakeholder involvement in the case based on
    - Law (mandatory participation)
    - policies (general guidance & principles)
    - adopted practice at the local level
- Are practitioners involved (do they provide feed-back in developing and adjusting adaptation plans, what mechanisms are in place for receiving input) ?
- Are public-private actions (partnerships) existing/emerging? How do they operate?
- What is the role of the sense & perception of community (cultural background) in fostering adaptation?
- Are all relevant interest groups, stakeholders involved (who are involved, characteristics of..., what opportunities exist for them to participate, are they encouraged to express their wishes, demands...) What kind of evidence might be provided to demonstrate the accomplishment of this goal?

What is the impact/effect of studied case? (All)

- Has the process led to the development of a concrete plan or action program for adaptation?
- Has the process led to changes in infrastructure management (e.g. more dams, flood protection, managed realignment etc.)?
- Has the processes led to institutional changes to make them more responsive?
- Has the process studied led to better understanding of adaptation needs amongst key actors?
- Has the process studied led to better understanding of adaptation needs amongst key actors and the public?
- Has the process studied led to changed understanding of adaptation needs amongst key actors and the public?
- Has the studied case led to a number of different knowledge is being used to understand adaptation needs?
- Have the studied processes helped key actors understand policy spill overs and inter-linkages between sectors?
- Has the studied case led to more or less inclusiveness in the decision making processes?

6.3 Economics of adaptation: key questions

A stepwise guidance for the economic evaluation of adaptation options is provided in chapter 4 (see also table 25 for a summary of this guidance). The following table is a summary of the key and auxiliary questions to be answered by each case study in order to conduct this stepwise evaluation approach and to fulfil the data requirements from WP6 for upscaling.

Table 25 Key questions for economic evaluation of adaptation options in the case studies and data requirements for upscaling

Key questions	Auxiliary questions
Step 1 Preliminary risk assessment	

What is the climate change related problem/risk you would like to mitigate by adaptation?	Which problems already exist, what is/are the current risk/s?
	Which assets and sectors are at risk?
	Which adaptation or protection measures are already in place?
	How do these risks presumably change due to climate and socio-economic change?
Step 2 Identification of adaptation measures and adaptation pathways	
What are the alternative adaptation measures?	What are the primary and secondary objectives of adaptation?
	What are potential measures to meet these objectives?
	What is your baseline option (the "business-as-usual"-option)?
	Are there complementary measures? Is it appropriate to bundle these measures?
What are alternative adaptation pathways?	What is the "sell-by"-date of the measures or bundles of measures? I.e. when will they – under conditions of climate change – not be able any more to meet the defined objectives?
	What would be alternative measures or bundles of measures at these "tipping points"?
Step 3a Selection of evaluation criteria	
Which evaluation criteria should be used?	What are the relevant positive and negative aspects of the measures (costs and benefits) to be considered in the evaluation process (economic, ecological and social effects)?
	What is the appropriate unit to measure each of these criteria? Is the performance of the adaptation options measured in qualitative, monetary or other quantitative terms?
Step 3b Selection of evaluation method(s)	
What is the appropriate evaluation method?	Is it possible to express all relevant cost and benefit criteria in monetary terms? (→ cost-benefit analysis)
	Is it possible to express the positive effect (objective) by a single non-monetary indicator? (→ cost-effectiveness analysis)
	Are there several relevant criteria which cannot or cannot easily be expressed in monetary terms? (→ multi-criteria analysis)
Step 3c Weighting of evaluation criteria (applicable only to multi-criteria analysis)	
What are the preferences of stakeholders regarding the different	Are there different stakeholder groups with different preferences regarding the evaluation criteria?

evaluation criteria?	
	Which weight do stakeholders and/or decision makers attach to a substantial change in the performance of the adaptation options regarding each evaluation criterion? (→ Swing-Weight method)
Step 4 Data collection	
What are the costs of the alternative adaptation options? What are the benefits of the alternative adaptation options?	For each cost and benefit criteria selected in step 3a: What potential data sources, including damage & impact assessment methods or existing CBA studies on adaptation measures?
	If no relevant data sources are available and modelling cannot be undertaken: Which experts can estimate proxies for assessing the performance of measures regarding the respective criterion?
What is the evaluation time frame	What is the lifespan of the measure with the longest lifetime?
Which discount rate should be applied?	Which discount rate is recommended by national guidelines for climate change adaptation measures (or public investments)? (In addition, for testing sensitivity of results against different discount rates also a low and high discount rate should be applied (1% and 5%))
How to deal with data uncertainty?	Can uncertainties related to the performance of the measures regarding certain evaluation criteria be described by a range (min-max), a triangular distribution (min, most likely, max) or any other kind of probability distribution?
Step 5 Evaluation and prioritization	
What is the ranking order of alternative adaptation options (measures, bundles of measures or pathways)?	For cost-benefit analysis: What is the net-present value (discounted benefits – discounted costs) of the alternative options? What is the benefit-cost ratio?
	For cost effectiveness analysis: Which alternative option achieves a defined objective at lowest costs? What is the cost-effectiveness ratio?
	For multi-criteria analysis: Which adaptation option performs best? (e.g. for PROMETHEE approach: which option has the highest net flow?)
	What are the uncertainties associated with the performance of the different options? Is there and, if so, to what extent uncertainty in the ranking of options? Is it possible to determine which option most likely performs best or is it necessary to gather further information to reduce uncertainty (go back to step 4)?
Information required by WP6 for upscaling	
What is the baseline option? (see above step 2)	As a business as usual strategy (recommended) or, or as a no adaptation strategy?
	• How is this baseline built up? • What is included and what is excluded?
	What is the ambition level of the reference strategy? • Maintaining current risk levels or current protection levels (implying with CC risks may increase)? • Is current backlog of investments for adaptation measures included or excluded? • Does it include only planned adaptation or also autonomous, non-planned adaptation?
Which evaluation method is applied? (see above step 3	• CBA? • CEA?

	• MCA? • Other?
Which cost categories are included? (see above step 3)	• Investment costs, operation & maintenance cost? • Other negative effects (economic, ecological or social)? • Direct, indirect costs? • Tangible, intangible costs?
Which benefit categories are included? (see above step 3)	• Which positive effects are included (economic, ecological or social)? • Direct, indirect costs? • Tangible, intangible costs?
Which discount rate is applied? (see above step 4)	• National discount rate? • Low discount rate (1%)? • High discount rate (5%)?
Which evaluation outcomes are available? (see above step 5)	• CBA: present value of costs, of benefits, net present value, benefit-cost ratio? • CEA: net present value of costs, effectiveness, cost-effectiveness? • MCA: qualitative or quantitative performance of adaptation options in single criteria, overall performance of adaptation options, ranking of options?

6.4 Participatory approach: key questions

Case studies (both retrospective and prospective) adopt participatory approach need to answer the following the questions:

General:

- What is the democratic and political tradition for involving experts, stakeholders and citizens in spatial planning in the country, and how is climate adaptation situated within that tradition?
- Is the involvement of experts, stakeholders and citizens in your country and case study based on formal laws, general guiding principles or more informal local initiatives, and how exactly is the framework for this involvement described?
- What guidelines for participation are in place, related to the case, and how clear are they?

Specific:

10 Which participatory methods have been used at which stage of the adaptation/planning process? Who (experts, practitioners, stakeholders, citizens) have been involved at which stages of the decision-making process (from early decision to act, to setting objectives, to identifying measures, and to implementing them)?
11 What have been their roles in this involvement (from being informed, to being asked for feed-back, to co-designing – and have they been asked to contribute with knowledge and/or views)?
12 What has been the distribution of power between the experts, practitioners, stakeholders and citizens, and what influence have they had on the adaptation/planning process?
13 How could the participation of experts, stakeholders and practitioners in the adaptation/planning process be improved?
14 How and at which stages of the adaptation/planning process have economic assessments of adaptation actions been used (and which kind?), and how much influence have they had on the adaptation/planning process?
15 Which experts, stakeholders and citizens have been involved in making the economic assessments and the decision about which kinds of costs and benefits to assess, and how influential have their respective contributions been?

Re 1) “Citizens” refer to a broad category of people (for example the residents in a municipality) who themselves will not directly be affected by climate change (for example flooding of their house) but as a resident (and taxpayer) could have positions or ideas for how to priorities land use and climate change measures in the future.

Re 4) Try to sketch out the different phases of the adaptation process and write who were involved in these phases, for example from where came the initiative to start adaptation planning, who did (and who were actively invited to) contribute with ideas to adaptation measures etc.

Re 5) In the retrospective cases it would be relevant to analyse (for example via interviews) the impact of participation in the adaptation process.

Re 6) Which kind of experts have been involved and what has been their role? Stakeholders are a diverse group of different interests, from big powerful organizations to local informal groups with specific interests. Try to set out the influence of the different groups in relation to the decision making process. Has ordinary (local) citizens without a specific stake been involved (where and how)?

Re 7) For example, were there phases in the decision making process where certain groups were not involved but where the process could have gained if they had? And could the process have been improved with another kind of involvement in certain phases?

Re 9) In retrospective cases you could interview people who have been involved in the case. It would be useful to ask if they found the selected costs and benefits relevant and adequate.

A questionnaire (probably online) will be prepared in order to secure a standardized feed-back for some of the questions, i.e. listings of participants in the different stages of a decision-making process about climate adaptation.

With the information thus collected, analysis of the “width” (the variety of societal actors involved) and the “depth” (the level of influence and responsibility given to the actors involved) of participation can be assessed and useful conclusions possibly made.

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8 Appendix I Case Study Living Document (prepared FFCUL)

The case study living document (CSLD) will be one instrument for guiding case study research and pacing reporting on it. The outline included into this appendix will be used for first periodic reporting the purpose of which is to generate some of the results needed for the preparation of **D5.1 Climate change, impact and adaptation scenarios for case studies**. The CSLD will be updated and detailed periodically so that it can guide the reporting needed for the compilation of other deliverables of WP5.

LOGO/PICTURE

Subgroup: XXXXXXXXXXXX

Case-study: XXXXXXX

(Partner, Country)

Date

BASE report

Document prepared by:

Name of Researcher responsible for the case study

Partner

Project:

FP7/ Project BASE [2012-2016]

Date of release:

XX/XX/XXXX

Purpose of this document:

"The Case Studies Living Document (CSLD) will be the document that each case study leader will use to share the information that (i) characterize and give context to its case study, (ii) the goals within BASE, (iii) the methods used and mainly (iv) a synthesis of the results that that case study is providing to BASE project. This will allow the CS leader to understand how its own case is going (having a good overview), but also (v) will allow the sub-group to which the case study belong to know what is happening and what can be done (mainly on synergies and so on) as well as to (vi) WP4 & 5 coordinators to use that information to report (including each WP task leaders). These living document will also (vii) allow WP6 & 7 partner to know the information."

Index

1. General Case Study Description

A. Location

(Please insert the coordinates of the geographical centre of your case study and additionally the area of the entire are under investigation. For a city, for example, use the city centre and the area of the municipality. Illustrate in the map the area in study)

GPS: N________/ W(?) ____________
Area: km^2

IMAGE / MAP / AREA

B. Case Study Summary

(Máx 500 words)

C. Context

(Máx 500 words) *If relevant to the understanding of the Case Study , please provide any contextual information of the region, history, etc of the case study*

D. Brief General Information on Climate CHANGE and related issues

(Máx 2000 words) *Please state which is the European climate zone of the case study and insert any information regarding the current available information regarding the case-study, namely expected impacts, scenarios.*

E. Existing Information on Case Study's adaptation history

(Máx 2000 words) *Please insert a Short resume of the Case study existing information related to Climate Change Adaptation (major goals, plans, measures and timelines already defined or implemented), important Milestones in its "Adaptation Journey" as well as relevant state-of the art regarding the implementation of Adaptation Strategies and Specific Measure*

F. Connection with other research projects:

(Please list and shortly describe previous or ongoing research projects directly related with the Case Study)
Please write the name and summary of the project, relevant partner institutions, year of beginning and end of project)

G. Case ID, Typologies and Dimensions

Having in mind the following BASE Objectives; Categories of Case Studies, please fill in the following table.

BASE OBJECTIVES

1. Compile and analyze data and information on adaptation measures, their effectiveness. (…)
2. Improve current, develop new and integrate methods and tools to assess climate impacts, vulnerability, risks and adaptation policies (…).
3. Identify conflicts and synergies of adaptation policies at different levels of policy making with other policies (including climate mitigation) within and between sectors. (…)
4. Assess the effectiveness and full costs and benefits of adaptation strategies to be undertaken at local, regional, and national scales using innovative approaches (mainly by integrating bottom-up knowledge/assessment and top-down dynamics/processes) with particular attention on sectors of high social and economic importance.
5. Bridge the gap between specific assessments of adaptation measures and top-down implementation of comprehensive and integrated strategies.
6. Use and develop novel participatory and deliberative tools to enhance the effective use of local contextualized knowledge in adaptation strategies to assess perceptions of adaptation pathways and their co-design by citizens and stakeholders.
7. Disseminate findings by sharing the results of the project with policy-makers, practitioners and other stakeholders. (…)

CASE STUDIES CATEGORIES

A. Public administration (municipality, regional, national, european)
B. Research and education Centres (universities, research centres, projects and groups, schools)
C. Public companies
D. Companies (farms, SMEs, big businesses)
E. Social enterprises (cooperatives, non profit companies, woofing farms, etc)
F. Consortiums (partnerships, campaigns),
G. NGOs (environmental NGO, local development NGO, charities, etc)
H. Transition Initiative
I. Ecovillage
J. Informal groups, Movements

Case ID			Typologies and characterization					
Country & Name of CS	BASE Objectives to be answered by the CS	Category of case study	Territorial zones	Scale	Process Direction	Temporal Definition	Timescale[16]
	☐ Objective 1 ☐ Objective 2 ☐ Objective 3 ☐ Objective 4	Example: ☐ Companies (Farms)	☐ Rural ☐ Urban ☐ Coastal ☐ River Basin	☐ Local ☐ Regional ☐ National ☐ Transnational ☐ European /Global	☐ Bottom-Up ☐ Top-Down	☐ Retrospective ☐ Prospective	yyyy - yyyy

16 Please insert year of start and year of end of case study.

	☐ Objective 5 ☐ Objective 6 ☐ Objective 7						

H. Impacts, Sectors and Implementation

Please tick the relevant boxes for impacts and implementation and insert the number 1 for primary sector and the number 2 for secondary sector.

Impacts		Sectors		Implementation	
Primary CC Impacts (Climate-Adapt)	Primary CC Impacts (BASE)	Primary and Secondary Sector (Climate Adapt)	Primary and secondary Sector (BASE)	Implemented [17]	Phase of Implementation[2]
☐ Temperatures ☐ Water Scarcity ☐ Flooding ☐ Sea level Rise ☐ Droughts ☐ Storms ☐ Ice and Snow	☐ Extreme temperatures ☐ Water scarcity ☐ Flooding ☐ Coastal Erosion ☐ Droughts ☐ Soil Erosion ☐ Vector Borne Diseases ☐ Damages from extreme weather related events (storms, ice and snow)	☐ Agriculture and forest ☐ Biodiversity ☐ Coastal Areas ☐ Disaster risk reduction ☐ Financial ☐ Health ☐ Infrastructure ☐ Marine and Fisheries ☐ Water Management ☐ Urban	☐ Agriculture ☐ Biodiversity & Ecosystems ☐ Coastal and Marine systems ☐ Energy ☐ Health and Social Policies ☐ Transport ☐ Production Systems and Physical Infrastructures ☐ Water resources ☐ Tourism	☐ Yes ☐ Ongoing ☐ No	☐ Assessment ☐ Planning ☐ Implementation ☐ Monitoring ☐ Evaluation

I. Importance and Relevance of Adaptation

Please tick the relevant box for the case study.

☐ Case developed and implemented as a climate change adaptation measure

☐ Case developed and implemented and partially funded as a climate change adaptation measure

[17] When the case study consists of a public administration with a top down approach, implementation can be an approved legislation or regulation. When the case study is about practical adaptation measures like a sand dune, for example, implementation should be considered finished when the dune is built in situ.

☐ Case mainly developed and implemented because of other policy objectives, but with significant consideration on climate change adaptation aspects

Case study research Methodology

a) Research Goals

(Max 500 words) *Please insert which are the General Goals for the case study as well as how will the case study contribute for BASE projects and BASE key research questions.*

b) Stakeholders involved

(Max 2000 words) *Please insert any information about the stakeholders involved in the adaptation process with which you will relate to, namely their nature, involvement in the process, etc. If possible highlight the decision-making process as well as the leadership process for Climate Adaptation Strategies. Do Mention if there exists any kind of public engagement and participation within the Adaptation process.*

c) Methodology

(Max 2000 words) *Please insert what will be your research approach regarding this case study, how did you define it (did it include participatory sessions or not) and how you will implement it during the BASE Project period.*

- Note: Partners/Case Studies using PRIMATE tool will be using CBA (to prioritize) and/or MCA (with stochastic PROMETHE II) and the Monte Carlo Uncertainty Analysis, so please check these boxes.

METHODS to be used in Case Studies[18]	YES // NO
A) Methods for prioritizing adaptation options	
Cost-Benefit Analysis (CBA)	
Cost-Effectiveness Analysis (CEA)	
Multi-criteria Analysis (MCA)	
Analytic Hierarchy Process (AHP)	
B) Quantification of impacts and relationships between factors affecting adaptation	
Causal Diagrams	
Influence Diagrams	
Process-based Modelling	
Welfare variation analysis under restrictions	
C) Uncertainty and sensitivity analysis	
Probabilistic multi model Ensemble	
Monte Carlo simulations (PRIMATE uses this method)	
Real option analysis	
Climate risk management process	
D) Participatory Methods	
Scenario Workshop	
Participatory Cost Benefit Analysis (PCBA)	
Participatory add-ons to CBA	
Participatory add-ons to Multi Criteria Decision Analysis	
Participatory add-ons to Adaptation Pathways	
Other (add extra lines if necessary):	

[18] For descriptions and references of the Methods please refer to Milestone 8. For data requests from specific Work Packages please refer to Deliverable 4.1

(Máx 500 words) *Please highlight if you have any special need or focus regarding any of these methods and their use on your case study.*

d) Case study Timeline

(Please insert and image/graph of the Timeline of your Research Approach, highlighting important milestones and deliverables.)

e) Collaboration with other Partners and Case studies

Collaboration with BASE case studies **(see list in EMDESK)**:

Case: ______________________________; Person: ______________________

Case: ______________________________; Person: ______________________

Case: ______________________________; Person: ______________________

Case: ______________________________; Person: ______________________

Case: ______________________________; Person: ______________________

Case: ______________________________; Person: ______________________

Collaboration within BASE partners/researchers **(EX: for a specific competence)**:

Name: ________________________________; Partner: ______________________

Name: ________________________________; Partner: ______________________

Name: ________________________________; Partner: ______________________

Name: ________________________________; Partner: ______________________

Name: ________________________________; Partner: ______________________

Name: ________________________________; Partner: ______________________

Name: ________________________________; Partner: ______________________

f) Research Outputs

a. Scientific Publications

- Interim reports + final case study report for D5.5 (Month 30)

- Scientific papers: #

Provisional Title:

____

Month/Year: ___/_______

(add more papers in case you need)

b. Other Publications

- Books/Books Chapters: # 1

Provisional Title:

____

Month/Year: ___/_______

c. Other

- Scientific conferences: # ___

Provisional Title:

____

Conference: ______________________________ Month/Year: ____/______

Provisional

Title____

Conference: ______________________________ Month/Year: ____/______

-    Invited seminars, presentations at local events, etc…

3 References