Statistiska centralbyrån
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Institute for European Environmental Policy

Identification and elaboration of methodology to be used in the classification and costing of projects and programmes for adaptation to climate change

Final report 2011-02-07: contract SI2.550218

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Summary

This project focussed on government measures for adapting to climate change, with the goal of proposing a system to standardise data flows for the measurement and ex-post monitoring of economic data as well as proposing a methodology used to calculate adaptation costs. The report focuses on two relevant aspects: quantifying the cost of adaptation, and expenditure on adaptation. Regarding cost estimates of adaptation projects and measures, the report provides a proposal for the assessment of cost estimates based on what economic data is currently being compiled, what different approaches are available to do this, and what the differences are between the approaches. Regarding expenditure on adaptation, the report proposes a new methodology to quantify adaptation expenditure through the compilation of new statistics. It describes how the EU is currently accounting for past spending on adaptation in its budget, whether EU Member States hold any statistics on how much they have spent on adaptation, and if so, what types of measures are included as part of these statistics.

The project has only looked at planned measures (i.e. government activities). Aspects related to autonomous measures (i.e. private activities) are not covered as part of this report.

A literature review and searches of standardised classifications have revealed that there is an abundance of studies in the field of cost estimates for adaptation to climate change. It is frequently repeated throughout the relevant literature that there is a lack of data to use in existing models and a need for standardisation. This lack of data availability, together with the lack of transparency in model calculations, has been used to justify a new system for the classification of adaptation measures, and to determine how spending on them can be accounted for either in budgets, or in the case of the EU, as part of funds that will consider adaptation measures.

From a statistical point of view the standards aim at consistently categorising items so that adaptation measures do not blend into one another. But more than that, they provide a framework to which additional information can be added to enhance a specific study or project, if applied correctly.

The project emphasises the need for testing the developed proposals. Even though the work builds fully on existing approaches and methodologies, the standardisation process always takes time. By testing the proposals, adjustments and improvements can be made in order to provide the maximum possible benefits in the form of reliable results and credible platforms.

This project was developed by the European Commission, DG Environment and subsequently moved to DG Clima.

The project proposes:

- Applying a single definition of climate adaptation for statistical purposes and for cost estimates; the definition proposed to be followed is that developed by the IPCC.
- A typology following the statistical classification COFOG (Classification of the Functions of Government) for data reporting, to enable compilers to rely on existing and established processes of allocating measures, projects or other activities.
- A five-step methodology to assess the cost of adaptation. This five-step methodology is preceded by a scoping exercise to establish the project boundary in relation to the implementation of measures and the assessment of adaptation cost(s).
- That determining cost now, at a specific temperature, will set a precedent in terms of establishing a trend in the change of cost relative to temperature.
- That the link to cost estimates for specific projects be elaborated on. System boundaries for measurements are currently different (scale, time, local effects) and therefore not comparable.
- A classification of standard measures (that would turn into projects when they are realised at a local level) for the use of compilers. A first attempt based on the Impact Assessment for the Adaptation White Paper has been undertaken and is described in the report.
- The report does not advise gathering cost estimates as part of a standardised statistical data-gathering exercise given the variability in cost calculation outputs, and the impact of different contextual factors. It would be possible however, to use a register such as the Adaptation Clearinghouse to track estimates for analytical and comparative purposes
- That national statistical offices should support continuation of the work undertaken by the project by establishing a new statistical area on expenditure for adaptation, through either DG Clima or DG Eurostat.
- That DG Clima could lobby for the area of expenditure on adaptation to become part of the future statistical legislation on Environmental Accounts.

1. Project specification

1.1 Introduction

The Intergovernmental Panel on Climate Change (IPCC) states that there is no doubt that the climate system is warming. Empirical observations reveal increases in global average air and ocean temperatures, widespread melting of snow and ice, and a rising global mean sea level. Analysts agree that climate change will have significant economic and social impacts with some regions and sectors likely to bear greater adverse affects. Certain sectors of society (e.g. the elderly, disabled people, low-income households) are also expected to suffer more (EC 2009).

The European Commission is stepping up its efforts to combat the effects of climate change. In a recent White Paper a framework is proposed in order to help reduce the EU's vulnerability to the impact of climate change (EC 2009a). This framework highlighted (section 8.2.) the notion that information on the costs of adaptation measures remains fragmented and limited, although estimates and methodological guidelines are provided in various reports (e.g. EEA, 2007; OECD, 2008; Parry et al., 2009, EC 2007, IES 2006). Some preliminary results have already been produced as part of the FP6 ADAM project[1] (EC 2009b).

Statistics Sweden (SCB), in cooperation with the Institute for European Environmental Policy (IEEP), have produced this report as part of a project commissioned by DG Clima to develop a new methodology on the statistics needed to help define the cost of climate change adaptation. This work is guided in part by the principles outlined in the impact assessment of the White Paper on adaptation to climate change (European Commission 2009/387).

The project has benefited from additional expertise from staff within Statistics Sweden: Maja Cederlund and Leif Norman (Unit for Environmental Accounts and Natural Resources), Vera Norrman (Unit for Economic Analysis), Petros Likidis (Unit for Process Implementation), Jukka Laurila (Unit for Financial Services and Accounting), Giuseppe Picone (Unit for Price Statistics) and Alvaro Miranda (Unit for Social Welfare) who assisted with data collection (Chapter 8 and Annex 9). Thanks also go to Mats Bergdahl (Research and Development Department) for guidance on data collection frameworks (Chapter 9 and Annex 10).

Additional expertise was provided from IEEP by Sarah Gardner and Noel Lobo who conducted the evaluation on predicting future mean and variance in monthly temperature from historical data (Chapter 7 and Annex 6). Thanks also to Dan Shurey who participated in the final work of chapter 6 and 7 and Annex 5.

[1] ADaptation And Mitigation (ADAM) strategies for climate change. More information available http://www.adamproject.eu/

1.2 Project setting

In recent years, the European Commission and EU Member States have increased support for climate adaptation through numerous EU and national funded projects and programmes. However, the way in which costs are presented for projects funded by the EU structural funds or the European Bank for Reconstruction and Development for example, does not allow for a proper assessment of the funds allocated to adaptation. The lack of a comprehensive approach could mean that many adaptation projects are overlooked in the calculation of funding support. Agreeing on a methodology for calculating the costs of adaptation is likely to become even more pertinent given the UNFCCC reporting requirements[2]. Given the uncertainty surrounding the future of the Kyoto Protocol, certain assumptions may need to be made around the applicability of the UNFCCC requirements.

Many of the priority areas for internal EU funding (i.e. EU Structural and Cohesion Funds - the EU's main instruments for supporting regional development) either directly or indirectly benefit the environment and climate. However there is currently no accepted methodology for calculating the percentage allocated to adaptation as part of these projects and programmes. The forthcoming EU budget review could further assess the options available for future adaptation funding as part of the post 2013 multi-annual financial framework.

This action requires quite a lot of prior information and knowledge on the relevance of the climate change challenge for the appropriate EU funded measures. Thus preparatory actions for this option should include a dialogue with Member States' management authorities (or potentially through a dedicated Adaptation Committee), climate experts, exchange of information (maybe through a platform consolidating the information available), training, improved use of existing programme management control and monitoring tools.

1.3 Objectives and scope

The objectives of this study are in accordance with the tender specifications:

A) To conduct an extensive review of available information on expenditure and costs[3] of adaptation (from projects, programmes and appropriations) on adaptation measures within the EU (and when appropriate neighbouring

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[2] The EU is a party to the United Nations Framework Convention on Climate Change (UNFCCC). The UNFCCC contains very clear substantive obligations for all parties on adaptation to the adverse impacts of climate change, most of which are found in Article 4. (see http://unfccc.int/essential_background/convention/background/..) Under Article 4(1), all developed and developing countries agree to formulate and implement national programmes containing measures to facilitate adequate adaptation to climate change.

[3]. The term "expenditure" in the context of this report is used to describe funding that has already been allocated to adaptation measures or adaptation related programmes for various levels of government; while adaptation cost refers to unforeseen expenditure commonly determined on the basis of forecasting models.

countries) and a review of existing methodologies for identifying these expenditures and costs.

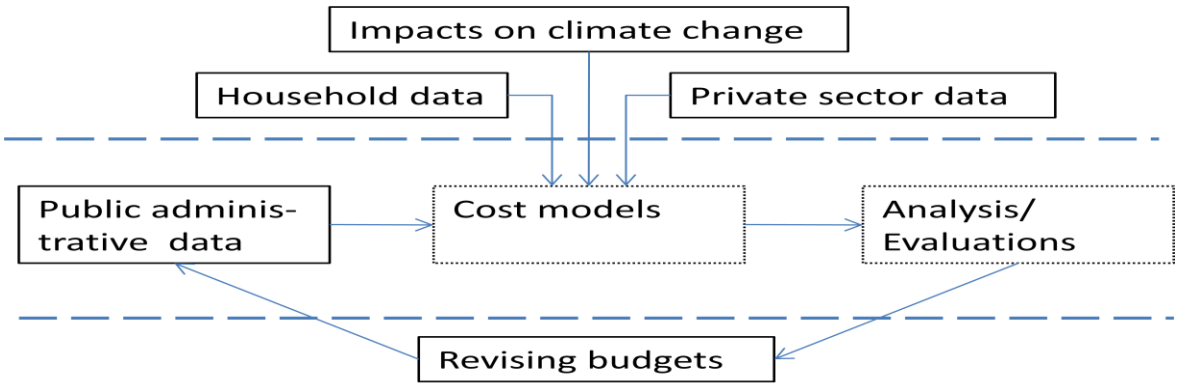
B) On the basis of the research/fact-finding, to assess and compare such methodologies identifying the methodological and data challenges associated with calculating the expenditure on adaptation.

C) To propose a set of criteria for classifying different projects, programmes or budget lines and calculating the expenditure on and propose a system to estimate the "adaptation share" for projects not exclusively intended for adaptation as well as producing a list of frequently occurring cases and borderline cases.

D) To elaborate on the linkage between the cost curves that concern the future cost and the expenditure that measures the current cost.

While the scope of adaptation options considered as part of this project focuses on planned adaptation measures fully or partially financed by public authorities, some small-scale private autonomous adaptation measures (e.g. farm-level adaptation practices, air conditioning, etc.) may be used to illustrate some of the complexities associated with cost calculations. Figure 1 outlines the overall scope of the project, while also illustrating the interaction between private autonomous measures and some of the input data required to estimate costs for both types of measures. While the analysis of cost methodologies will contribute to the formulation of a new methodology that could be applied to EU budgetary line items, this contract does not undertake any work of the budgets themselves.

Figure 1: Scope of the project



The Adaptation White Paper indicates that there is a lack of statistical standards that can be applied to adaptation measures. Despite the fact that the issue has recently been highlighted on the political agenda, its standardisation has not yet come to fruition. It is the opinion of the contractors undertaking the analysis outlined herein, that closer cooperation between the scientific and the statistical community is required if robust results are to be produced that are comparable across countries.

The application of methodologies to calculate adaptation cost in the context of budgetary decision-making, and the allocation of funds, could vary considerably depending on the corresponding user needs. As outlined in Chapter 6 the combined

weight of both previous spending estimates and forecasted cost estimates as part of an adaptation cost calculation will vary depending on the availability of data, the type of adaptation measure under consideration, the year in question, and the need to determine new spending requirements that are "additional" to business as usual. The need to determine new and additional spending will apply equally to planned measures and autonomous measures, and to decision-makers who are in the process of allocating funds specifically to climate change adaptation.

Evaluating existing spending requires involvement of an institution with access to budgetary data, or administrative registers. This project outlines a similar data collection system using the statistical concept known as Environmental Accounts. This is an area that resembles the National Accounts (from which e.g. Gross Domestic Product is estimated), but also includes environmental and environmental economic parameters. At the moment there is a proposal to the European Parliament and Council to include parts of the Environmental Accounts under a Commission Regulation. These relate to air emissions, environmental taxes and material flows (EC 2010). It would be possible to continue and extend the Regulation in time with additional environmental economic statistics.

Standardising the collection of data related to adaptation will be crucial in forecasting adaptation cost. For any country to be able to accurately quantify cost, more information on impacts will need to be collected and other potential default values of the cost function will need to be determined. Determining a cost function therefore serves two purposes: it helps to determine what information is needed to calculate cost, and it helps policy makers determine what constitutes additionality in terms of allocating funds for climate change adaptation objectives.

1.4 Consultations

This project has benefited from the expertise of people already involved in the area of adaptation. The following groups and experts have been consulted during this project.

Eurostat Reflection Group

At the Joint Eurostat/EFTA Working Group on Environmental Accounts held in Luxembourg March 23-24 2010 a new "Reflection Group" was established for the assistance of this project. Seven countries volunteered to participate in the group: Slovenia Vida Butina (Statistical Office of the Republic of Slovenia), The Netherlands Sjoerd Schenau and Isabel van Geloof (Centraal Bureau voor de Statistiek, CBS), Austria Alexandra Wegscheider-Pichler (Statistik Austria), the UK Donna Livesey (Office for National Statistics (ONS) and Rocky Harris Department for Environment Food and Rural Affairs (Defra), France Stephane Levasseur (Ministère de l'Ècologie, de l'Ènergie, du Développement durable et de la Mer (MEEDDM)), Finland Eila Salomaa (Statistics Finland) and Italy, Cesare Constantino, Istat.

The Reflection Group has provided:

- An overview on countries' experiences/activities/definitions in the area of climate change adaptation (including monetary information).
- Comments on the proposed definitions for expenditure on adaptation to climate change.
- Comments on a categorisation/classification of expenditure on adaptation to climate change as well as how to assign the expenditures to these categories.
- Comments on a standard statistical approach to be developed, including an outline of a new set of standard tables. These could be developed in such a way that DG ESTAT would take over the data collection and in such a way ensure the data quality of the gathered information. This would mean the involvement of national statistical offices or similar.

Benefits from reference group meetings

The project has benefited from three discussions in Brussels with officials and experts:

DG Clima: Vaidotas Kuodys, Adeline Dontenville

DG Environment: Jaques Delsalle, Alessandra Vakrou, Birgit Snoeren, Astrid Ladefoged, Tom van Ierland, Karin Zaunberger

DG Agri: Myriam Driessen, Joao Silva

DG Aidco: Alessandra Sgobbi

DG MARE: Ana Ruiz

DG Eurostat: Julie Hass, Marina-Anda Georgescu and Velina Pendolovska

European Environment Agency: Stephan Isoard

European Investment Bank: Giulia Macagno

Additional consultation (meetings, telephone conversations and email contact) has been carried out with other key stakeholders as outlined below in Table 1.

During the last week of the project additional helpful comments and ideas were provided by: Salvador Barrios Joint Research Center, Dr. Jochen Harnisch Competence Center Environment & Climate KfW Development Bank, Gianluca Azzoni DG AIDCO, Alistair Hunt University of Bath and Reinhard Mechler IIASA - International Institute for Applied Systems Analysis. Many thanks go to them for their time and most useful comments for improving the report.

Table 1: Consultation Overview

Relevant Organisation	Contact	Information Obtained	Relevance to Report
European Bank for Reconstruction and Development (in reference to a meeting of the European Financial Institutions Working Group)	Craig Davies	Discussion of methods to assess adaptation cost in the private sector.	Discussions determined that most banks still have not agreed on a specific approach to determining to cost of adaptation.
Department for Food and Rural Affairs, UK	Michael Mullan	Emphasised importance of UKCIPS information, and that of the UK Treasury.	Information used extensively in the development of a replicable cost assessment methodology.
University of Reading	Dr. Paul Williams	Discussion of forecasting; challenge of predicting climate events and to what extent it is possible to determine a "business as usual scenario" for climate variability.	Findings discussed in Chapter 7; emphasised the need for policy makers to agree on a specific baseline year.
Free University of Berlin	Dr. Martin Wattenbach	Ibid	Ibid
University College of London	Dr. Anne Johnson	To discuss possibility that the formulation of health plans could be relevant to adaptation planning given the unpredictability of both types of events.	Discussions indicated that in the case of the swine flu in the United Kingdom, government officials did not utilise a formalised decision-making process to respond to unanticipated threats to public health.
DG Aid	Alexandra Sgobbi	Methodology related to OECD DAC and Rio Markers	Chapter 5: Overall literature review; comparison of cost assessment approaches
DG Env	Guenter Raad	Discussion indicated challenge to harmonising a single approach to cost assessment	Chapter 7: development of a cost assessment methodology
DG Budget	Philippe Cattoir	Information on EU and public finance	Chapter 8: Summary of conclusions
Centre for Research on the Epidemiology of Disasters	Régina Below	Methodologies on damage costs and typologies	Chapter 3 and Chapter 4

1.5 Statistics and modelling

A brief description of the basic principles of statistical data gathering is crucial in order to understand some of the limitations of data collection in relation to this project. In relation to adaptation cost estimates, which are based heavily on modelling approaches, it may be possible to gather data in relation to a number of data inputs, but it will be more difficult to gather data in relation to specific cost models given the variability in applied approaches. As explained below, statistical data gathering needs to adhere to the standard European Statistics Code of Practice.[4] Modelling is based on a specific objective and the ambition of the entity or person undertaking the analysis. Many good practices in the statistical field, such as the issue of "Coherence and Comparability", justify the completion of a number of tasks as part of this project; the need to establish definitions for key inputs for example, is crucial in order to generate comparable cost estimates.

There are many types of data that feed into the calculation of costs for various projects (not just those related to adaptation). Some of this data is produced in a regular fashion, typically by national statistical offices. If the intended data collection efforts are part of the government's statistical data collection plan, they are often called official statistics and their compilation requires compliance with the accepted European quality criteria.[5] The compilation of statistics primarily involves reporting on what has already happened, showing national trends from year to year. Statistical data today is generally gathered in relation to the general population, or features of the general population, and other key elements of the economy. This information is generally collected either through questionnaire-based surveys where specific questions are posed to different respondents or from administrative registers where the compiler makes do with the information already available.

When compiling data in relation to the environment, the types of inputs that are measured vary widely. Some inputs relate to the quantification of the usage of resources that have more direct implications for the economy, (e.g. energy use, water use and waste management) and are collected using questionnaire based survey methods similar to those used for other data parameters connected to the general economy. Other data related to the state of the environment is collected through research projects undertaken 'in the field' (e.g. taking samples of aquatic species from lakes, or using satellite images to calculate the average growth of forests). In short, most of the data gathered is based on empirical observations.

Gathering statistics involves collecting data that is not based on subjective analysis, and that is obtained on the basis of a standardised data collection approach involving a more straightforward quantification of different input variables. For this reason, the usage of data collected through economic analysis such as cost benefit analysis can be a delicate issue in a statistical context. In some studies, the value of

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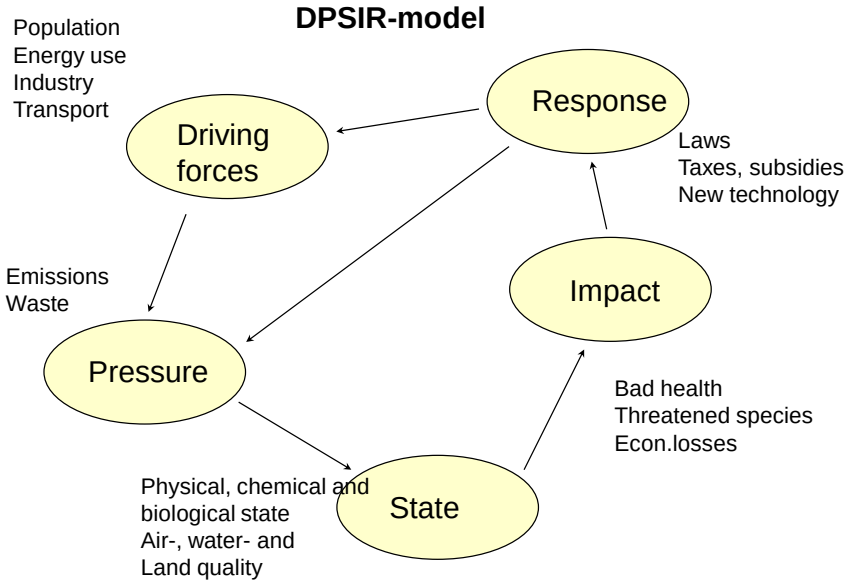
4 . See p. 7, http://epp.eurostat.ec.europa.eu/portal/page/portal/quality/documents/code_practice_EN.pdf

5. Ibid

intangible assets (or services) that are not bought and sold on markets is required. In these instances, it will not be possible to gather statistics in relation to the more objective and often qualitative appraisal of non-market cost variables obtained through willingness to pay analysis for example. The results of such analytical methods may depend too much on contextual project circumstances to be regarded as valid for statistical purposes.

Figure 2: The DPSIR-model



The differences in the availability and the stability of statistical data can be illustrated by the DPSIR-framework.[6] The statistical system is designed to measure the impacts of drivers such as the rate of population growth, the rate of economic growth, changes in land use, and the nature of changes to the transport sector (such as the number of vehicles purchased, the number of trips taken, etc…). From an environmental standpoint, statistics can measure the pressure of driving forces such as the rate of emissions growth, and trends in the accumulation of waste. The state of the environment is often represented through the use of a wide range of local measurements which, along with pressure related indicators, are often scaled up in different ways to produce meaningful figures on a national scale.

When it comes to environmental impacts, there is often a considerable amount of modelling in the data presented, especially if a causal link is to be established between data outputs and the phenomena leading to those outputs. For example, it is possible to measure the number of hospital visits associated with the impact of heat waves, but in order to understand the reasons behind the total number of hospital visits, assumptions have to be made and hypotheses tested to determine whether heat waves are truly the cause of the stated hospital visits. Therefore, while

6. The DPSIR-model (Drivers, Pressures, State, Impacts and Responses) was designed by the OECD and further developed by the EEA in order to describe the different components needed to develop environmental indicators.

statistics can illustrate the correlations between different variables, the causal links are not always easy to establish.

If one considers the national responses to driving forces, outlined in the DPSIR model, statistics on economic responses (or ways through which to address the economic impacts of some of the driving forces) are available from budgets. This could include the total amount of revenue collected through tax collection efforts; a tax that may have been implemented to fund the pressures or impacts of driving forces. Statistics could also illustrate how the public responds to stringent laws on technology development in terms of measuring behaviour change in relation to purchasing particular goods. (Laws encouraging the uptake of more environmentally friendly products could be measured in this way.)

Returning to the project at hand, we are looking at ways in which to make the use of statistics as user friendly as possible in order to measure different elements of adaptation to climate change. It is important to note however, that some of the data for the cost estimates needs to be assessed for local cases. The cost estimates could use statistics to assess the price impacts of goods vulnerable to climate change, but the key concern of such a calculation involves estimating the impacts associated with future events. In some cases, assessing costs, also involves measuring the value of applicable benefits; a variable that is not easily quantifiable. Estimating both the future costs of adaptation and the potential benefits presents a challenge in terms of accounting for adaptation cost in a deterministic fashion.

As a brief example, the Swedish assessment of future adaptation costs (SOU 2007:60) can be used. The study calculated cost estimates of future costs for adaptation in Sweden. According to this assessment, the bottom-up cost estimates are so locally determined, and so uncertain, that is was difficult to use cost curves in selecting the most appropriate measure (a technique often applied to mitigation). When looking at the benefits of the adaptation measures, these are not one-dimensional. Some measures are intended to save lives, others to minimise economic damage to property or to production. Referring to this example, while it may be possible to measure cost using comparable units, the qualitative assessment required to measure benefits makes a comparative assessment of outputs extremely challenging.

In summary, while it is possible to standardise the use of various data inputs in calculating the cost of adaptation. It would not be advisable to gather cost estimates as part of a standardised statistical data-gathering exercise given the variability in cost calculation outputs, and the impact of different contextual factors. It would be possible however, to use a register such as the Adaptation Clearinghouse to track estimates for analytical and comparative purposes.

1.6 Project objectives and overall methodology

1.6.1 Basic analytical approach

The research and analysis completed as part of this report followed a series of building blocks in order to determine past funding amounts and what additional funding may be required to address future adaptation in the EU. The analysis sought answers to a number of different questions:

1) What types of methodologies exist today that measure either past spending or anticipated costs for adaptation?
2) What definitions have been used in relation to data inputs used as part of these methodologies?
3) What typologies have been applied for the classification of measures assessed as part of spending and cost methodologies?
4) How can cost methodologies be improved to better reflect the complexities of estimating adaptation cost?
5) How can the existing accounting systems be improved to better reflect expenditure on adaptation to climate change?

The completion of various tasks as part of this project addressed these questions, although to a large degree, authors of this report faced a significant challenge in terms of the availability of relevant information. In short, while there is a vast amount of literature available describing international approaches to adaptation cost and expenditure, there is a lack of information available to substantiate national accounting for adaptation spending and the application of methodologies to quantify cost. The recommendations made as part of this report, and the establishment of improved accounting methods, will help address the fundamental information gap associated with this project.

1.6.2 Project contents and outline

The report includes nine chapters addressing four tasks outlined in the initial terms of the contract. These are:

1) **Outline a typology of adaptation measures and cost curves** (setting the scope): As described in the initial terms of reference, the project sought to review measures that "may require public financing." Based on a review of available measures, outlined in the Impact Assessment of the White Paper, and existing typologies in reference literature a new typology to classify measures has been proposed along with delimitations of the area in terms of definitions and guidelines. These are described in Chapters 3 and 4. In relation to specific cost assessment approaches the report proposes a way forward in relation to a range of measures which is described in Chapter 7. A specific analysis of predicting climate scenarios is provided in Annex 6.

2) **Undertake a literature review and data collection** (a methodology for the literature review is available in Annex 1. This is in addition to the consultation schedule outlined in this chapter): The literature review is embedded in Chapters 2, 3, 5 and 6: more detail is provided below. The data collection process and results (primarily in relation to adaptation expenditure statistics) are presented in Chapter 8 for expenditure statistics on adaptation;
3) **Assessment and comparison of existing data collection and cost assessment methodologies:** Assessments and comparisons are embedded in each chapter. For example, assessments of various model approaches for cost estimates are presented in Chapter 5 while a comparison of expenditure statistics is described in Chapter 8;
4) **Establish** a **set of possible evaluation criteria (propose a methodology in relation to data collection):** This particular task involves proposing a set of criteria that can be used to classify projects, programmes and budget lines as "adaptation." This report states that characterising adaptation expenditure will involve establishing a new set of statistics; a system outlined in Chapter 9.

More detail on the contents of each chapter is provided below:

Chapter 2: Standard definitions that could be applied to a cost methodology and to a typology for statistical data-gathering were reviewed. The applicability of different definitions (particularly of the term adaptation) to statistics is discussed, as is the possibility of selecting preferred terms on the basis of standard statistical principles. The definition of "measure" and the need to distinguish between business-as-usual practices and those undertaken in response to climate change was discussed in relation to a definition of "additionality."

Chapter 3: Existing typologies in literature were reviewed and assessed. The sixth step involved outlining a methodology to classify measures as they relate to budget lines. Providing that the classifications in use are transparent, easy to interpret and do not contain double-reporting items they are used to help facilitate the communication of spending on various adaptation measures as part of national accounts, national budgets, and the EU budget. These headings could be used by policy makers to help attribute adaptation expenditures associated with a range of different policies and programmes.

Chapter 4: Chapter 4 presents a proposed typology based on an existing international typology, the Classification of Functions of Government, to be used when compiling foremost expenditure statistics on adaptation. However, even though the proposed typology follows a statistical set-up of groupings they adhere quite closely to the typology used today in reference literature on cost estimates. It is therefore possible to adjust with minor changes the classification also for cost estimates.

Chapter 5: Based on the literature review completed in Chapter 5, this assessment considered some of the pros and cons of cost methodologies in terms of their ability to accurately estimate cost.

Chapter 6: Borrowing heavily from the literature review undertaken in Chapter 5, Chapter 6 examines issues related to project boundary in significant detail. It provides an indication of how undertaking a cost assessment will involve determining the limits of direct and indirect costs, and the extent to which defining the cost of a particular measure will involve considering other sectors of the economy.

Chapter 7: Based on the methodology derived as a result of the analysis completed in Chapters 5 and 6, what steps are involved in calculating the cost for different types of measures? Chapter 7 illustrates some of the challenges associated with the monetisation of impacts. Chapter 7 presents a proposed methodology on how to proceed with establishing a cost estimate routine, and Chapter 9 presents a proposed methodology on how to proceed with establishing new statistics on adaptation expenditure.

Chapter 8: The project has conducted a review of how European countries work with measuring adaptation activities in monetary terms. Through the National Communications to the UNFCCC some information has been made available. However, the review also shows that there is at the moment no incentive yet to provide a complete overview of how much the national strategies' set up will cost or how much they have spent already.

Chapter 9: The final task involved outlining a methodology to collect and present measures as they relate to budget lines in terms of ***a posteriori*** monitoring. A proposal is presented for a way forward. This methodology is a set of tables that can be used for future data collection in Europe. The tables are based on the typology described and proposed in Chapters 2 and 3, and general statistical classifications are already established worldwide.

2. Definitions

Summary of findings

This chapter can be viewed as a glossary. As a result of a completed literature review, this project has been able to identify several key terms that are needed for a thorough analysis of costs, and the inputs to those calculations, that can be easily compared. The terminology draws on the experience of previous analysts and researchers, some of which is being used within the research community. However, as revealed by the literature review, some terms can have multiple meanings. As such, there are a number of ideas and concepts that have not been developed as part of a standardized approach to either cost calculations or to the gathering of adaptation cost or adaptation expenditure related statistics. (For the purposes of this report, guidance related to the use of the terminology in similar analytical exercises is provided to help illustrate the meaning of the terms.)

The term "Adaptation" for example, has itself generated a number of associated definitions. The IPCC, the OECD and the World Bank definitions encompass more technical adaptation measures while the EEA and the OECD definitions encompass measures that facilitate behaviour change. In relation to statistical data gathering exercise, the authors of this report maintain that it is important to apply a definition that encompasses the widest possible range of attributes for a given term, and that can be used to describe a number of different situations. For this reason, it is important for a statistical data compiler to be familiar with the range of applicable definitions, to be able to consider these in producing statistical end results, and to choose that which best reflects these realities. This helps ensure that the system boundaries of a given term or account entry has been determined based on the necessary due diligence.

2.1 Introduction

A definition includes text that explains the meaning of a term (a word, a phrase or other sets of symbols) or a type of thing[7]. In the statistical sphere, definitions are a fundamental starting point prior to proceeding with a new data collection process. The definition guides the compiler as to what should data be gathered, it explains the scope of the area or object and enables the compiler to uncover similar data on a global scale that is applicable to the definition in question.

In Europe, the standards for statistical data gathering are determined by the European Statistical System (ESS). The ESS is a partnership between the Community statistical authority, which is the Commission (Eurostat), the national statistical

[7] http://www.merriam-webster.com/dictionary/definition, http://en.wikipedia.org/wiki/Definitions

institutes (NSIs) and other national authorities responsible in each Member State for the development, production and dissemination of European statistics.[8] The partnership ensures that data that is developed, produced and published in such a way that European harmonization of data is maintained. Eurostat collects and maintains a database "Eurostat's Concepts and Definitions Database" or CODED. CODED contains definitions of key terminology and concepts used within the ESS, which enables any compiler of statistics to keep up to date on several definitions and concepts, as well as providing transparent information to the user of statistics.

A number of different definitions exist that relate to the terminology for "Adaptation". In order to apply a definition that covers the measures of interest, it is important to consider the differences between definitions and to see which one may serve as the most useful basis for the development of a statistical work package, and for the development of an adaptation cost methodology. This means that the applied definition should be as transparent as possible, easy to interpret and operationalize. One could say that the purpose of a definition is to bring meaning to a specific concept. With respect to this project, selecting an appropriate definition will help to scope out the right type of measures for analysis.

Comparable statistics across countries, sectors or areas can only be created if certain rules are set and applied by the statistical compiler. This includes specifying sampling units, sampling frequencies, the time of data compilation and coverage. As the definition sets out the coverage it is important to consider following principles (Reingruber and Gregory 1994):

- It communicates what the area represents[9];
- It states the general meaning followed by some relevant details, exceptions, and a couple of representative examples;
- This definition stands alone; it is not dependent on other definitions to convey its meaning. Circular definitions would violate this rule;
- It is logically organized and articulated in full sentences.

The language used to define adaptation should cover as many measures as possible without limiting the selection of such to what is "on the agenda" at the current time. A definition could be applied in this way to help determine the appropriate typology for adaptation measures. While it would have been possible to base a selection of measures on an existing definition of adaptation, the project team has considered three types of measures based on those outlined in the White Paper Impact Assessment (green, grey and soft) in analyzing the appropriate cost assessment approaches. Referring to this typology of measures has enabled us to assess the costs of measures that could be implemented by different levels of government across a range of economic sectors. This ensures that any proposals to enhance budgetary allocations consider a sample that is representative of a wide breadth of policy alternatives.

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[8] http://epp.eurostat.ec.europa.eu/portal/page/portal/about_eurostat/european_framework/ESS

[9] It avoids describing how, where, or when the definition is used, or who uses it. This means that the same definition can be used in different situations regardless of who is applying it.

A number of already existing potential definitions are outlined below.

2.2 List of definitions

2.2.1 Definition – adaptation measures

The IPCC is the leading body for the assessment of climate change today. It has a data provision mandate and provides scientific reports on climate change.[10] A definition for adaptation was provided in its Third Assessment report which was again reiterated in the Fourth Assessment report as outlined in point 1 of Box 1 below. The definition focuses on two elements of adaptation indicating how specific measures may respond to climate change. The first focus of the measurement should be activities that respond to actual or expected climate stimuli. The second focus of the measurement should be activities that respond to the secondary effects of actual climate change stimuli. The World Bank definition, included as part of point 5 of Box 1 has not deviated from this practise despite their own modification of it.

The OECD definition (according to ADF France) in point 4 clearly states that it is the intention behind the implementation of an adaptation measure that separates it from business as usual practices associated with day to day resource management. This means that adaptation can be an activity that has been put in place before the actual event takes places or reduces damage that has already occurred. The definition does not specify whether the implemented measure needs to be effective but only that it should respond to stimuli based on a stated intention to address climate change adaptation as an area of concern.

The EEA and the OECD definitions, as outlined in points 2 and 3 in Box 1 focus their respective definitions of adaptation practises or projects that are able to moderate harm or realise opportunities. The effectiveness of the measures in terms of their ability to meet these two requirements are crucial elements of the compilation of statistics.

[10]. Intergovernmental Panel for Climate Change

Box 1: Adaptation definitions by four international organisations

1. **IPCC TAR/AR4 (2001/2007):** adaptation is defined as "adjustment in natural or human systems in response to **actual or expected climate stimuli or their effects**, which moderates harm or exploits beneficial opportunities associated with climate change."
2. **EEA (2005):** adaptation is defined as "policies, practices and projects with the **effect** of moderating damages **and/or realising opportunities** associated with climate change, including climate variability and extremes and sea level rise."
3. **OECD (2009):** Adaptation **reduces the impacts** of climate stresses on human and natural systems. It consists of a multitude of behavioural, structural and technological adjustments.
4. **OECD (according to ADF France):** An activity should be classified as adaptation-related if it **intends to reduce the vulnerability** of human or natural systems to the impacts of climate change and climate-related risks by maintaining or increasing adaptive capacity and resilience.
5. **World Bank:** Adjustment in natural or human systems in **response to actual or expected climatic stimuli or their effects**. Adaptation can be carried out in response to (ex post) or in anticipation of (ex ante) changes in climatic conditions. It entails a process by which measures and behaviors to prevent, moderate, cope with and take advantage of the consequences of climate events are planned, enhanced, developed and implemented (adapted from UNDP 2005, UKCIP 2003 and IPCC 2001).

The UNFCCC[11] is enhancing the work of the IPCC by requiring countries to report on adaptation measures in national reports known as National Communications with respect to their national implementation of the Convention to the Conference of the Parties (COP) although the required detail has never been specified. The White Paper of the European Commission in their assessment followed the IPCC definition for their use and if the IPCC definition was to be applied in future work it would have a worldwide impact.

2.2.2 Definitions and guiding thoughts on the adaptation component of a measure

Prior to defining the adaptation component of an actual measure, it is important to have a clear understanding of the term measure itself. There are numerous types of measures that could be considered. Adaptation measures can be hard measures including those implemented as part of infrastructure projects for example, or soft measures such as broader policy measures. The standard IPCC definition (2001/2007) states that an adaptation measure represents an "adjustment in natural or human systems in response to **actual or expected climate stimuli or their effects**, which moderates harm or exploits beneficial opportunities associated with climate change".

[11] United Nations Framework Convention on Climate Change

Adaptation to climate change can be "autonomous" or "planned". As defined by the IPCC (2007), autonomous adaptation "does not constitute a conscious response to climatic stimuli, but rather is triggered by ecological changes in natural systems and by market or welfare changes in human systems." Planned adaptation is the opposite of autonomous adaptation and "is the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain or achieve a desired state (IPCC 2007)".

(The issue of planned adaptation could raise some questions around additionality. In a mitigation context, reductions are not typically considered additional if they are legally mandated given that they become part of the business as usual scenario. See definition of additionality in section 2.2.7 below.)

Unfortunately, it was not possible to identify a precise definition for this term in the literature. One could assume however, that in applying the definition of measure to the assessment of past or present funding, you would need to consider to what extent this "adjustment" (as outlined above) is additional to a business as usual scenario.[12] In other words, to what extent has climate change necessitated the adjustment of measures in order to cope with the impacts of climate change. Increasing the height of a sea wall to cope with predicted impacts represents the "additional component" of a measure. Parry et al. (2009) describe how adaptation is part of the overall response to climate change, but their definition of this response subsumes broader objectives such as mitigation (reducing the extent of climate change) and the residual impacts (damages that will happen even though mitigation or adaptation measures have been implemented). They conclude that most estimates on the costs of adaptation are underestimating the true cost given that *"the additional costs of adaptation have sometimes been calculated as "climate-mark-ups" against low levels of assumed investment"* (p. 7).

In the case of management of the built environment, this includes responding to an increased number of events and natural hazards. This includes funding for strengthening of roads, harbours and dams. These costs will be covered by any cost estimate or expenditure statistics but the specific detail relating specifically to adaptation to climate change needs to be clearly identified. The difference between business as usual investment and additional investment needs to be assessed. This problem has been tackled within the statistical community in relation to environmental protection expenditure statistics, to solve the issue of what part of an investment can be considered 'environmental' (Eurostat 1995, 2005). If for example you invest in a new fleet, which happens to perform slightly better than the old one, then only a minor part of that investment can be regarded as environmental.

Eurostat has created a tool that could simplify the determination of additionality in an adaptation context. Tools that are used to determine how much additional funding is allocated to environmental technologies as opposed to generic

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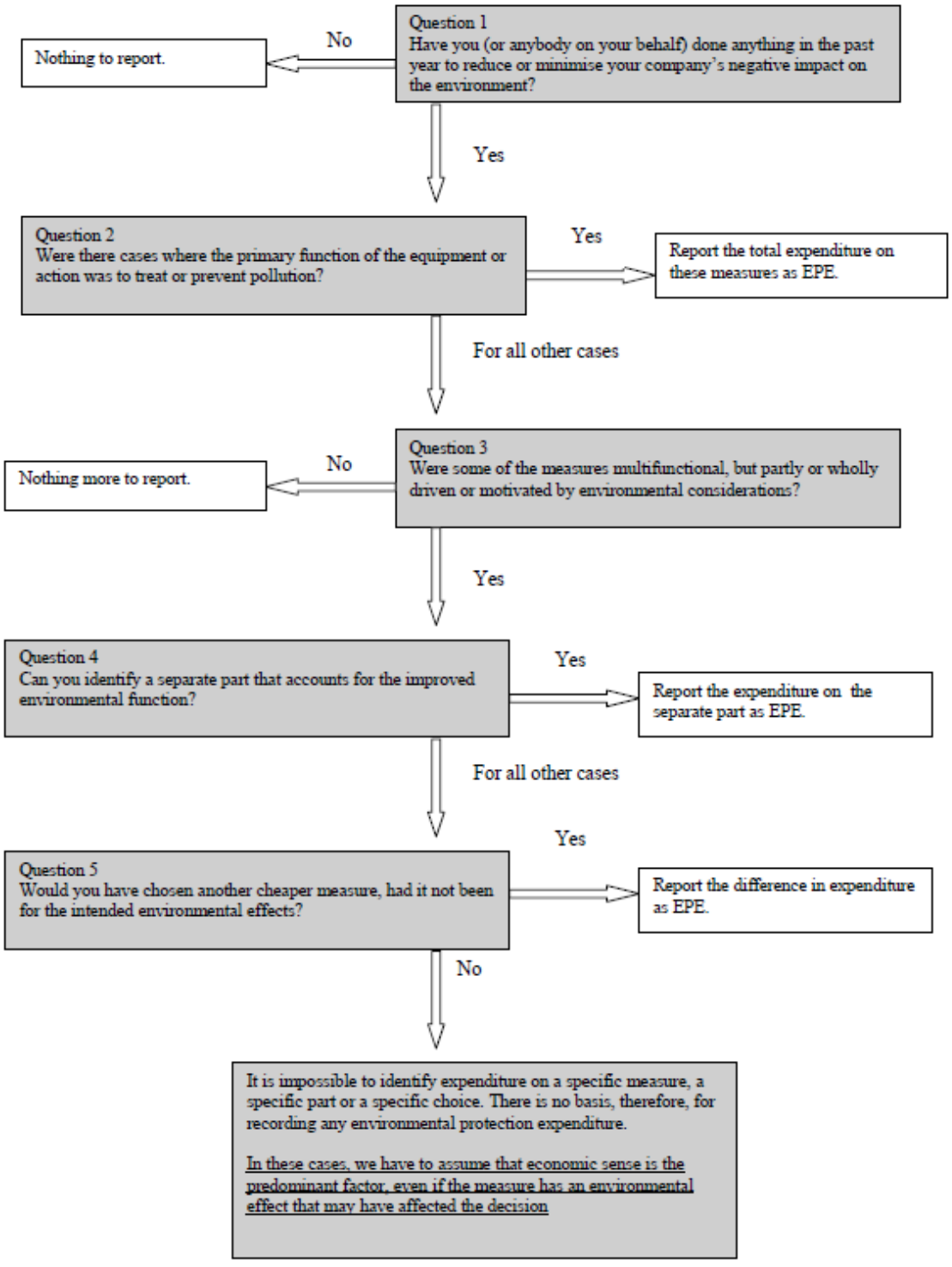
12. The term "business as usual scenario" is used throughout this report to illustrate the fact that adaptation measures have not been applied. The term "baseline" is used to describe the actual measurement of a particular scenario. Greater detail on the use of this terminology is provided in Chapter 7, and as part of the relevant definitions in section 2.2.7.

technologies, could be used to assess the additionality of adaptation spending. Using a survey approach, it has been possible for Eurostat to ask enterprises how much they invested in environmental technologies as a percentage of their total investments. (The same method could be used also for adaptation expenditure and will be described in chapter 9.) Additionality in an expenditure context is slightly different from that used in the assessment of adaptation cost. Determining how much additional funding has been allocated to adaptation is a straightforward exercise; it is simply a matter of stating that expenditure can be considered adaptation. This is what is referred to in this project as determining the "adaptation share" of spending. In projecting the cost of adaptation in relation to specific measures, additionality is a question of determining the incremental cost of responding to impacts based on different scenarios. (A more elaborate definition of additionality is provided in section 2.2.7)

Eurostat has provided guidelines on how to proceed with such issues in that several steps needed to be thought through before reporting the added share. Ideally, expenditure related to the adaptation component of infrastructure should be publicized. Making expenditure more transparent could help determine to what extent the percentage expenditure on adaptation deviates from standard spending totals. This is discussed in the context of national accounts in the next section.

Figure 3: Guideline for determining extra share in environmental investments



Eurostat 2005, page 19.

2.2.3 Definition of total adaptation expenditure

The technical details related to the establishment of national accounts are described in the European System of Accounts 1995 (ESA95). EU Member States are obliged to deliver data to Eurostat in relation to their national accounts; these data are structured within tables that constitute the ESA95 Transmission Programme. Through this reporting mechanism several important macro indicators of the economy are produced, such as the Gross Domestic Product (GDP) of a nation, the Gross Value Added of a specific sectors contribution to the GDP but also total expenditure of government objectives (or functions).

European System of Accounts (ESA 95) input variables for total expenditure	
Gross capital formation + Acquisitions less disposals of non-financial non-produced assets (transaction OP5AK2)	+
Subsidies (D3)	+
Property income (D4)	+
Intermediate consumption (P2)	+
Other taxes on production + Current taxes on income, wealth, etc.+ Adjustment for the change in net equity of households in pension funds reserves (OEB)	+
Total expenditure of functions of government	

As this report will demonstrate, including spending in relation to adaptation as part of such a system would help set an important precedent. Including adaptation expenditure as part of a transparent, itemized system, will make governments and other stakeholders accountable for any action they are taking to address the impacts of climate change.

2.2.4 Definition of total adaptation costs

As outlined in the EU White Paper on Adaptation, adaptation cost includes the "costs of planning, preparing for, facilitating, and implementing adaptation measures, including transition costs." This is a concept from the IPCC TAR 2001. In other words, it could include anything from start up capital cost to operations and maintenance, associated labour, and the loss of economic returns that could be associated with the "adjustment" or "moderation of harm" throughout the period in which the project is implemented (transition costs). The costs associated with the implementation of various measures will vary significantly according to the measure in question, and the context in which it's implemented. Project developers need to consider what additional costs could be associated with the lack of adaptive capacity in specific regions, and specific geographic vulnerabilities. The OECD also mentions that this is an open ended concept as seen above (OECD 2006).

Parry et. al (2009) states that the ideal assessment of adaptation costs should consider the "net present value of costs over the entire lifetime of the project, including preparation costs, investment costs, operations and maintenance costs and decommissioning costs." (p. 27).

2.2.5 Definition of terms used to assess cost of measures

There are a number of terms that relate to adaptation cost methodologies. These terms comprise the various tools and data needs that can be used in extrapolating cost. The terms as they relate to adaptation cost methodologies can be used to assess four distinct features of adaptation cost:

1) Core variables required to determine cost: type of adaptation measures, scope of climate impacts, vulnerability, resilience and adaptive capacity.

2) Additionality: The term "additionality" refers to the amount of investment in adaptation measures representing a quantum which is additional to the business as usual scenario. This involves defining two distinct scenarios: a with project scenario (or adaptation measure) and a without project (or adaptation measure) scenario.

3) Bottom-up economic valuation: Bottom-up economic valuation refers to the use of standard economic valuation tools such as cost benefit analysis in order to assign a monetary value to the implementation of adaptation measures. The application of these tools generate results that are based on a greater degree of disaggregated data.

4) Top-down modelling approaches: Top down modelling approaches as applied in the context of adaptation cost methodologies are used to either determine total estimates of cost at the macro level and in some cases to assess the equilibrium of cost among different types of economies.

2.2.6 Core variables needed to determine adaptation cost

Aggregate Impacts: In terms of assessing the cost of adaptation it is important to make the distinction between aggregate impacts and individual impacts. As defined by the IPCC, "aggregate impacts are those summed up across sectors and/or regions. The aggregation of impacts requires knowledge of (or assumptions about) the relative importance of impacts in different sectors and regions. Measures of aggregate impacts include, for example, the total number of people affected, change in net primary productivity, number of systems undergoing change, or total economic costs." (IPCC TAR, 2001, Annex B, p. 365) In scoping out the scope of impacts as part of a given cost assessment, aggregating impacts over a particular region would be a reality for higher levels of government.

Individual impacts represent the "consequences of climate change on natural and human systems." (Ibid, p. 375) They can be either potential or residual; potential impacts may occur given a projected change in climate, without considering adaptation; "residual impacts" on the other hand refers to the impacts of climate change that would occur after adaptation has taken place.

Adaptive capacity: The overall cost of implementing measures could be impacted by the capacity of given project stakeholders to cope with climate change.

According to the IPCC, it is "the ability of a (human) system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences." (Ibid, p. 365) One would also need to consider the "resilience" of the natural environment to cope with climate change. Other IPCC sources indicate that "when referring to natural systems, the amount of change a system can undergo without changing state." (IPCC AR 2007). Both adaptive capacity and resilience would need to be assessed in light of identified risks and vulnerability to climate change. Vulnerability is normally defined as "the degree to which systems affected by climate change are susceptible to and unable to cope with adverse impacts". (Ibid, p. 388).

Vulnerability: Determining the extent of **vulnerability** will also help determine which measures to implement in light of the identified risks and impacts. Project developers or decision makers will need to avoid implementing measures that result in "maladaptation". Maladaptation as defined by the UNDP represents "an action or process that increases vulnerability to climate change-related hazards. Maladaptive actions and processes often include planned development policies and measures that deliver short-term gains or economic benefits but lead to exacerbated vulnerability in the medium to long-term."[13] Given the uncertainty surrounding future climate impacts, it is preferable to undertake "No-regret adaptation" or to implement "win-win" projects. These types of measures or projects allow developers or decision makers to accomplish other co-benefits such as mitigation or that contribute to best practise in the sector in question thus maximizing the use of public or private funds.

Implementing measures that represent "no-regrets" or "win-win" scenarios essentially involves consideration of "reversibility." In short, measures should be flexible enough to cope with the unpredictability of impacts and the changing policy environment.

2.2.7 Definition of additionality, baselines, and baseline methodology

Additionality: There are a number of different ways to define additionality. In a number of cases, additionality is used to justify an increase in resources as part of a public intervention. An accurate assessment of additionality will typically involve establishing key data parameters and tools that can be consistently applied across comparable projects or policies as part of a political decision. In the carbon market, additionality is used to determine whether greenhouse gas emission reductions can be attributed to a percentage of project investment representing a tradeable commodity. Under the Kyoto Protocol for example, the additionality of reductions is a function of a politically negotiated baseline year: 1990.

Additionality in adaptation context is much different from that of a mitigation context. In a mitigation context, greenhouse gas reductions are not deemed tradeable commodities unless financial additionality can be determined. This interpretation of additional differs from that applied in an adaptation context,

[13] http://www.undp.org/climatechange/adapt/definitions.html

particularly given that incremental efforts to cope with adaptation do not have a market value. In an adaptation context, determining additionality seems to be a way through which to determine the required level of public funding, and to legitimize climate change as a recognizable phenomenon. To this end, we refer to a broader definition put out by the UK's English Partnerships, given that it can be used to assess the value of public intervention in relation to public spending and environmental improvements.[14] Their guideline to additionality assessment states that: "Additionality is the extent to which something happens as a result of public intervention that would not have happened in the absence of the intervention."

While determining baselines in both contexts will be a crucial part of its measurement, additionality in a mitigation context cannot be politically mandated. Once a mitigation measure is politically mandated, it becomes part of the business as usual scenario. As the OECD definition of adaptation on page 23 suggests, adaptation measures are implemented in response to public intention. Adaptation measures are additional merely in the sense that they are implemented to respond to the impacts of climate change.

This description of additionality illustrates the importance of determining baselines. In mitigation terms, a "baseline methodology" is one which uses the baseline as the basis for determining the additionality of reductions on the basis of an established time series. In quantifying the additionality of the amount of finance required to address the cost of adaptation, analysts will need to select a baseline year to simplify calculations.

Baselines: The UNDP, the IPCC, and the OECD all provide different definitions for the term "baseline." The OECD (2006) describes how there are at least 4 types of baselines that need to be considered for adaptation. Climate baselines, socio-economic baselines, policy baselines and a baseline that incorporates elements of "adaptive capacity", and baselines that incorporate other social and economic variables.

Baseline/Reference – According to the IPCC, the baseline (or reference) is any datum against which change is measured. It might be a "current baseline," in which case it represents observable, present-day conditions. It might also be a "future baseline," which is a projected future set of conditions excluding the driving factor of interest. Alternative interpretations of the reference conditions can give rise to multiple baselines. (IPCC TAR, 2001 a)

Adaptation baseline – Also referred to as an adaptation policy baseline, this includes a description of adaptations to current climate that are already in place (e.g., existing risk mitigation policies and programmes). (UNDP, 2005)

Baselines: Used in two distinct ways in the UNDP Adaptation Policy Frameworks for Climate Change, the term "baseline" can refer to either a project baseline or a future baseline or reference scenario. The project baseline indicates the project's starting point, while the reference scenario provides a plausible overview of a future

14. (http://www.englishpartnerships.co.uk/communitiespublications.htm)

where adaptation measures are not applied to allow for a comparison of different adaptation strategies, policies, and measures. (UNDP, 2005)

2.2.8 Bottom-up economic valuation and decision rules

Decision Rules: Economic valuation involves refers the application of tools generating economic outputs that could be used as part of other decision rules such as cost benefit analysis, cost effectiveness analysis and multi-criteria analysis. In short, undertaking cost benefit analysis, and thus the monetization of impacts on the natural environment, involves determining whether economic data exists to determine the value of resources. Monetization will differ for "use" values and "non-use values"; use values are those that have a market value, while non-use values are typically valued in terms of their aesthetics.

Undertaking the monetization of non-use values (particularly in relation to biodiversity measures) involves undertaking either benefits transfer exercises or primary valuation. Benefits transfer exercises look essentially at transferring the previously determined valuation of the aesthetic elements of another project to the context in question. Primary valuation involves undertaking site specific research to determine the value of resources using information such as the number of visits to the site in question. It can also involve determining the local "willingness to pay" for the preservation of resources.

Bottom up estimates: Bottom up quantification approaches in any discipline typically involve the consideration of more disaggregated data inputs, based on a broader project boundary. If one considers the project implementation context, bottom up approaches will be required to assess the cost for involving a wide range of resources that respond to a number of different local impacts.

Cost benefit analysis: Cost benefit analysis is typically undertaken in order to determine the overall cost of adaptation options relative to benefits. This can be determined through a combination of approaches some of which are more quantifiable than others. Undertaking net present value (NPV) analysis will involve selecting the adaptation option with the highest NPV based on a more qualitative analysis of the benefits (including avoided costs.) As long as the NPV is found to be above zero, then it would typically be feasible to implement a given option. Options could also be evaluated on the basis of determining internal rates of return (where IRR exceeds the applied discount rate), or on the basis of benefit/cost ratios. Options that are found to have a benefit to cost ratio greater than one would typically be economically feasible. (UKCIP, Overview of Guidelines, p. 43)

Exposure Unit: An exposure unit is defined "as the system considered at risk from climate change. An exposure unit is often described in terms of the geographical extent, location and distribution of the population or populations of receptors at risk." The completion of a more bottom-up cost assessment would involve quantifying the risks associated with different exposure units (UKCIPS, Implementation report, p. 2-5).

2.2.9 Top-down modelling approaches

Top down approaches: Top down approaches to calculate the cost of adaptation are used primarily by international organizations. These approaches rely on a number of different models to determine an aggregated cost for adaptation at a global level. Models such as Computable General Equilibrium models are used to attribute costs to different regions of the world. They could also be used at a national level to assess the impacts of climate change across an entire economy.

Investment and Financial Flow or "Stock and Flow": This approach essentially involves determining what percentage of the economy is sensitive to climate change. This percentage is then "marked up" based on an assessment of future climate change impacts and an estimate of the total amount of investment required to enhance the resilience of the economy. (UNFCCC, May 11, 2010, p. 28)

Integrated Assessment Model: The integrated assessment models represent what is essentially a "flow" approach. According to the IPCC definition, integrated assessment represents "A method of analysis that combines results and models from the physical, biological, economic, and social sciences, and the interactions between these components, in a consistent framework, to evaluate the status and the consequences of environmental change and the policy responses to it." Based on analysis undertaken by the OECD, cost estimates generated through the application of IAM are based on shorter time frames and do not consider the future cost of impacts. (OECD, 2009, p. 37)

2.3 Conclusions: the need to operationalise the definitions and guidelines

This chapter has listed and discussed a wide range of definitions and guidelines related to the climate change adaptation field. The need to establish definitions in a statistical context is important for two reasons: firstly, it is necessary to select definitions based on language that allow the compiler to apply a considerable amount of flexibility in accounting for a wide range of variables, and secondly, particular definitions need to be agreed to by the relevant decision makers and project developers in order to help develop a consistent approach as part of both statistical data compilation. This involves determining what the appropriate definitions may be for specific data inputs and the applicable tools necessary for the estimation of future adaptation costs.

Developing consistent approaches that are compatible with the quality criteria for the compilation of statistics will be based largely on commonly accepted definitions for a range of analytical tools. Determining applicable definitions for key technical terms such as "baseline" will help establish ensure a consistent approach to the calculation of cost, similarly for the definition of terms such as of "total adaptation expenditure" and "adaptation measure" in relation to statistical data gathering exercises.

Some definitions provided in this chapter relate less to the need for standardization, and more simply to the need to provide clarification of some of the concepts discussed, particularly in terms of evaluating different cost assessment approaches. For example, both the bottom-up and the top-down approaches to economic valuation have been described. The description of these concepts illustrates the difficulty in developing a consistent approach to cost quantification given that they are often combined in assessing costs. While bottom-up approaches are crucial in order to determine the key data parameters of a particular project, the use of top-down approaches is used to help assess the impact of climate change across an entire economy. Depending on the context, both tools could be applied in parallel.

3. Typologies

Summary of findings

In summary, most of the information reviewed thus far shows that there is a strong consensus on what to communicate, at least for the more important areas where vulnerability is an issue, e.g. for different business actors who are reliant on natural resources, social segments and ecosystem services. The literature review for this project covers typologies for both cost estimates and national reporting obligations to the United Nations for example. Disaster prevention, agriculture, infrastructure and human health are almost always shown in the studies covered. The studies specify in general terms which measure goes to which category and communicate the cost implication of that particular adaptation measure. However, even a superficial overview shows that the main headings in the studies examined have trouble with clear allocation techniques and transparency, something that is very important for evaluating and concluding results.

The typologies indicate that any measure could be categorised under any of the headings making it difficult to determine how it could be categorised. The typology of existing expenditure categories becomes more complex if certain parameters are to be cross-referenced against what is produced for different economic sectors. This is particularly true for additional environmental statistics required in undertaking an integrated assessment. The cross-dimensional nature of the categorisation of adaptation measures throughout the literature does not allow for a clear indication of what the measures mean to the economy at large and cannot be linked to other environmental economic statistics.

The proposal is therefore to establish a clear categorisation of adaptation fields by using existing statistical classifications such as the NACE[15] and the COFOG[16]. With regards to regional interest there are classifications that could be used also to break the information down into regions but this would apply more to autonomous measures. It is very difficult to establish to what region a national or even a supra-national budget a certain measure belongs.

During the project it became clear that the different stakeholders within the European Commission would like to find their specific topic clearly visible in a new typology on adaptation. However, each sector-specific topic would need the underlying statistics to be openly available and not subject to major confidentiality issues. The proposal is therefore to compromise, focusing on parameters that should be comparable across sectors and across countries. It should also be possible to link any subject matter to the typology while also linked to other general economic or social statistics.

[15] Statistical Classification of Economic Activities in the European Community

[16] Classification of Functions of Government

3.1 Introduction

It is important that the project establishes a draft outline of where and how certain measures should be classified/categorised early on. This will facilitate the communication of the area to users that are not necessarily experts in this field. It will also facilitate the data collection as clear guidelines will need to be available for the data compiler. The idea of using statistical classifications in the context of expenditure for adapting to climate change is to use existing statistical frameworks as much as possible, and to facilitate the link between the economy and the environment.

A classification is defined by a boundary of the total set of categories. The scope of the NACE classification is defined by the term "economic production boundary" as found in the *System of National Accounts (SNA-93)*. Extending the scope of a classification requires extending the conceptual boundary (Hoffman, Chamie 1999).

Building a classification is designed to create an exhaustive and structured set of mutually exclusive and well described categories. There are certain principles and established practices to follow when constructing a new classification (Hoffman, Chamie 1999):

a) The objectives and statistical priorities to be served must be clearly stated;
b) The organisation responsible for the preparation and maintenance of a classification (the custodian) should be clearly identified and responsibilities stated;
c) A time table for the work must be well publicised and allow substantive experts who are users and producers of statistics, to contribute to the process at appropriate junctures;
d) A well-defined classification structure must be prepared. Depending on descriptive and analytical needs, aggregated categories of statistical classifications may be organised in a hierarchy representing different levels of detail for measurement of the variable.
e) Descriptive definitions or exhaustive listings of the contents of the defined categories are needed. Listings will not be needed for aggregate groups when the codes are constructed to make transparent where the correspondent groups are located in the hierarchical structure.
f) Instructions are needed on effective use of classifications for data collection and analysis;
g) Guidance and training materials are a necessary part of the development process for a new or revised classification.

3.2 Review of typologies in literature

There are now multiple studies on adaptation and cost models are being improved upon with each study. However, little attention is being paid to the typology in the studies. It is explained to some extent by the studies focusing on one particular

domain or sector but overall typologies are only a tool to present the results as the study requires. It therefore omits the idea of using the resulting typologies in connection to other relevant social-economic information.

3.2.1 Literature on typologies

The OECD (2008) highlights the challenges of designing adaptation typologies. It explains that adaptation measures have been classified according to: timing (anticipatory vs. reactive); scope (local vs. regional, short-term vs. long-term); purpose (autonomous vs. planned); and adapting agent (natural systems vs. humans, individuals vs. collective, private vs. public) (p. 22). However, the report stops short in evaluating the typology to any further extent. The issue of typologies are evident in that very report. A summary of priority projects from the National Adaptation Programmes of Action (NAPA) were broken down into eight categories and summarised (OECD 2008 p. 65) (see Annex 2) .

The NAPA typology demonstrates that coastal zone activities could be reported in almost all sectors; and that conversely, any type of water activity can be located in a coastal region. Many economic activities have the potential to be cross-sectoral despite the corresponding executing agency. In statistics, avoiding this cross-sectoral complication is normally dealt with by categorising activities according to their main purpose. Activities which are difficult to allocate to a specific sector are usually located under "other" or "non-specified" which could mean that some activities are not accurately accounted for.

The ADAM project mentioned above produced 10 broad categories also based on the policy instruments described in the NAPAs to the UNFCCC but did not for example include categories such as infrastructure and cross-sectoral measures. Instead they wanted to highlight energy measures, development support and financial aspects. The categories from the ADAM project are more detailed and the risk of allocating a project or a measure wrongly is reduced.

The White Paper assessment

The White Paper sorts measures under the general headings of Grey infrastructure, Green infrastructure and Soft-non structural measures. In addition it sorts measures with respect to general policy, forestry, biodiversity, water, soil, agriculture, fisheries, energy, infrastructure, tourism, industry, health and coastal areas. More succinctly, this means, for example, that the grey infrastructure relates to the industries that build and maintain society's roads, dams, harbours and communications, the soft non-structural approaches relate to the policy instruments that the state can administer, and the green infrastructure is represented by the industries that maintain the green infrastructure, that is the agriculture and forestry sectors.

Table 2 below maps the main groups related to grey and green infrastructure measures. For the purpose of this report the categorisation of grey and green to each sector of the White paper the most common measure (i.e. the measure that is most likely to be implemented) has guided the results in Table 2. That means that the

categorisation of grey and green is not without measures from one another, or from soft non-structural approaches either. A more detailed table is available in Annex 3.

Table 2: EC typology

EC	Category	Description
Green	Biodiversity	Ensuring high diversity in species, compliance checks into spatial planning, strengthen nature conservation measures table 5, p.66
Grey	Water	Desalinisation, addressing flood risks, water demand management, ensuring stable water cycles, technological measures to help soil infiltration, anti-erosion measures etc. Table 6p.69
Grey	Soil and land use	Flooding, reducing loss of organic matter by adapting existing cultivation practises, soil improvers/fertilisers, controlling erosion, controlling salinisation, changing crops to halt loss of biodiversity. Table 7p.74 (only land use, no description for soil)
Green	Agriculture	Changes in land use/management, irrigation practises, crop changes , reducing/avoiding soil degradation (loss of organic matter, erosion, salinisation) by adapting existing cultivation practises (ploughing in crop residues, using green manuring) use of soil improvers and organic fertilisers. Table 8p.80
Grey	Forests	Reforestation and reconstruction after large storms, reducing habitat fragmentation to increase resilience of forest, diversified species and age structure, changing land use to forest for habitat restoration. Table 9p.86
Grey	Fisheries and Aquaculture	Productivity aspects, efficiency in production by more energy-effective fishing gear and methods, removing over capacity, to allow the recovery [of fish stock?] up to an adequate level of resilience. Fishing new species. Table 10p.91
Grey	Energy	Supply and demand. Measures to deal with demand changes, adapting nuclear plant maintenance, investing and installing extreme peak load facilities or alternatives, policies to ensure sustainable generation and distribution, location of energy supply, energy grid management. Table 11p.95
Grey	Infrastructures and Buildings	Public infrastructure (road, water ways, bridges etc), coast defences, both hard and soft, vulnerability of transport networks to climate events. Planning and building codes, materials, techniques, urban planning, land use planning, relocation activities. Table 12p.100
Grey	Industry and Services	Tourism and industry: ski-resorts' adaptive measures, industry production, investments and location issues, increase efficiency in the use of raw materials, water and energy in the production process. Table 13p.103
Grey	Health	Air quality controls, food safety, acclimatisation, heat related mortality, greening of urban areas, green roofs, location issues of public health. Table 14p.108
Grey	Coastal areas	Includes parts of measures described above: tourism, industry, water availability, water quality, biodiversity-ecosystems, protection against flooding etc. P.109-113

The categorisation of the White Paper (grey, green and soft) measures is intuitively not easy to understand, i.e. they do not speak for themselves without direct explanations as to the corresponding measures. This situation might of course apply to other types of classifications as well. What is important in this case is the issue of enabling the connection of basic support statistics to the analysis. For example, if there is a cost estimate or even expenditure statistics on grey infrastructure measures the user of the results would be quite limited in terms of utilising conclusions that could be drawn based on that data. In order to enhance that analysis by linking these measures to other related statistics/data, the user would have to first find out what type of activities had been included (e.g. new roads, irrigation techniques applied, or

construction activities) and then see if those exact activities could be matched with sectoral economic statistics (e.g. value added from the contraction industry or the output of the agriculture industry) to further enrich the conclusions. Statistics today are developed with different categorisation techniques.

In brief; the evaluation shows that the previous use of the categorisation of grey and green infrastructures and soft non-structural approaches has been to include the same type of measures under different main sector headings (e.g. grey infrastructure measure flood control ended up in both the Water and the Soil and land use sectors). The evaluation undertaken as part of this literature review was not able to determine if the measure was actually the same measure recorded twice or two different measures with different purposes. In general, the typology of the White Paper Impact assessment showed that this approach was repeated throughout all the data and tables presented, making it easy to determine whether double counting was in fact occurring.

3.2.2 Database typologies

Several databases have been established on-line related to adaptation. However, they are mainly related to listing programmes, projects or good practices. For statistical purposes they have a limited use. The exception was the database on emergency events developed by the organisation The Centre for Research on the Epidemiology of Disasters (CRED) in cooperation with the WHO.

UK Climate Impact Programme[17]

UKCIP is a mainly government-funded programme and has since 1997 been working with the public, private and voluntary sectors to assess how a changing climate will affect the economy and nature. In a database called The Adaptation Actions database they demonstrate how organisations in the UK are adapting to climate change through a variety of projects and programmes. Searchable *by sectors* (agriculture, local and regional impacts study etc,) and *adaptation type* (e.g. create supportive governance, exploit opportunities). Details on funding for each programme or project are not provided.

AMICA[18]

AMICA is a European project that aims at developing local and regional strategies which adopt a comprehensive approach to climate change. The project developed a matrix-based table for the presentation of adaptation measures. The matrix lists measures by *category of measures* (e.g. Vulnerability assessments, planning, building etc. and *impact type*, e.g. Flooding rivers in urban areas, droughts and floods in rural areas etc.). Each measure is described in terms of how the measure can be directed,

[17] http://www.ukcip.org.uk/index.php?option=com_content&task=view&id=286&Itemid=423

[18] http://www.amica-climate.net/home1.html

the area in which it can be implemented and if there is a bridge to mitigation activities. Economic aspects are described in general terms.

UNFCCC[19]

The UNFCCC has developed a database *on local coping strategies* with examples of projects/case studies in the developing world that are linked to coping with climate change. The database is searchable by: *type of hazard* (e.g. droughts, heat, etc), *type of impact* (e.g. loss of crops, water shortage, damage to human settlements etc.) and *type of strategy* (e.g. appropriate crop selection, rainwater harvesting etc). A general description of the projects and contact details for the persons involved are available but no financial information.

Umweltbundesamt[20]

The Austrian environmental protection agency has developed a database for activities for adaptation related to research and development. The search can be made according to *sector* (e.g. agriculture, forestry, tourism, energy, biodiversity etc) and *the administrative region in which it is taking place* (e.g. Austria, Burgenland, Kärnten, etc) and by the geographical structure (e.g. alpine region, Vienna region, city, countryside, etc.). Each research project is explained but the financial aspects are not included.

CRED[21]

The Centre for Research on the Epidemiology of Disasters (CRED) has since 1988 co-operated with WHO in developing a database called Emergency Events Database (EM-DAT). EM-DAT contains data on the occurrence and effects of over 18,000 mass disasters in the world from 1900 to the present including damage cost estimates. The database is compiled from various sources, including UN agencies, non-governmental organisations, insurance companies, research institutes and press agencies. The database is searchable by r*egion* (continents), by *country* (all continents covered), by *time* (intervals or individual years), by *disaster group or type* (e.g. natural, biological, etc. or droughts, epidemics etc.). The output of the database can be either number of deaths, number affected, number of homeless, total affected or total damage cost (in US dollars).

Routeplanner for the Netherlands[22]

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[19] http://maindb.unfccc.int/public/adaptation/

[20] http://www.klimawandelanpassung.at/datenbank/

[21] http://www.emdat.be/

[22] http://www.enr.wur.nl/NR/rdonlyres/C5116C22-0259-40AD-8BC6-FBA94705C41F/69791/Routeplanner_Aqualitativeassessmentofclimateadapta.pdf

A project called "Routeplanner" aimed at providing a 'systematic assessment' of potential adaptation options to respond to climate change has been developed in the Netherlands in connection to spatial planning.

The project developed a database which allows users to rank the various options according to a set of criteria and to obtain a relative ranking on the basis of these criteria. The database summarises the identified adaptation options and the associated effects, and an inventory of institutional aspects related to their implementation on the basis of existing studies; the database provides very good examples of different measures of adaptation on the basis of the climatic impact. The database is presented in the report as excel-spreadsheets but nonetheless easy to follow and use. The annexes of the report, where the database is presented are divided into 6 sectors: "Agriculture", "Nature", "Water", "Energy and Transport", "Housing and Infrastructure", and the final sector is "Health, recreation and Tourism" (De Bruin et. al, 2009).

3.2.3 Existing statistical classifications

Even though statistics today do not specifically measure adaptation activities there are certain classifications that could be applied when developing new statistics in the field. Below follow the most important foreseen in this project.

The institutional sectors of general government

The sector "general government" (S.13) includes all institutional units considered non-market producers (see paragraph 3.26) whose output is intended for individual and collective consumption, and mainly financed by compulsory payments made by units belonging to other sectors, and/or all institutional units principally engaged in the redistribution of national income and wealth. §2.70

§2.70 The general government sector is divided into four sub-sectors:

a. central government (S.1311);

The sub-sector central government includes all administrative departments of the state and other central agencies whose competence extends normally over the whole economic territory, except for the administration of social security funds.

Included in sub-sector S.1311 are those non-profit institutions which are controlled and mainly financed by central government and whose competence extends over the whole economic territory. §2.71

b. state government (S.1312);

The state government sub-sector consists of state governments which are separate institutional units exercising some of the functions of government at a level below that of central government and above that of the governmental

institutional units existing at local level, except for the administration of social security funds.

Included in sub-sector S.1312 are those non-profit institutions which are controlled and mainly financed by state governments and whose competence is restricted to the economic territories of the states. §2.72

c. local government (S.1313);

The sub-sector local government includes those types of public administration whose competence extends to only a local part of the economic territory, apart from local agencies of social security funds.

Included in sub-sector S.1313 are those non-profit institutions which are controlled and mainly financed by local governments and whose competence is restricted to the economic territories of the local governments. §2.73

d. social security funds (S.1314).

The sub-sector social security funds includes all central, state and local institutional units whose principal activity is to provide social benefits and which fulfil each of the following two criteria:

by law or by regulation certain groups of the population are obliged to participate in the scheme or to pay contributions;

general government is responsible for the management of the institution in respect of the settlement or approval of the contributions and benefits independently from its role as supervisory body or employer (see paragraph 4.89).

There is usually no direct link between the amount of the contribution paid by an individual and the risk to which that individual is exposed.

Classification of Functions of Government (COFOG)

COFOG was developed by the Organization for Economic Cooperation and Development (OECD) and is published by the United Nations Statistical Division (UNSD). It can be applied to government expense and the net acquisition of non-financial assets.

The COFG has no way of identifying specific measures related to adaptation at the current moment. Eurostat and the Task Force on COFOG are actively working on improving the classification. There is the possibility of approaching them for potential adjustments of the classification if the work on adaptation is ready to be standardised.

The UN COFOG guide is available online at the following link:

http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=4

Top-level categories of COFOG

- 01 - General public services
- 02 - Defence
- 03 - Public order and safety
- 04 - Economic affairs
- 05 - Environmental protection
- 06 - Housing and community amenities
- 07 - Health
- 08 - Recreation, culture and religion
- 09 - Education
- 10 - Social protection

In relation to adaptation interests, there are a number of sub-categories which would be interesting to highlight in a future possible application.

For example: Under 01, General public services, one will find sub-components such as Foreign economic aid, Economic aid routed through international organisations and R&D. Under 04, Economic affairs, sub-components include Agriculture, Forestry, Fuel and energy, Transport etc. And under 06, Housing and community amenities, one will find Water supply and Housing developments,

Statistical Classification of Economic Activities in the European Community, Rev. 2 (NACE Rev. 2)

NACE Rev. 2 is a classification that presents economic activities. It is a classification regulated under Regulation (EC) No 1893/2006. Any statistics that follow the NACE can link to other statistics that follow the 6 listed classifications below:

1) International Standard Industrial Classification of All Economic Activities (ISIC);
2) Statistical Classification of Products by Activity in the European Economic Community (CPA);
3) Central Product Classification (CPC);
4) Harmonised System (HS);
5) Combined Nomenclature (CN);
6) PRODCOM List.

Details of the 21 sections of the NACE

A Agriculture, forestry and fishing

B Mining and quarrying

C Manufacturing

D Electricity, gas, steam and air conditioning supply

E Water supply, sewerage, waste management and remediation activities.

F Construction

G Wholesale and retail trade, repair of motor vehicles and motorcycles.

H Transportation and storage

I Accommodation and food service activities.

J Information and communication

K Financial and insurance activities

L Real estate activities

M Professional, scientific and technical activities

N Administrative and support service activities

O Public administration and defence, compulsory social security

P Education

Q Human health and social work activities

R Arts, entertainment and recreation

S Other services

T Activities of household as employers, undifferentiated goods and services producing activities of households for own use

U Activities of extraterritorial organisations and bodies

With regards to adaptation the NACE would be most suited for information that covers both planned **and** autonomous measures. Government activities are included under NACE in relation to Public administration and defence, and compulsory social security. If the NACE were applied to adaptation statistics or costing models one would need to develop a matrix to determine both who is funding the measure, but also to determine what sphere of interest the funding is aiming to address. Those sorts of matrices are available today within almost every type of statistics that present information related to economic activities.

Classification of Environmental Protection Activities and Expenditure (CEPA 2000)

Another type of classification that could serve to address the discussion on adaptation is the CEPA classification. This is a functional classification used to classify activities, products, outlays and other transactions whose primary purpose is environmental protection. However, as the field of adaptation covers a range of other areas (health for example), CEPA only covers environmental issues.

9 Classes of CEPA

1 Protection of ambient air and climate

2 Wastewater management

3 Waste management

4 Protection and remediation of soil, groundwater and surface water

5 Noise and vibration abatement (excluding workplace protection)

6 Protection of biodiversity and landscapes

7 Protection against radiation (excluding external safety)

8 Research and development

9 Other environmental protection activities

3.3 Conclusions: review of typologies in literature

It is clear that the issues relating to the development of an adaptation typology is not discussed in elaborate detail in the studies reviewed. Most studies have a few measures that are categorised based on subjective interpretation on the part of the typology author. Overall, the typologies work for the purpose of that single study and for the analysis conducted.

Throughout the literature review it has been difficult to assess whether one measure is included under several different headings (thus indicating that it serves a different purpose in relation to each separate heading), or if the same type of measure is being included under headings related to different projects categorised on a sectoral basis Any typology that invites the user to summarise the applications of a particular measure, should be developed in order to avoid double counting. In order to compile comparable statistics and estimates across sectors and across countries it is important to have a fully developed typology to rely upon. Before a set structure of typologies is developed it is recommended to test the proposed approaches. The following chapter describes the approach proposed.

4. A proposed new typology

Summary of findings

During the literature review it became clear that the same headings were repeated in the typologies described in all studies. It also became clear that the descriptions of what each heading included were ineffective in terms of explaining that it would, for example, not be possible to summarise statistical findings across sectors (in relation to one particular measure) or add additional information from other sources. Using the existing labelling of headings from literature, it is possible to distinguish between measures that are intended for environmental protection as opposed to those related to economic production related issues. The evaluation showed that the allocation of certain measures was not clear-cut and there was a question about the arbitrariness of the allocation technique.

The proposed typologies below are a result of adjusting to the needs of the European Commission to recognise some particular domains of interest and the statistical pathway to increase the transparency of the allocation. But it is also developed so as to enable other types of statistical information to be added in relation to future analysis of the area. It is a typology that would cover all sectors of interest equally. The reason is that future statistics need to have a link to other related socio-economic statistics to enhance the analysis and the structure of that specific sector of interest. We have not developed a separate typology for each sector because of this line of thought.

The proposed typology follows the Classification of Functions of Government (COFOG) presented above in Chapter 3 and is a type of hierarchical classification. This means that it provides a pyramid-like structure and ranges from the broadest level to the most detailed level. The typology is also extended to add an extra dimension in the form of types of climatic events by following the classification structure of the Emergency Events Database (EM-DAT).

This project only looks at planned (governmental) measures which should typically render a simple matrix-free typology. However, as there will most likely be a wider interest in the future to also classify expenditure and cost estimates for autonomous measures, this report also proposes a typology that can be cross analysed using a typical classification of economic activities, in Europe called NACE[23] as a second step after the establishment of government-related information.

Statistically the problems of multipurpose measures and activities have been a long-standing issue. In most cases the reality of the world and the reality of statistics are different. This means that with statistics, most items needs to be allocated to one and only one box, category or such like. The reason being that most statistics should be compiled to facilitate a total to be calculated and avoid double counting. In relation to government statistics but also general environmental economic statistics, the

[23] Statistical Classification of Economic Activities in the European Community

solution has been to look at the main purpose criterion. In terms of government spending it has proven less complicated than for enterprise-related statistics, given that the public sector does not undertake certain activities to increase its own profit (as a general rule). By using the main purpose criterion and not the effect of the implemented measure, there is a question of the time scale, i.e. the effect of a measure sometimes takes longer to show and the second reason is that the effect needs to be evaluated separately.

The proposed typology should be applied to highly aggregated data on planned measures. This means that the typology does not include a specific heading related to regional issues.

It is also proposed not to create a specific table on the grey and green infrastructure measures and soft-non-structural approaches due to the difficulties this will create to link this categorisation to other relevant economic or environmental data. Instead the European Commission can allocate the different sector categories as proposed in Table 2 in Chapter 3.2.1 above, bearing in mind that consideration has to be made to the quality of the data as each sector can contain all three aspects of grey, green and soft-non structural approaches.

4.1 Introduction

As noted above the proposed new typology will contain classifications of established practises but also new categorisations that will need to be demonstrated and described.

What is the purpose?

A new type of classification system is needed in order to accurately account for the purpose of payments to adaptation measures.

Statistical classifications are used for:

a. presenting statistical information;

b. the collection of information and/or organisation of information already collected;

c. aggregating and disaggregating data sets meaningfully for purposes of analysis, including the construction of indexes;

In this specific project we are considering measures that meet a public purpose. Here, there is a need to combine some existing environmental classifications with outstanding issues that are of interest to this project. Such outstanding issues are notably the health issue and the economic losses from climate change that are not labelled as environmental, but focussed more on core human interests that the average citizen cannot control. These areas are also in need of some more specified categories that outline the types of hazards that produce damage, making it easier to determine adequate response measures. According to the literature, human health

issues are attributed to heat waves, flooding, storms and possibly also some climate-related sicknesses.

4.2 A list of measures – helping the categorisation

A list of measures has been compiled from the Impact Assessment of the White Paper 2009/387. The examples of measures from the document served several purposes. Firstly it is a list of ideas that the European Commission felt were important in order to address adaptation issues and should be ideas that Europe listens to and perhaps even implements. Secondly the list of measure was a way to use the IPCC definition as a starting point when scoping the area. The Impact Assessment follows the IPCC definition in its own scoping of the area and it was interesting to find out how they had interpreted the definition. Thirdly the list of measures served as a good point of departure to test the typology approach anticipated for this project.

Each measure was extracted from the White Paper Impact Assessment and then further checked with the categorisation chosen and the definition of an adaptation measure. Through this work a total of 167 measures, checklists and other credible concepts were recorded.

It was clear that the not all measures followed the IPCC definition (as the authors see it). Some measures were clearly related to mitigation issues, e.g. energy issues and energy efficiency. Some measures were too broad to really provide informative guidance, such as measures only described as “General economic measures - social inclusion and immigration”. Also removed were ideas such as “Measures to improve air quality”. The White Paper reasons that it improves the resilience but the authors do not see how the IPCC definition relates the improvement of air quality, unless air quality improvements are associated with specific weather events.

Table 3 shows how the measures can be categorised:

Table 3: summary of the list of measures by proposed categories

category secondary aggregates	Total
Biodiversity	16
Biodiversity/checklist	1
Biodiversity/Forest	2
Economy/Biodiversity	4
Economy/Social protection	3
Health	13
Other	20
Other/checklist	16
Social protection	11
Soil	10
Soil/Economy	1
Soil/Water	7
Water	6
Economy/construction	5
Economy/urban planning	3
Economy/government	4
Economy/agriculture	14
Economy/insurance	1
Economy/production	7
Economy/energy distribution	3
Economy/tourism	4
Economy/fisheries	5
Economy/aquaculture	1
Economy/other	2
Economy/transportation/energy distribution	1
Economy/Forest	7
Total	167

The issues that the Commission will need to address are assessments of the funds allocated to adaptation, how much is given and how it could trace spending on new approaches or initiatives. Additional analysis relating adaptation measures to mitigation activities also comes within the Commission's remit.

The categorisation could take a couple of directions; this paper suggests two distinct versions following the established classifications of existing data collections.

This area of statistics is still in its infancy. It is clear that obtaining detailed information will be difficult, and that it would be preferable to focus on a higher level of data aggregation. Departure from the list of measures shows that in terms of supra-national or national involvement most measures are related to setting up strategies, implementing them and ensuring sufficient communication among stakeholders.

Initially the project anticipated that, like the three broad categories of the White paper, some similar categories should be needed in terms of assessing some broad aspects of adaptation. The proposal was evaluated on the basis of the list of measures from the White Paper and several points were seen that did not render it useful for further development. The first issue concerns Research and Development (R&D). Expenditure for R&D could be allocated to all three categories. However, it could be that R&D activities would be very interesting to follow separately.

The second issue concerns insurance activities. The White Paper describes several insurance activities that could also be included in all three categories in relation to planned measures. It could be argued that planned measures would not include insurance activities and not be an issue here. However, it could be that government legislation or incentives to encourage the development of insurance tools would then fall under the definition.

This categorisation is very rough and there could be a potential problem of separating governance from management at all times which was seen as the third problem in the categorisation.

However, based on these findings and the experiment, the work could continue to look into other classification options.

4.3 How could the adaptation measures be structured?

Who are the actors?

Planned measures are mainly government interventions to the economy or to society. Today there exists a statistical framework measuring the activities of government and their functions. The European System of Accounts of 1995 (ESA95) clearly sets the system boundaries for a number of issues related to the economic welfare of a nation.

For the purposes of this particular study we will apply the system boundaries of ESA95 for the institutional sectors related to government. It will also rely on the existing classification of government functions (COFOG). The classification is used

to allocate government outlays by certain categories of specific objectives. This classification is described below.

How can new information be organised?

If the COFOG were to be applied, adaptation measures are likely to be found in all categories and if the categories are kept there is an excellent opportunity to create indicators that match existing macro level statistics. Annex 4 shows the full COFOG classification including sub-categories. By following COFOG the statistics compiled on adaptation expenditure would cover all aspects of government spending ranging from housing, health, education and environmental protection. It would thus ensure that all areas are considered and it would be easy to describe where data is readily available and where it is not.

In future applications of the classification it might be of interest to follow autonomous measures. In such a case, we are able to base some of our analysis on the existing industrial classification system that defines the following economic agents: agriculture, forestry, fisheries, energy producers, water industry, construction industry and diverse industries including the service sector where tourism is covered through the NACE classification. Households could also be added to that list in order to cover the entire economy.

Through literature it is evident that the main focus of adaptation today is on disaster prevention. The COFOG does not enable such an analysis and a new typology needs to be established. The Centre for Research on the Epidemiology of Disasters (CRED) hosts the Emergency Events Database (EM-DAT). The reason for proposing this classification is that it is established and has well-defined categories with a specific allocation technique available. By extending the typology to also cover climatic impacts one would be able to assess how much is spent on preventing/adjusting/accepting climatic events by each specific category. Today there several measures implemented for coastal protection. These are a response to e.g. storms and floods. There are also measures to deal with wild fires or severe temperature changes.

Through their work the typology related to climate events can also be established for the area of adaptation. The project has identified that most countries support adaptation activities after an impact assessment and that climatic events are somewhat easier to deal with in terms of data availability. The proposal is shown in Figure 4.

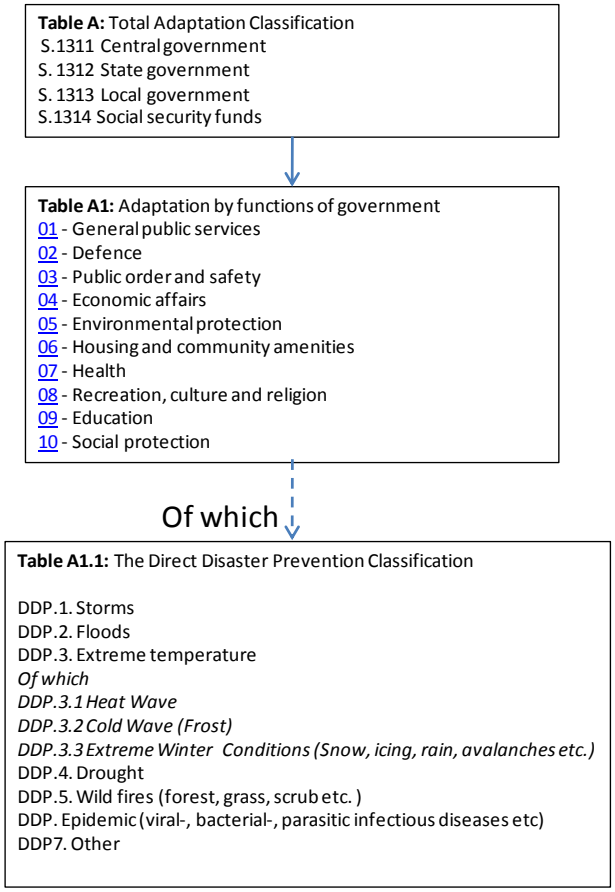
In order to compile desired statistics or cost estimates it may be necessary to create a number of different data compilation tables. These tables will vary depending on the level of interest, data availability and the relevant analytical requirements. In this paper a step-wise approach is suggested made up of three levels, see Figure 4 below.

- First level A: contains total expenditure for adaptation to climate change;
- Second level A1: contains the same information broken down into more detail using the COFOG, i.e. the totals of A1 equals A;

- Third level A1.1: sub-component of level 1 and 2 where specific analysis is made based on data availability and interest. In our case the specific interest would be to evaluate the expenditure due to extreme weather events.

It is anticipated that the headings outlined under Table A1 could in the future be divided into NACE categories using a cross-sectoral matrix or into larger groups e.g. General government, Private sector and Households.

Figure 4: Proposed structure of typologies on adapting to climate change



4.4 Conclusions: importance of integrated assessments

The challenges of establishing a new typology are multitude. The typology needs to be communicative, not be difficult to use as a result of operational compilations and preferably, suitable for use in combination with other existing typologies. The proposal builds on the idea that all sectors should be treated equally. However, sector-specific experts might argue that one cannot treat each sector equally in the actual calculation of the estimate or statistic. One will lose some of sector-specific quality by following a general approach but the point of departure for this proposal is for the results to be used by, for example, the European Commission or analysts that look at nation-wide information. As such, the importance lies in international comparisons of results and transparency of overall methods.

The Eurostat Reflection Group was consulted on the typology and the allocation techniques. Their answers indicate a movement towards a typology that clearly separates measures directed at the environment, society and economic affairs as is now being proposed. Knowing the work of the national statistical offices the Eurostat Reflection Group could see that as the area is completely new in relation to expenditure statistics a path forward is to look for easy targets and quite highly aggregated information before moving towards more refined solutions.

The proposal given is therefore based on existing international statistical classifications that will facilitate any future needs of integrated assessments. The proposal is to use the Classification of Functions of Government (COFOG) and the classification on natural disasters from the Emergency Events Database (EM_DAT). This will enable a connection to government expenditure through the framework of the European System of Accounts (ESA95) but also a link to weather-related phenomena.

As the classifications have been established for some time, the allocation technique is well described but still recognisable from existing literature in terms of continued analysis.

Table 4 show an example of how the COFOG related statistics can be viewed today. Each category can be further disaggregated and also shown by country. In relation to adaptation, one can already see that the expenditure in 2008 would certainly not exceed 1.8 percent of GDP in EU27 in, for example, economic affairs if we followed the COFOG typology. This would mean that the subsidies provided to the economic actors of a country would not be above 2 percent of GDP. We can also see that the share in most categories has remained stabile over time in relation to GDP revealing that any allocation of funds for adaptation would not have affected the totals.

Table 4: Total general government expenditure by function, percent of GDP

	2009	2008	2007	2006	2005	2004	2003	2002
Total	:	46.8	45.7	46.3	46.9	46.9	47.3	46.7
General public services	:	6.3	6.2	6.2	6.4	6.4	6.6	6.6
Defence	:	1.5	1.5	1.5	1.6	1.6	1.6	1.6
Public order and safety	:	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Economic affairs	:	4.2	3.8	3.9	3.8	3.9	3.9	3.9
Environment protection	:	0.8	0.8	0.8	0.7	0.7	0.7	0.7
Housing and community amenities	:	1.0	1.0	1.0	1.1	1.1	1.1	1.0
Health	:	6.9	6.7	6.8	6.7	6.6	6.5	6.4
Recreation, culture and religion	:	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Education	:	5.2	5.1	5.2	5.3	5.2	5.3	5.3
Social protection	:	18.2	17.8	18.2	18.5	18.6	18.7	18.4

Source: Eurostat database on government finance statistics, Extraction date 2010-10-06

Table 5 on the other hand show how many disasters have been registered in EU27 countries at 10-year intervals between 1970 and 2010. The table show that each

category of events has a high variation indicating the difficulty of establishing a sound forecast of coming events. In terms of adapting to climate events the cost estimates could still show if the estimates are reasonable for the number of events a specific year that they are targeting.

In terms of collecting expenditure statistics of adaptation broken down into the same categories as seen in Table 4, one would be able to say how much had been spent on adapting to flooding through dams or dikes during a certain year and match that information to the actual number of events that same year. It would not relate to the user if the event was in fact due to climate change but it would indicate the response to climatic events.

Table 5: Number of disasters by EU27 and year*

	2010	2000	1990	1980	1970
Drought	..	2	2	1	3
Epidemic	..	2	..	..	..
Extreme temperature	2	5	1	..	..
Flood	7	22	0	3	..
Mass movement dry	..	..	..	..	1
Mass movement wet	..	2	1	..	1
Storm	5	10	60	1	1
Wildfire	..	5	2	..	..
Total	14	48	66	5	6

*Not all countries had events at these specific points in time and have therefore nothing to report.

Source: EM-DAT. Extraction date 2010-10-06

It was a wish of the European Commission to continue the typology proposed in the White Paper Impact Assessment related to grey and green infrastructures and soft non-structural approaches. Very specific analysis would be required for that typology to be used by anyone else other than the people most involved in following the directions and strategies related to adaptation within the European Commission. The typology would also require additional efforts trying to link other relevant economic or social data. Another approach is that the European Commission themselves, after data collection according to standard classifications, apply the grey/green infrastructure approach to the main domains as described in Table 2 in Chapter 3 above. However, by doing so, their analysis would be hampered by the possibility of errors. It would relate to, for example, the main share of grey or green measures in one specific category to be skewed. One example would be in, for example, the agricultural sector. This report has labelled the agriculture sector as green even though irrigation systems are regarded as grey and highly likely to be implemented. It could be that the expenditure for irrigation is higher than the costs for crop diversification.

With regards to the "soft" non-structural approaches (measures) expenditure statistics would not capture these. As these measures cover activities such as

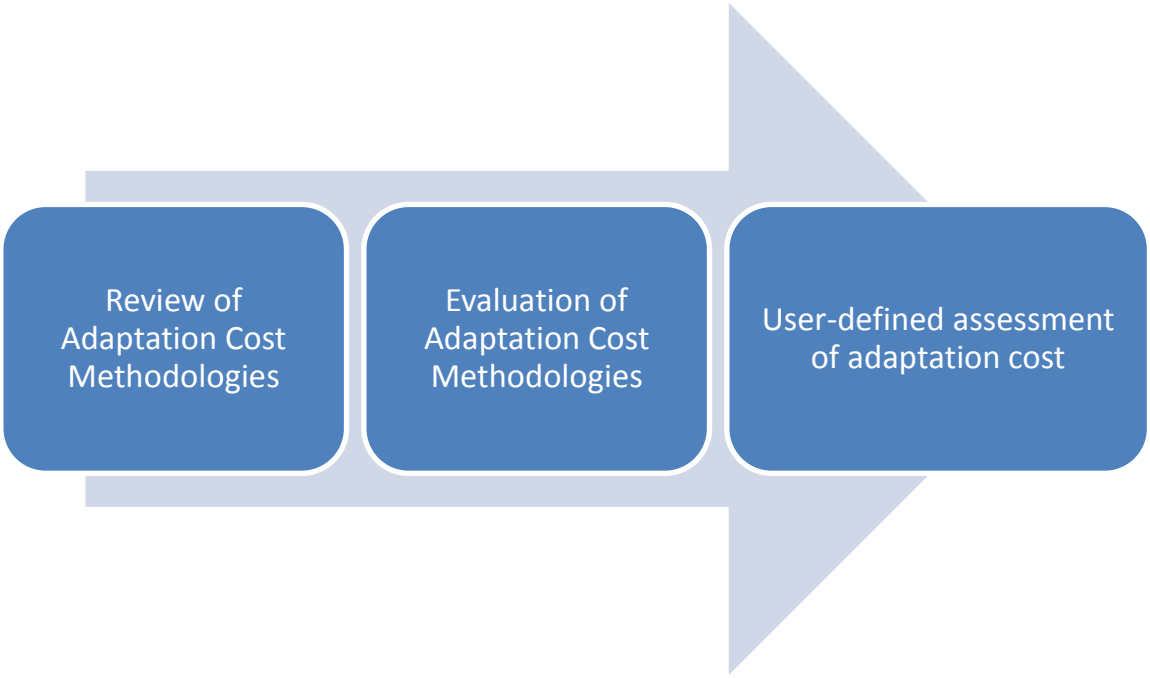
developing regulations, taxation and information platforms these are either part of everyday business for a government or not considered expenditure but revenue. In relation to cost estimates the situation is largely the same but with the consequence that if legislation activities are included as a cost, would the work of not conducting a regulation then be seen as a benefit? It is not likely that government activities in relation to "soft" non-structural approaches would be included in cost estimates for some time yet.

Cost estimates could potentially build on the same typology as the statistics. However, the sequence of events of calculating the cost including the difference of scope in terms of project versus a measure could render the typology not applicable. By that, it is meant that the categorisation might be too rough. This part of the work would require testing before being recommended fully.

5. Overview of methodologies to extrapolate adaptation cost

Summary of findings

As indicated in the introduction to this report, a literature review has been undertaken to determine what methodologies have been applied in determining adaptation cost. An overview of different analytical perspectives, with work completed by policy analysts and decision makers in the public and private sectors, has provided the project team with an indication of the types of cost assessment methodologies that could be applicable in specific situations. These approaches have been evaluated bearing in mind the realities of the EU decision making process and the structure of the EU budget.[24] The methodology applied in this chapter is summarized as follows:



The different approaches are evaluated based on their application in different policy contexts, using key adaptation cost assessment criteria outlined in authoritative information sources. This evaluation is summarized in a table at the end of this chapter. A methodology has been applied to a range of selected measures in chapter 7, based on the applicability of these different approaches to the three categories of measures outlined in the White Paper Impact Assessment, while considering the likelihood that adaptation cost will be considered by a range of different

[24] . For a more in depth discussion of the methodology applied to this literature review, refer to Annex 1.

stakeholders throughout Europe.[25] They could be applied by decision makers at the EU level, by decision makers at the national level, and by decision makers at the local level.

In order to be applied effectively, cost assessment will need to apply a methodology that is replicable, transparent and flexible. Determining a specific approach may be more a question of standardizing default values and data inputs allowing for a more meaningful comparison of cost calculations across the EU. Having a methodology that emphasizes the importance of harmonized data inputs, will allow decision makers to allocate funding equitably. This will ensure that adaptation needs are based on an objective assessment of cost, given the application of a pre-determined cost assessment approach that has been developed throughout the EU as a whole.

5.1 Introduction: estimating adaptation cost an overview of ongoing work

Adaptation cost has become an area of increasing importance in the context of work funded through a range of different organizations at the international level including the UNFCCC, the IPCC, the OECD, the World Bank, and the UNDP. Within Europe, the issue has been taken up by the European Environment Agency, the European Commission (through a number of different research projects and contracts), and by a number of different universities and research institutes. For the most part, international organizations and international financial institutes have focussed either on global cost assessments, or on cost assessments at the project level in developing countries. Justifying expenditure on adaptation in developing countries is typically more straightforward, given the number of "win-win" scenarios associated with adaptation in a development context.[26] In short, one cannot analyze the approaches advocated by these organizations without consideration of their respective mandates.

At the international level, the research undertaken by the UNFCCC in particular, has become a part of the climate change negotiations process, looking to advance methods and tools that can be applied by all Parties to the Kyoto Protocol. The work of the UNFCCC falls under the Nairobi work programme on impacts, vulnerability and adaptation to climate change. As part of this work programme, the SBSTA (Subsidiary Body for Scientific and Technological Advice) commissioned work summarizing existing analysis on adaptation cost, and a workshop was recently held in Madrid, Spain, in June, 2010. As such, the UNFCCC has been responsible for synthesizing a lot of varying viewpoints on the assessment of adaptation cost, but

25. Indeed, the possibility that the assessment of cost will differ based on the option in question and the decision maker involved has been stated in a report issued as part of the European Environment Agency's 2010 SOER.

26. Investment in adaptation in developing countries under a "win-win" scenario could have other positive co-benefits in terms of enhancing overall capacity and improving the resilience of infrastructure.

has not yet endorsed specific approaches (nor is it likely to do so). It has not taken the same hands on approach as it has with mitigation.[27]

The role of the UNFCCC is a significant contrast to that of the UNDP for example, given that the UNDP is mandated to address economic development and adaptation in developing community based projects. Interestingly, the need to consider how approaches may need to be adjusted for local realities coincides with the recent outcome of the SBSTA workshop on adaptation cost, which indicated that it will not be possible to apply one uniform approach to the calculation of adaptation cost. (UNFCCC, 09/2010, p. 8) This is the underlying hypothesis of this report, that an approach to project adaptation cost will need to consider local economic and social realities that relate to the decision maker in question.

Within the EU, determining the cost of adaptation has obviously been a topic of investigation by the European Commission and by the European Environment Agency. While the work of the Commission and DG Clima focuses more on the development of policy and approaches to calculating adaptation cost, that of the EEA focuses more on data needs.[28] The work of DG Research at the Commission focuses on a wide range of issues related to adaptation cost, as part of both FP6 and FP7 projects.[29] While some of the analysis is more academic, there has also been the development of a number of cost models that will be discussed in relation to the assessment of specific measures in Chapter 7.

Work of member state governments, other research institutes within the EU, and the private sector are also described in this chapter.

5.2 Methodologies to calculate cost: international organizations

As outlined above, allocating funding allocated to adaptation measures in developing countries has been more straightforward in the sense that funds will serve a number of different benefits outside the adaptation rubric. In summary, and as outlined below, international organizations have not applied methodologies related to adaptation cost in the context of budgetary planning from an ex ante perspective. The World Bank report of 2006, the Stern review, and the work of the UNDP in 2007, all determine costs based on standard development considerations which are marked up based on an additional adaptation investment needs: this cost assessment approach is known as "Investment and Financial Flow" (I&FF).

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[27] . The UNFCCC has approved specific baseline methodologies to quantify greenhouse gas reductions as part of the governance process of the Executive Board and the implementation of the Clean Development Mechanism.

[28]. For a description of the EEA's mandate, refer to: http://www.eea.europa.eu/about-us/who.

[29]. For a description of the relevant FP6 and FP7 projects, refer to: http://ec.europa.eu/research/environment/index_en.cfm?pg=projects&area=climate#fp6subarea7.

5.2.1 Work of the UNFCCC

The text of both the UNFCCC Convention (1992) and the Kyoto Protocol (1998) focuses more on greenhouse gas mitigation targets based on consideration of climate change impacts. Adaptation in the context of international negotiations heightened in importance following the establishment of the Nairobi Work Programme (NWP) established at COP 12, and the subsequent design of the Bali Road Map at COP XIII. The NWP programme is a five year programme (2005-2010) implemented by Parties, intergovernmental and non-governmental organizations, the private sector, communities and other stakeholders. Its primary objective is to assist developing countries (including least developed countries and small island states) to improve their understanding and assessment of climate change impacts, and to make informed decisions on measures implemented to address adaptation including an assessment of costs and benefits.[30]

A research project launched by the UNFCCC secretariat in 2007 generated a document that provided an overview of financial needs in relation to the costs of both mitigating greenhouse gases and adapting to climate change up until 2030. However, while some UN material has been mandated through the NWP in order to review some of the technical challenges associated with adaptation, and the implementation of adaptation measures, this particular report's primary goal was to evaluate the Protocol's financial mechanism and its ability to meet gaps in climate finance.

The 2007 UNFCCC report provided an initial overview of adaptation costs in the key sectors of the IPCC's 4AR (Agriculture, forestry and fisheries; Water supply; Human health; Coastal zones; and Infrastructure.) These estimates were subject to further scrutiny on the part of academics at both the Grantham Institute at the London School of Economics, Imperial College and the Institute of International and Economic Development. However, while this report is known to have underestimated the costs of adaptation based on the use of highly aggregated approaches, it does provide a significant amount of useful input in terms of definitions, a review of existing international spending, and in terms of measures.

Two other reports were mandated by the NWP, looking specifically at the need to develop a robust approach to calculating the cost of adaptation. At the request of the secretariat, a technical report was issued in December of 2009, and a subsequent synthesis report in March of 2010. The December 2009 report essentially provides a broader overview of a number of methodologies applied by all levels of government, with a stronger emphasis placed on those applied by international organizations.

The UNFCCC December 2009 report further reinforces the notion that it is difficult to compare national level studies on adaptation cost given that analytical timeframes differ, in addition to the applied metrics. As outlined on page 3 of the summary

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30. http://unfccc.int/adaptation/nairobi_work_programme/programme_activities_and_work_areas/items/3922.php

report, approaches to estimate adaptation cost "fall into two broad groups: those that adopt an aggregate level analysis and those using a more disaggregated approach. The aggregated approach is more basic and relies on a number of assumptions that are difficult to substantiate. The disaggregated approach provides better estimates at the sectoral level; but when implementing this approach, one faces considerable uncertainty relating to future developments in the economy and likely impacts from climate change. It is difficult to obtain reliable data at an adequate geographical resolution to allow accurate assessment of the adaptation options."

A number of international organizations have attempted to quantify adaptation cost primarily using aggregated approaches through I&FF analyses, or through integrated assessment models (known hereafter as IAM). In considering the value of the estimates they have come up with, one needs to consider the objective of their cost assessment. For a number of international organizations, and even for a number of reputed academics such as Stern, estimates may have been used as the basis for galvanizing further action on climate change. The application of I&FF approaches by the UNFCCC in 2007 were considered "relevant to the development of an effective and appropriate international response to Climate change."(Ibid, p. 5) The application of I&FF approaches or IAMs by other international organizations in assessing cost, were primarily used to assess developing country needs, or to determine the level of mitigation required minimize the impacts of climate change and hence the costs of adaptation.

The UNFCCC report summarizes some of the other shortcomings of both IAMs and I&FF. The application of the I&FF approach in both the UNFCCC 2007 study and that of the World Bank in 2008 bases its cost estimates on longer term time scales, and does not provide estimates of economic benefits of adaptation or residual damages. As indicated by Parry (p.5), the estimates are low given that they do not consider ecosystem services. (Ibid, p.5) Uncertainty is not accounted for, and the relative vulnerability associated with distributional impacts is not described either.

As outlined in the UNFCCC study, some of the aggregated cost assessment approaches have also been applied at the national level. In addition to the application of IAMs and I&FF, a number of countries have used Computational General Equilibrium models (hereafter known as CGE). Generally speaking, countries that have applied the more disaggregated approaches, such as sectoral impact assessment, end up with higher estimates than those achieved when using the more aggregated approaches. (Ibid, p.7)

The UNFCCC summary report provides an extremely thorough overview of a number of key terms and methodological issues related to the development of an appropriate cost assessment methodology as part of either bottom up or top down estimates. The three key methodological challenges relate to the ability of methodologies to account for uncertainty; the data needs of various types of economic valuation and "equity". Uncertainty can relate to a number of issues including the accuracy and scope of data inputs, and the uncertainty associated with the actual cost estimates themselves. There are a number of issues associated with the actual implementation of measures which also increase the uncertainty that projects will deliver the anticipated adaptation objectives. The possible reversibility

and lack of flexibility of measures themselves in terms of coping with impacts, combined with a lack of adaptive management all increase the likelihood that projects could fail.

With respect to the different approaches to adaptation cost assessment, the term "equity" describes the ability of a methodology to account for impacts within one sector or area, or across an entire economy. Impacts could manifest themselves in terms of damage, or in terms of benefit. For the purposes of our analysis of cost assessment approaches, we will use the term sectoral vs. multi-sectoral to facilitate the description of methodologies in terms of their ability to account for "equity."

The term economic valuation encompasses a number of variables that make up any cost methodology. These variables include discount rates; time horizons; monetary vs. non-monetary cost assessment approaches; the linkages between mitigation and adaptation; public as opposed to private adaptation; ancillary benefits and hard vs. soft valuation options. These three concepts (uncertainty, sectoral vs. multi-sectoral and economic valuation) will be used to help determine the effectiveness of the different approaches in an EU context. These variables will be used to assess methodologies and their applicability for the three types of measures outlined in the White Paper Impact Assessment (green, grey and soft).

The discussion of public vs. private measures as outlined in the UNFCCC December report underlines the importance of public intervention as part of adaptation funding, and helps provide a rationale for EU involvement. The role of the public sector helps to correct for market failure, particularly in terms of addressing gaps in insurance provision throughout the EU. Public funding also helps both to support individuals that are most vulnerable to the impacts of climate change and to protect resources that are in danger of overexploitation. At the same time, the public sector will need to avoid implementing adaptation options that are irreversible, to avoid the risks of mal-adaptation. One most also consider the fact that implemented measures will have different results. Soft approaches such as policy or insurance may cost less, but may achieve better results if implemented effectively.

The December technical report of the UNFCCC provides an excellent overview of the application of all cost assessment approaches. A table summarizing the pros and cons of these approaches is provided at the end of this chapter.

While the UNFCCC technical report provides a good overview of a number of key variables that would need to considered as part of a cost assessment, the report issued in March of 2010 provides more of an overview of the more qualitative considerations required to outline the fundamental boundary of the project. These are issues that should be considered prior to undertaking an actual cost assessment, and will form part of the methodology applied in the assessment of specific measures in Chapter 7. These steps could comprise a project "screening tool", used to establish project boundaries. This screening tool is outlined in Chapter 6.

Other UN bodies such as the United Nations Development Programme have also developed screening tools that can be used to assess the "adaptation deficit" of countries on a sectoral basis. The United Nations Development Programme Climate Capacity program has issued specialized guidance for the assessment of adaptation

in the following sectors: forestry, health, water, tourism, agriculture, biodiversity, coastal zones and fisheries.

5.2.2 Work of the OECD

The OECD initiated a program related to adaptation in 2002, with a more recent focus on the economics of adaptation. A paper released in 2008, looked specifically at issues related to the assessment of adaptation cost in a number of areas, and at the potential role of a number of different policy measures in encouraging the uptake of adaptation measures. This report provides insight in to the involvement of various actors in implementing adaptation measures, with a discussion around the need for greater involvement on the part of the public sector.

The OECD has commissioned a number of specialized technical reports that can be used to help evaluate cost assessment methods. In terms of assessing Integrated Assessment Models, we can say the following: none of the existing versions of the model integrate adaptation in a satisfactory manner. The implementation of adaptation measures responds to impacts at an "optimal level" meaning that they are not able to account for residual damage. Without being able to determine the extent of damages on resources that remain despite the implementation of adaptation measures, it is impossible to determine additionality. OECD discussions around the application of the DICE and RICE models have been scaled down for more regional applications as part of AD-DICE, and AD-RICE models. These applications however, look at adaptation in relation to mitigation efforts.

5.2.3 Work of the World Bank

The Methodology Report of the World Bank published in February 2009, no doubt provided the basis for a lot of the UNFCCC conclusions as part of the December 2009 Technical Report. Issues related to Uncertainty, Timeframe, Discounting and Equity – are also outlined as key considerations in the calculation of adaptation cost. The World Bank places importance on the need for planned vs. autonomous adaptation, indicating that it is the public sector that will play a crucial role in financing planned adaptation.

With respect to uncertainty, the World Bank report indicates that the unforeseen events resulting from climate change (impacts) can be addressed through the implementation of a risk management framework and the derivation of probability curves in relation to climate change indicators. These indicators can be used to help outline the probability of events occurring. Strategies would be implemented that are able to cope with the most extreme events.

The rate at which projects are implemented will depend on the timing of impacts, but may also need to consider the rate of technological progress in relation to "productivity of adaptation investment", the ability to reduce uncertainty ranges, "irreversibility of the costs of adaptation", the application of the social discount rate, and the actual availability of finance. According to the World Bank, policy makers should not look to estimate cost beyond 2050, given that most measures will not

extend beyond this timeframe. However, it would be worth looking at a series of different discount rates to determine longer term costs.

The World Bank proposes an interesting bottom up approach to the assessment of adaptation cost which involves projecting impacts, assessing the exposure of the local population and resource base, and their sensitivity to changes in the climate. It essentially outlines the need to determine who needs to adapt, and to what. Assessing cost in this way is further complimented by an assessment of adaptive capacity and adaptation deficit. At the national level, adaptation deficit or capacity can be ascertained by looking at: public good provision, existing climate proofing of public investment, legislation that enables private adaptation, and provision of a safety net.

A more recent global study published by the World Bank, "Economics of Adaptation to Climate Change (EACC) Study 2009", reiterates a lot of assumptions as outlined in the previous World Bank report in terms of timeframes, and the use of development baselines. While it uses a country specific approach to calculating adaptation cost, it provides an interesting participatory tool that could be used to scope out potential adaptation projects (projects where measures are implemented.) The notion of undertaking stakeholder consultation could be applied as part of contingent valuation methods in the EU.

5.3 Methodologies to calculate cost: EU

5.3.1 European Commission

There are a number of Directorates General within the European Commission that have completed work related to impacts, and the cost of adaptation measures. Work has been undertaken by DG Research, DG Clima (formerly DG Environment), DG Mare, DG Agri, ECFIN and others. The work of these government bodies is summarized as follows:

DG Research: There are a number of ongoing projects at DG Research related to the calculation of adaptation cost, and to other pertinent variables of the cost equation (both under the FP6 and FP7 frameworks). The most pertinent project is ClimateCost; aimed at determining the cost of climate change based on future effects. A number of complementary projects are ongoing under the FP7 framework one of which looks at vulnerability assessment (MOVE project), and other projects aimed specifically at the identification of impacts. The "ice2sea" project for example looks specifically at the impacts associated with the contribution of ice to sea level rise. These projects are all ongoing and it is not yet possible to extract any meaningful data from them as of yet.

The adaptation issue has been a subject of research as part of projects falling under the FP6 framework as well. Projects like ADAM (ADaptation And Mitigation) considered climate scenarios in outlining adaptation needs and the necessary greenhouse gas reduction targets to avoid further temperature increase. The

"Ensemble" and "Peseta" projects looked more specifically at the forecasting of climate change and its associated impacts.

Sectoral based research: There were two communications released by the Commission that accompanied the Adaptation White Paper. One communication dealt with plant, animal and human health in relation to climate change, and the other with water, coasts and marine issues. The health related report identifies health risks attributed to climate change throughout Europe (for plants, humans and animals, while also looking at the relationship between the three species), while also reviewing Europe's capacity to mitigate these risks. Referring to a number of completed and ongoing FP6 and FP7 projects, the possibility to improve the identification of risks through enhanced warning systems is emphasized.

The Communication related to water, coasts and marine issues provides a general discussion of the impacts of climate change on Europe's water resources. It emphasizes the possibility that enhancement of existing water related policy could help minimize the impacts of climate change. Indeed, the White Paper indicates that enhancement of the Water Framework Directive, and other policies such as the Integrated Coastal Zone Management directive, could help address adaptation to climate change. Mainstreaming adaptation in to policy is considered an adaptation measure in according to the Commission.

5.3.2 Member States

The majority of Member States (MS) have not yet documented systematic overviews of their respective methodologies to quantify the cost of adaptation; this was demonstrated at the onset of this project when authors of this report reviewed a large number of National Communications for all MS.[31] While the majority of MS are in the process of implementing adaptation strategies, it is really only the United Kingdom that has provided the most comprehensive approach to quantifying cost. Nevertheless, examples of relevant government programs are provided below.

AUSTRIA

The Austrian Environment Ministry, together with the University of Graz, will shortly begin a small project on 'the social costs of adaptation: approaches for an evaluation of adaptation costs' (SALDO). The SALDO project will be a precursor to a larger, nationally funded project on the topic. The aim of SALDO is to evaluate the existing adaptation cost assessment frameworks and to design indicators to evaluate the cost of adaptation options. It is based on the principle that knowledge-based policy decisions for concrete adaptation measures must be informed by sound

[31]. National Communications outline steps taken by Parties to the UNFCCC in terms of implementing the Convention. National Communications are submitted to the UNFCCC secretariat every four years or so. Submission dates to date have been: 1994-95, 1997-98, November 2001, January 2006 and January 2010. While reporting guidelines have been outlined by the Commission, the quality of information prepared varies, and Parties are often late in submitting documents to the Secretariat.

decision support systems, and one element of decision support is the cost to society. SALDO will base its evaluation on: economic criteria such as social costs and benefits, as well as an assessment of residual damages; additional criteria such as enhancing adaptation capacity, synergies with other sectors and with mitigation strategies, social impacts of adaptation – particularly the distribution of welfare, social acceptance of measures and their sustainability; and criteria for tackling uncertainty in adaptation, such as risk management, setting clear priorities, and avoiding reducing the flexibility of other sectors or regions.

The intention is not to produce measurable outputs of figures and numbers, but a sound base for a framework for the assessment of adaptation costs in Austria – a methodological basis for the assessment of adaptation. In order to enable the ranking of different adaptation options, a mostly qualitative evaluation tool will be used, based on the criteria listed above. (Email from Martin Koenig at Austrian Environment Ministry, on 12th July 2010)

GERMANY

Initial, rough estimates by the German Institute for Economic Research (DIW) put the accumulated cost of climate change impacts in Germany at up to €500 billion until 2050. It should be noted that this figure incorporates mitigation and adaptation. The DIW hope to decrease this figure by systematic analysis of vulnerability and realising adaptation measures. The German Adaptation Strategy (Deutsche Anpassungs Strategie, or DAS), published in 2008, outlines a framework for action. The first adaptation action plan is not expected until 2011 and will be published by the Federal Government. It will include cost-benefit analysis, monitoring and evaluation. (UNFCCC, November 2009, p. 8)

ITALY

In 2007 the National Environment Protection and Technical Services Agency of Italy attempted its first quantification and monetary evaluation of the cost of climate change impacts. Again, this did not relate exclusively to the costs of adaptation, but also wider to the impacts of climate change. It focuses on four of Italy's vulnerable regions: coastal zones; arid areas; areas at risk of flood and landslide; the Alps and glacier ecosystems. The methodology aims to identify and quantify the physical impacts of climate change for each area, informed by existing literature, and to estimate their economic value.

Firstly they quantified the monetary costs of climate change impacts on key vulnerable sectors. Secondly the aggregated these impacts into a Computable General Equilibrium model. Thirdly changes in GDP (losses) served as a macroeconomic indicator of the economic value of future impacts (C. Carraro and A. Sgobbi 2008). The foundation of the study is looking at the economic loss of income to identify specific vulnerable sectors.

The most recent adaptation strategies in Italy are presented and evaluated, and a macro-economic model based on climate change costs is used to examine the impact on Italy's GDP (sectoral and total).

The methodology is known to underestimate the cost of climate change given the inherent data gaps. These gaps include the lack of accurate projections of the physical impacts of climate change, difficulty in assigning economic values to these physical impacts (especially concerning biodiversity and landscape) and difficulty in costing both inaction and the benefits of adaptation. (Ibid, p. 9)

THE NETHERLANDS

An assessment of the incremental costs and benefits associated with different adaptation options was carried out in 2006, as part of a Scientific Assessment and Policy Analysis of climate change (WAB) (full report http://www.rivm.nl/bibliotheek/rapporten/500102003.pdf). This assessment concluded that useful cost benefit analysis requires some degree of consensus on applied uncertainties – the application of different probability co-efficients can lead to substantially different conclusions.

The literature on adaptation options for the Netherlands to date has primarily been qualitative. That said, there is a large knowledge base of cost estimates for water management, which has often been used in decision making for their national flood protection strategy. There are also some cost estimates for coastal protection under the Delta Programme (http://www.deltacommissie.com/doc/deltareport_full.pdf) put together by the Delta Committee. It is estimated that the package of measures will cost an additional €1.2-1.6 billion per annum until 2050 and €0.9-1.5 billion in the period 2050-2100 ('additional' to current budgets assigned to this). (Ibid, p. 10)

SPAIN

The Spanish Climate Change Adaptation Strategy has just begun its second work programme. It includes plans to mainstream adaptation into legislation and national planning, though there has been some progress on this already, in the National Plan to Fight Desertification and the Water & Forestry Policy. A series of activities are planned to study the costs and benefits of adaptation, including the costs of inaction. (Ibid, p. 11)

SWEDEN

The Commission on Climate and Vulnerability was appointed by the Swedish Government in June 2005 to assess regional and local impacts of global climate change to Swedish society and the associated costs. Sweden will be greatly affected by climate change and adaptation to climate change should start now. This is the conclusion drawn by the Commission on Climate and Vulnerability in its final report. The report recommends increased responsibility for municipalities and

county administrative boards, and also government support for large-scale high-cost initiatives.

In order to gain an understanding of the costs that may arise as a result of the climate changing, two possible scenarios were devised: a High scenario and a Low scenario. The High scenario represents a medium-high development path for the changes in climate. The Low scenario is a medium-low climate scenario. The purpose of presenting damage costs as part of two distinct scenarios is primarily to illustrate how society may be affected by climate change in economic terms.

The Swedish study indicates that a cost-benefit analysis of adaptation measures may be implemented for each measure individually, and an assessment of the current cost situation, the conditions for technical development and the possible cost trend are balanced against the damage that is to be prevented. The baseline scenarios relate to costs for damage that can arise if no preventive measures are taken. The precondition is consequently that no erosion protection, raising of roads, etc., have been implemented. In cases where it is possible to predict damage, it is probable that measures will be implemented before the damage occurs. The applied time horizon is up until 2100. The calculations are based on the systems' current vulnerability and scope.

In most cases there are no regular probability calculations for the various weather events that cause the damage. In many cases, the cost calculations apply to a restricted incident, such as a stretch of road being washed away or a water source becoming contaminated. In most cases, however, it is not possible to estimate how often such events will occur based on the climate scenarios and the produced climate indices. This means that it is impossible to produce a compilation of the costs covering the entire period up until 2100 other than in the form of a general sample calculation that illustrates what the cost could be in the event of certain possible courses of events.

The estimated costs and earnings for two scenarios were calculated for a range of communication and technical installations, as well as for buildings, forestry and agriculture.

Costs for extreme weather events

The work undertaken in the Swedish case indicates that damage costs can be set in relation to the actual costs for natural damage in today's climate. Several major landslides, storms and floods have occurred in Sweden over the past ten years. The extent of the costs these events have caused has only been compiled in exceptional cases. One indication is the insurance companies' compensation for natural disasters.

The Stern review of 2006 shows that the insurance sector's costs as a consequence of extreme weather events, have increased by 2 percent annually since the 1970s. The report also maintains that if this trend continues, the annual costs caused by extreme weather events could increase to 0.5–1 percent of global GNP by 2050. It is not possible to conduct a corresponding analysis for Sweden, as there are no comprehensive statistics that distinguish the costs for natural damage in Sweden. Insurance compensation payments purely for major natural disasters for the period

1997–2007, dominated by the costs for Hurricane Gudrun, averaged at SEK 600 million annually. (SOU 2007:60)

UNITED KINGDOM

There is a considerable amount of work that has been undertaken in the United Kingdom in relation to the assessment of adaptation cost. An economic analysis of adaptation options is to be completed by mid-2012 by the UK Environment Agency and DEFRA, as part of the Climate Change Risk Assessment. The Stern Review commissioned by the UK Treasury in 2005 in addition to the work of the United Kingdom Climate Impacts Programme (UKCIP), indicates that there is a lot of UK based research that could be considered relevant to the analysis undertaken as part of this contract.

The work of the UKCIP provides a detailed cost methodology for a number of different sectors including coastal zones, water resources, agriculture, buildings and infrastructure in relation to "marketed goods". The adaptation costs of non-marketed goods are also analysed such as: habitats and biodiversity, human health, recreation and amenity, cultural objects, leisure and working time, all of which exemplify the challenges to valuating non-use benefits. The UKCIP cost methodology involves identifying measures and quantifying climate impacts in relation to a total number of physical units and converting these physical impacts into monetary values. This further involves calculating the resource costs of adaptation options; and "weighing up the costs and benefits of the adaptation options, and choosing the preferred option, taking account of risks and uncertainties." (UKCIP, Overview of guidelines, p. viii)

Work issued by UKCIP as part of a series of implementation guidelines outlines the pros and cons of a number of the more bottom up disaggregated approaches to calculating adaptation cost with a particular emphasis on Cost Benefit Analysis, Cost Effectiveness Analysis and Multi-Criteria Analysis. Depending on the particular needs of the user undertaking the cost assessment, a combination of these three approaches could be required. There are essentially two broader steps to undertaking cost assessment as outlined in the UKCIP implementation guidelines which include:

Step 1: Climate change risk (impact) assessment and measurement. In step 1, it is assumed that the user has undertaken a risk assessment to consider the types of impacts associated with the project.

Step 2: Economic valuation of impacts. Step 2 involves valuating these impacts. Interestingly, the author proposes that lower order impacts (those that are more direct) should involve estimation approaches associated with replacement costs or preventative expenditure; higher level impacts (those that are less direct) would involve "contingent valuation methods."

The additional steps outlined as part of the UKCIP approach are similar to those outlined in the UN synthesis report of this year (UNFCCC, March 2010). As outlined in chapter 7, undertaking the assessment of costs in various contexts would

involve determining the following: the purpose of the primary study; the scope of required economic values; whether values are ex ante or ex post; whether the data assumptions are appropriate; the applicable uncertainty or margin of error; whether the benefits estimates are robust; and whether the benefits should be aggregated over the population in question.

5.4 Methodologies to calculate cost: private sector

With significant contributions from the insurance company Swiss Re, a methodology has been determined using input data from a number of different case studies. Their methodology was based on a "broad metrics of climate-related economic loss" including GDP, asset value, and agricultural production. While it does not consider the social and environmental costs of impacts, it does however cover human costs. These costs cover impacts on human health, homes, and economic losses to sectors such as power generation. It is based on the premise that proactive investment is cheaper than disaster relief.

Unlike the aggregate cost estimates suggested above, applied by multilaterals more to determine actual cost at a given point in time, the analysis completed in the compilation of the Swiss Re approach illustrates the need for more systematic decision making that can be applied to different geographic areas in a short space of time. Given the use of local consultation in so doing, it underlines the importance of the EU clearinghouse for local data on impacts and costs. In the context of EU decision making, deriving cost would need to consider local detail. In cases where local detail is found to be lacking, a standard uncertainty range (or confidence level) could be applied to account for less representative data sets.

Similar to the objectives of this report, this approach emphasizes the importance of mainstreaming adaptation needs in to economic development. Apart from the consideration of cost, adaptation needs to be considered from a broader risk perspective. It analyzes the potential for the implementation of measures on the basis of a number of different scenarios including a business as usual scenario for today's climate and continuation of historical weather patterns in line with today's growth to 2030. The need for additional adaptation measures could be considered against both a moderate change scenario built on an average forecast for climate change impacts in the location under study, and against a high change scenario for extreme climate change based on existing data.

The methodology suggested outlines a way in which loss is calculated against these scenarios; more precisely, the impact of hazards is calculated against the location's total asset value. Apart from determining the asset value as such, calculations would need to integrate the perceived vulnerability of those assets to the impact in question. In an appendix to their report, as part of a methodology guide, the authors indicated that "expected loss is the amount of damage likely to occur in a defined time period (for example, one year)." In summary, the cost of adaptation becomes the investment required in adaptation measures aimed at minimizing future climate

hazards. This is distinct from the total cost of climate change which is the sum of the cost of adaptation and residual expected losses not averted by adaptation measures.

The risk assessment approach raises a series of questions, which could be considered the steps required in order to calculate cost. Steps 1-4 essentially involve determining a business as usual scenario.

1) Where and from what are we at risk? This indicates the need to assess both vulnerability, and the probability of weather events and impacts.
2) What is the magnitude of the expected loss in the absence of climate change adaptation measures? Any cost calculation would need to consider the importance of scenario building, and the use of Monte Carlo simulations in order to determine the frequency of weather events and their severity.
3) To respond to anticipated losses, we need to undertake the following steps:

   A. Need to determine the applicable measures and their implementation feasibility,

   B. Calculate societal costs based on a pre-determined discount rate,

   C. What is the rate of penetration for a given measure? Is it already being undertaken by the private sector?

   D. What is the actual cost of each measure? Need to determine the capital cost, the operating cost, and the implementation lifetime of the measure (is it longer than period being considered?). This will help in determining the annualized cost per measure.
4) Future costs can be extrapolated on the basis of locally verified estimates; a trajectory for the growth in cost can be based largely on inflation.
5) Once a trajectory has been established for a business as usual scenario, calculate the potential loss averted for each measure on the basis of different scenarios.

5.5 Conclusions: comparison of all approaches

The UNFCCC report from December 2009 provides an extremely thorough overview of a number of key terms and methodological issues related to the development of an appropriate cost assessment methodology. The importance of these three variables, equity, economic valuation and uncertainty, is also emphasized in the work of UKCIPS. Given that the use of cost assessment methodologies is user defined, the application of the appropriate methodology will reflect elements of these three variables in varying degrees.

In an EU context, decision makers at the local level will need to determine more accurate cost estimates. This is due to their accountability to local stakeholders, and the fact impacts on local communities are more direct. For this reason, local cost estimates will need to consider a more disaggregated approach that is more accurate, where estimates both around impacts and resulting cost estimates tolerate a lower

level of uncertainty. Equity considerations may be less prevalent given the preoccupation with local issues, although this will depend largely on the size of the jurisdiction in question. Distributional impacts will need to be considered by higher levels of government. The type of economic valuation applied will be more a function of the actual measure implemented. This is discussed in greater detail in Chapter 7.

The table below provides an overview of the different cost assessment approaches and compares them using the three distinct principles reiterated throughout the literature. This comparison provides a description of the cost assessment in terms of their ability to account for uncertainty, to reflect the distribution of costs and benefits among the population at large, and the types of parameters that would typically be associated with the applicable cost assessment approach.

Table 6: Overview of cost assessment approaches

Methodology evaluation				
Cost Assessment Approach	**Standard Application**	**Sector specific vs. multi-sectoral ("equity")**	**Range of Uncertainty**	**Scope of Economic Valuation**
TOP DOWN APPROACHES				
Investment and Financial Flow (I&FF) I&FF and Integrated Assessment Models produce global estimates where adaptation cost is expressed as a percentage of GDP.	UNDP for assessment of costs in developing countries; UNFCCC cost estimates 2007 Used more as a tool to push for more action on greenhouse gas mitigation as part of international negotiations.	Cross-sectoral linkages considered, although wider economic impacts are not.	I&FF does not include uncertainty – no explicit use of baselines, no use of projections, reversibility of adaptation measures not considered.	Time horizon 2030, annual cost not discounted, benefits and other non monetary values not assessed; focus on hard adaptation, ancillary benefits discussed qualitatively for some sectors, focus on public sector, no discussion of adaptation limits.
Sectoral Aggregated Assessment /Baseline Approach	IFPRI; World Bank: EACC	No cross-sectoral comparison or consideration of wider economic effects.	Uncertainty in climate projections but not in impacts or development paths.	Works with a development baseline – thus considering a number of variables that are not directly related to climate change. Reversibility of adaptation measures not included in the analysis although acknowledged. Time horizon 2050, no discounting, non-monetary values not really considered, no linkages between adaptation and mitigation. More emphasis on hard adaptation, but some soft considered, ancillary benefits not considered, focus on public sector, limits of adaptation not considered.
CGE models				Full economy wide impacts are typically assessed using CGE.

(Computable General Equilibrium)				This type of modelling could be used to complement more bottom up cost assessment approaches.
Integrated Assessment Models IAMs use an economic framework to study adaptation options including costs, benefits and residual damages – IAMs provide a wide range of outputs – provide direct information on the costs and benefits of adaptation and influence various choices and assumptions.		No cross sectoral comparison – consideration of economy wide impacts varies with models.		Some models use uncertainty – Monte Carlo analysis in PAGE provides uncertainty across parameters and results (including economic parameters and forecasted impacts). Standard use of SRES baselines. Issue of reversibility not generally considered. Time horizon to 2100 or 2200 – discount rate user defined. Some analysis provides uncertainty ranges – linkages between adaptation and mitigation highly aggregated, some built specifically around CGE models, mostly hard adaptation, ancillary benefits not considered, focus on public adaptation, functions place highly theoretical limits on adaptation. IAM does not consider the non-linear nature of weather events – and the uncertainty associated with forecasting climate change generally. No consideration of uncertainty or risk.

BOTTOM UP APPROACHES				
Cost Assessment Approach	**Standard Application**	**Sector specific vs. multi-sectoral**	**Range of Uncertainty**	**Scope of Economic Valuation**
Risk assessment approach	Swiss Re			Does not consider broader social and environmental costs of impacts.
Cost benefit analysis	RECCS REVIEW (Stern approach); Wetlands International; TEEB; UKCIPS	More flexible application: can define parameters and project boundary	Able to account for a greater uncertainty range	Difficult due to challenge of valuating non-monetary values; overall data intensity; used to help determine avoided cost, and cases where financial compensation (the calculation of benefits) could be required. For CBA – all values need to be expressed in money terms.
Cost effectiveness analysis	UKCIPS	More flexible application: can define parameters and project boundary	Able to account for uncertainty	Compares the costs of alternative options with different economic outputs; Less data intensive May be more appropriate in cases where you are able to determine the risk profile. Cost effectiveness considered in relation to risk tolerated, and cost per unit of impact removed. CEA determine the cheapest option – this will be a reality particularly in developing countries. How, despite adaptation, can we continue to supply certain services at the cheapest cost? Allows for comparison of non-monetary values CEA can be undertaken without valuing all impacts, but provides less accuracy. Identifies least cost options better – applicable at all levels

				of government.

BOTTOM UP APPROACHES				
Cost Assessment Approach	**Standard Application**	**Sector specific vs. multi-sectoral**	**Range of Uncertainty**	**Scope of Economic Valuation**
Multi-criteria analysis		More flexible application: can define parameters and project boundary	Able to account for uncertainty	Allows you to consider all values. MCA can consider all values – ranks all options and gives them relative values. MCA – economic valuation is not the only issue to consider. Need to look at flexibility, avoiding irreversibility of implemented measures, equity, risk and uncertainty, political sensitivity. The challenge of undertaking CBA has lead to MCA – which allows decision makers to consider all impacts – not just those requiring economic valuation. CBA can still be used within this type of analytical framework.

Referring to the evaluation criteria taken from the literature, the comparison of all cost assessment approaches reveals that bottom up methodologies are able to integrate a greater number of data parameters. Given the flexibility of bottom up approaches, they allow the user to consider the following issues:

- Uncertainty
- Allows for consideration of non-monetary values (multi-criteria analysis)
- Would provide the user with greater flexibility in terms of extrapolating cost on the basis of the project lifetime of a measure, the applicable discount rate, and in terms of consideration the limits of adaptation.

What the literature also indicates more generally speaking is that methodologies have been applied to the quantification of adaptation costs for a range of different economic sectors, and for different types of geomorphology.

5.5.1 Standardizing adaptation cost methodologies: data needs and associated level of government

The fact that there are so many potential approaches to determining the cost of adaptation, only serves to emphasize the complexity of standardizing a methodology to calculate the cost of adaptation given that the variables under consideration change depending on the context in question. While the application of methodologies differs in the context of economic or geographic realities, the literature also indicates that some methodologies are

more appropriately applied in relation to different levels of government. Lower levels of government will be able to determine more accurate cost estimates by applying more bottom up approaches.[32] As stated in the introduction to the literature review, a proposed methodology should be flexible. As such, our presentation of a methodology in chapter 7, consists more of a series of steps to be considered as part of any assessment, and places less emphasis on the application of a rigid cost function.

Furthermore, the uncertainty of the future impacts of climate change makes it difficult to establish a deterministic relationship between investment in the implementation adaptation measures and their ability to cope with future impacts. While it may be possible to undertake this analysis in relation to specific project sites, where detailed information on the resilience of adaptation measures is available, comparing the cost of adaptation measures at the national level for broader policy purposes may be complicated by competing political priorities.[33] Cost curves could only be used in instances where governments were to assess potential measures designated for large risks associated with known project boundaries. From a time horizon perspective however, cost curves could serve a useful purpose in terms of illustrating the dynamics of change.

In order for methodologies to become standardized, and easily replicated to a number of different situations, the scientific community and policy makers will need to determine whether it is possible to derive default values and acceptable uncertainty thresholds for climate scenarios as part of calculations. This has been done for the calculation of greenhouse gas inventories by the Intergovernmental Panel on Climate Change. A number of methodologies applied to projects in the developing world have come up with default values for adaptive capacity and resilience to climate change: perhaps this kind of index could be applied to the calculation of adaptation cost in the EU.[34] There is perhaps also scope to establish a particular reference scenario that could be consistently applied as part of any official estimates of adaptation cost.

In addition to the uncertainty surrounding climate events, there is uncertainty associated with the aggregation of costs over different locations, and the uncertainty associated with the coverage of all direct and indirect costs. The issue of adaptation coverage will be particularly important for EU decision makers given the trans-boundary nature of impacts, and the need to consider how adaptation measures may benefit a number both a range of different economic sectors and geographic locations.

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32. The OECD report from 2009 report indicates that IAM for example, is "weak in the context of decentralized decision making", OECD, 2009, p. 12.

33. Typically, cost curves for mitigation will be placed in comparative perspective. Policy makers at the national level may choose a portfolio of measures that balance the cost effectiveness of mitigation against their national circumstances. Given that adaptation measures have a more immediate purpose in terms of preserving the livelihood of communities it will be difficult at a political level to fund one type of measure over another. Funding will need to be allocated relative to local vulnerability and will need to be compared against measures that could be implemented by the private sector. This reality will have implications for the proposed methodology and data collection efforts.

34. The UNDP has established an index known as the Vulnerability Reduction Assessment made up of a number of indicators to determine the adaptive capacity of projects/local stakeholders to implement adaptation measures. This index is used to help allocate funding to communities that receive adaptation funding through the Small Grants Programme of the Global Environmental Facility. See:
http://www.undp-adaptation.org/projects/websites/index.php?option=com_content&task=view&id=204

The majority of the literature reviewed places tremendous emphasis on the investment needed to enhance the resilience in developing countries; given the level of economic development in the developing world, it is much easier to justify investment in infrastructure given that it addresses a number of standard economic development issues that are not typically related to adaptation. Determining the additionality of spending for adaptation measures in the European Union, may represent a significantly smaller percentage of cost attributable to adaptation alone, given that the level of adaptive capacity in the EU will be higher even as part of a business as usual scenario. As such, there could be less potential to implement no regrets measures although this could differ significantly by sector or measure.

6. Determining the scope of cost-benefit assessment: a proposal to define the cost assessment boundary

Summary of findings

Based on an overview of the applicable cost assessment methodologies completed in Chapter 5, this chapter provides a more thorough analysis of the key elements of bottom up adaptation cost methodologies. It serves to define the necessary steps required as part of a potential methodology, which is outlined in greater detail in Chapter 7.

As surmised as a result of the comparison of the different cost approaches, the more disaggregated bottom up approaches to cost assessment allow the end user to integrate more data parameters. For this reason, the decision maker undertaking the cost assessment will need to be careful in selecting the appropriate cost data that is applicable to the implemented measure. This is particularly crucial for decision makers at the local level (in regional or municipal governments), or for project developers in the private sector, given that they typically contend with a greater number of economic interests. The implementation of measures at the local level will involve the consideration of a greater number of direct costs in terms of quantifying the impacts of adaptation on local communities and the avoided cost of impacts associated with the actual implementation of the measure itself. The nature of the costs as they relate to the level of government responsible for the implementation of measures will play an important role in terms of defining both the methodology and the data necessary to undertake calculations.

Delineating the scope of applicable costs and data parameters is tantamount to determining a project boundary. Although for the purposes of this report we have chosen to use the term "cost assessment boundary." (Project boundary is used to illustrate the physical boundaries that the cost assessment encompasses.) Section 6.1 provides an overview of the key elements of the cost assessment, while section 6.2 outlines types of costs that should be considered in calculating the cost of implementing a specific measure. In short, the authors of this report argue that defining a cost assessment is based on the following considerations: it is a function of the actual measure in question, the applicable level of government, the tolerated level of data uncertainty on the part of the stakeholder or decision maker (less data will typically result in greater uncertainty), and the extent to which decision makers need to consider different economic factors. Given the fact that cost assessment is largely contextual, defining a cost assessment boundary will be a function of overall policy considerations.

6.1 Determining the cost assessment boundary

6.1.1 Introduction to the guiding principles

The need to determine the cost assessment boundary coincides with one of the objectives for this project. As stated on page 9 of this report, this report should accomplish the following: "That the link to cost estimates for specific projects be elaborated on. System boundaries for measurements are currently different (scale, time, local effects) and therefore not comparable." The inability to compare adaptation cost estimates is a reflection of the different types of costs to be considered as part of the implementation of measures, and the notion that they vary considerably in different contexts. This chapter provides an overview of the different types of costs that could be relevant to the implementation of different types of measures.

Obtaining data on adaptation cost involves will relate to two distinct elements of the adaptation cost equation: one element relates to the cost of the actual measure, and the other to the impacts of climate change that the measure seeks to address. This is summed up in the following definition of an adaptation cost methodology:

> The primary objective of the costing methodology is to provide guidance on how outcomes, corresponding to a particular combination of a specific option (adaptation response) and a specific state-of-nature (climate change impact scenario), can be described in monetary terms. (UKCIP, Overview of Guidelines, p. 11)

Simply put, adaption costing involves determining the cost of an actual measure relative to the impacts in question. However, additional information is required to clearly define all of the key variables of the cost equation. This involves characterization of the "adaptation response" or measure, and determining the "state of nature" in the context of a given time series. Assessing the cost of adaptation for of a specific policy/measure, would involve consideration of the following four components: project boundary, scope of impacts, affected assets, and adaptive capacity. Defining the scope of these four elements, will need to be undertaken by the decision maker in order to establish the necessary data requirements. The implementation of policy measures for example, will require more general data in relation to higher level indirect costs.

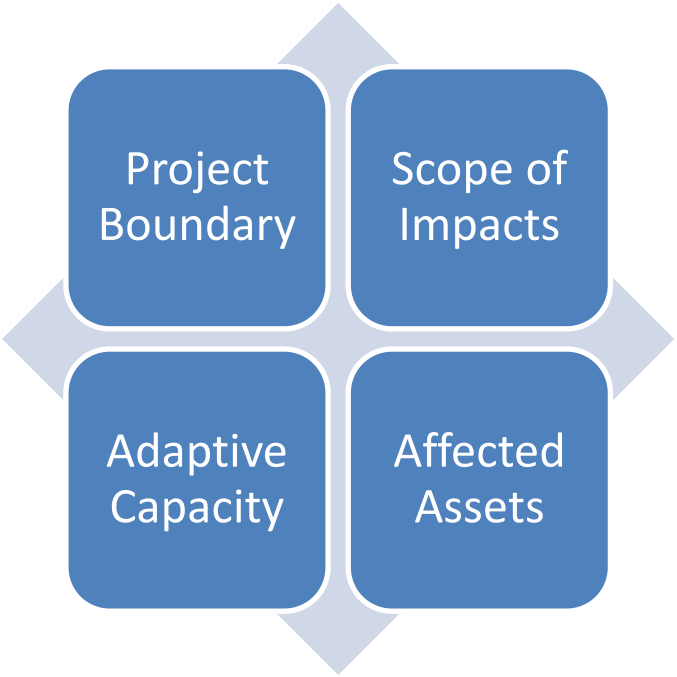
The issue of costs as they relate to the implementation of adaptation measures can be positive or negative. In this way, one cannot ignore the possibility that the implementation of measures may have a number of negative costs or **benefits**. As argued in section 6.2, benefits are often measured in relation to "non-use values". Although a net economic benefit can typically be measured in terms of net consumer and producer surplus (UKCIP, Implementation Guidelines, p. 6-20), benefits in an adaptation context are difficult to quantify and are more likely to be associated with overall improvements to societal welfare or to the natural environment. Other sources indicate that adaptation benefits can also be described as "the value of climate change damages avoided by adaptation." (UNEP, 1998, p. 103.)

6.1.2 Overall components of a cost assessment boundary

In scoping out the relevant components of a cost assessment boundary, and as illustrated below, one would need to consider the costs as they relate to the actual physical limits and jurisdiction related to the project or the "project boundary", the range of impacts affecting the delineated area, the assets affected by the impacts, and the ability of stakeholders to cope with the implementation of adaptation responses or "adaptive capacity". Determining the boundary in this way will help determine the type of data that will be required. Data needs must be defined prior to undertaking a cost assessment or valuation exercise. In some cases, there may be enough existing data to substantiate the valuation of costs and or benefits making the completion of primary valuation unnecessary.

If you consider these four components, the associated costs and data needs may vary considerably. While determining the physical limits of a cost assessment will help determine the scale of data required, determining the scope of impacts within that region will serve to identify assets that may be affected by climate change. In considering the implementation of a specific measure to respond to impacts in a particular region, there may be specific costs associated with the ability of a given stakeholder to undertake identified responses. One would need to consider the degree of adaptive capacity in relation to implementation costs.

The matrix below illustrates the interaction of these four key components of a cost assessment.



Project Boundary: In undertaking the assessment of costs of measures in different decision-making contexts, the boundary of the project as it applies to the implementation of different measures will need to consider the range of stakeholders and resources to be impacted by

climate change. Referring to the work of Willows and Connell (2003), this will involve looking at the impact of climate change on various exposure units. In essence, the decision maker should consider the following key questions: What is the scope of receptors to be considered as part of the cost assessment? What is the number of individual exposure units to be considered?[35]

Determining how impacts affect different economic agents will be a crucial element in determining a project boundary. For example, to what extent will drought in a rural area affect local stakeholders? A decision maker may need to consider the impacts not just on farmers, but on those selling and distributing produce. It will be up to the user in question to determine to what extent it should consider the economic repercussions of impacts beyond the scope of a defined project boundary. In cases where decision makers are held accountable by a greater number of stakeholders, they may chose to extend the project boundary to include a greater number of indirect costs.

Determining the scope of applicable costs is a function of the measure in question, the extent of climate impacts, but also of the stakeholder in question. Project boundary may therefore largely be a question of the applicable level of government. According to OECD statistical reporting requirements, national governments allocate resources to a on a number of defined economic sectors and spending categories, including: general public services (infrastructure); defence; public order and safety; economic affairs; environmental protection; housing and community amenities; health; recreation, culture and religion; education and social protection.[36] The range of costs that are more directly relevant to national governments will be connected to policies in these thematic areas, and to the impacts associated with them.

There are a number of examples that can be used to illustrate the complexity of direct vs. indirect costs. If one considers research completed to determine the cost of sea level rise, the direct costs of coastal protection have been quantified in parallel with the more indirect costs associated with the loss of wetlands associated with sea level rise. While this type of risk may not be an inherent reality for all impacts, those undertaking cost assessments will need to consider how to determine project boundaries, and what assets to include as part of a given project. (Darwin F., Roy; Tol, Richard S.; 2001) (Bosello et al, 2007). This is also an integral component of undertaking a vulnerability assessment that is outlined as part of the proposed cost methodology in Chapter 7, with the wetlands being subject to "second order impacts."

Scope of Impacts: Having defined the project boundary, the decision maker undertaking the cost assessment would need to consider the total number of exposure units to be affected, and the degree to which they may be impacted by climate change. Depending on the budgetary timeframe for the measure being assessed, there may be a number of issues related to the projection of costs.

Affected Assets: The degree to which one would need data on relevant assets will depend on the way in which one chooses to value the cost of impacts, and on the overall project boundary. More detail may be required in cases where more local decisions are being made

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35. For a definition of exposure unit, refer to Chapter 2.

36. http://stats.oecd.org/Index.aspx?DataSetCode=SNA_TABLE11)

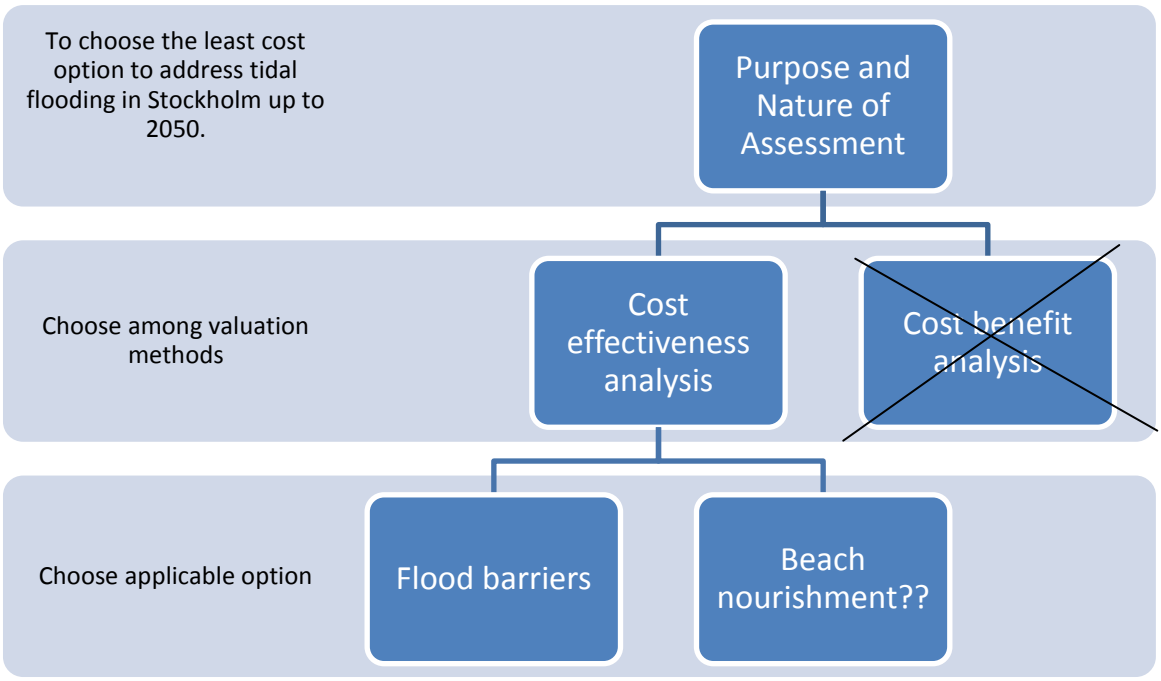
in terms of valuing benefits, and avoided cost. This would require obtaining data in relation to:

- resource prices;
- willingness to pay for goods or services;
- applicable discount rates;
- trade-offs between economic agents. To be assessed using Computable Generalized Equilibrium techniques.

Adaptive Capacity: As outlined in section 6.2, there are a number of hidden costs associated with the implementation of measures. This includes determining how adaptive capacity could increase the cost of implemented measures. This primarily involves a qualitative assessment of institutional capacity, and the experience of an administration in implementing a specific adaptation measure. As outlined in Chapter 2, p. 31, adaptive capacity is "the ability of a (human) system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences." The resilience of measures to impacts over time would not only be a function of the actual measure, but of the ability of local administrations to cope with extreme weather events, apply the required emergency response, or implement planned measures cost effectively. Lack of impacts data, of the appropriate emergency responses scheme or of an overall adaptation strategy are all indicators that could be used to assess adaptive capacity.

6.1.3 Determining the purpose of a cost assessment: importance of policy context

Apart from determining a project boundary, the user defining the scope of the overall assessment will need to determine its purpose. In some cases, decision makers may be looking at the most cost effective way in which to implement measures; it is this overall objective that could define the limits of a cost assessment boundary Looking at the list of costs outlined in section 6.2, if an authority decided that only one alternative was plausible in terms of addressing the impacts of climate change, it might not be necessary to determine opportunity cost. The Swedish Environmental Protection Agency for example, has undertaken cost assessments to ensure that funding decisions are made to meet overarching environmental goals in the most cost effective manner (SEPA, 2000, Report 2000:7). This would typically involve economic valuation of all variables affecting the cost of a specific measure. One could apply the following type of decision tree in determining the type of measure that could be applied:



Cost effectiveness analysis is typically undertaken on the basis of comparative Net Present Value (NPV) assessment. The Net Present Value of a range of measures could be compared to determine which option has the highest NPV or where the NPV is at least positive at the chosen discount rate. This approach coincides with projects that incur a "replacement" or "restoration cost." Replacement cost applies to projects that have a "one-time expenditure", with few maintenance costs, and are applied in cases where the impacts of climate change have been observed. (In cases where the local population is familiar with the benefit of implementing a particular measure, the less tangible benefits may not need to be factored in to the equation.) Referring to this example, building a flood barrier would in fact involve an initial up front capital outlay unlike beach nourishment, which would require ongoing maintenance.

As indicated above, the selection of the corresponding valuation method will depend largely on the objective of the cost assessment. Undertaking cost effectiveness analysis is much simpler in cases where valuating non-monetary variables is not required. However, in cases where it is necessary to attribute costs and benefits to society as a whole, particularly in terms of potential compensation, it is more appropriate to undertake standard cost benefit analysis. In cases where cost benefit analysis of non-market values is being undertaken, there are a number of analytical techniques that could be considered in order to improve the overall accuracy of the results. These are outlined in greater detail in Chapter 7.

The examples provided in Annex 5 illustrate how NPV analysis may have limited applicability in calculating adaptation cost. Adaptation measures are not implemented in order to generate profit; they are implemented in order to prevent damages. While it could be used in cases where policy makers are primarily concerned with cost effectiveness, it will have limited applications as an analytical tool in terms of assessing the co-benefits of measures that improve overall societal well-being. (See below for the definition of social cost.)

6.2 Types of costs related to adaptation and applicable terminology

There are a number of different costs that can be associated with the implementation of adaptation measures. They are described in order of decreasing importance.

Cost # 1

Economic cost and opportunity cost: The term economic cost will refers to the allocation of scarce resources in producing a given good. The term opportunity cost however, refers to the good or service that could have been produced or financed by that same amount of resources. Some sources indicate that it is "the key concept" to be considered in evaluating adaptation options. (UNEP, 1998, p. 25) In a decision making context, policy makers would need to consider what the opportunity cost of implementing a measure might be in comparison with other potential options. As such, one would need to consider a range of different adaptation options based on a significant amount of scenario analysis involving different baselines and projection of impacts. In cases where adaptation is competing with other important policy priorities, justifying adaptation expenditure may require justification in the context of constrained financial resources.

Once the opportunity cost of a particular option has been quantified, a decision maker needs to consider the total costs to society. This is based on the following equation:

Social Cost = External Cost + Private Cost

Cost #2

Social Cost: As indicated by the work of the UKCIP program "the theoretically precise measures of the costs of climate change, therefore, is the total value that society places on the goods and services foregone as a result of the diversion of resources from alternative uses. A cost assessment should ideally consider all value, or welfare, changes in resources demanded and supplied by a given adaptation option or climate change impact." (UKCIP, Implementation Report, p. 6-3). This statement emphasizes the importance of both opportunity cost, and social cost. In terms of social cost, decision makers cannot ignore the welfare implications of adaptation measures in terms of safeguarding human life and the physical environment. This emphasizes the importance of benefits to society; some of which may not be as easily quantified.

Work undertaken by UNEP also indicates that, "the purpose of the cost assessment is therefore to translate the effects of climate change into comparable quantitative units that reflect the impacts on society's welfare." (UNEP, 1998, p. 14). The notion of social justice is further reinforced by the description of cost in the context of the Stern Review. (Stern, p. 41) The language used in this report describes cost from a welfare perspective, reflected in part by Stern's assumed discount rate of 0.1. Stern places more importance on the welfare losses to future generations and less on shorter term economic losses.

As outlined in the calculation above, total social cost is based on total private costs, and total external costs. The type of data associated with private costs is essentially based on standard market data; referring to the cost of land, materials, labour and equipment. (UKCIP, Implementation Guidelines, p. 6-3). Data relevant to private costs, are referred to as "use values" in the literature on adaptation cost.

Cost #3

Private Costs: The standard definition of private cost in an IPCC context is defined as "Categories of costs influencing an individual's decision making". (IPCC definitions glossary, p. 382). These decisions are reflected through a willingness to pay, in relation to goods bought and sold on the market. If one considers the resources used in relation to the implementation of a measure, they can be quantified on the basis of a change in productivity. For agriculture for example, one would need to look at how climate change impacts the productivity of land. The subsequent damage to crops can be reflected in the corresponding prices of produce. Thus the productivity approach is really more of an issue for sectors like agriculture which have an economic output. In this way, a decision maker would be able to surmise the "minimum estimate of the impact cost" to determine what preventative measures could minimize lost productivity. This approach would rely more on observed economic behaviour.

The second way to assess the change to the value of assets is to simply look at the difference between inflows and outflows of capital on an annual basis in relation to the budget in question.

In addition to considering costs related to the market, any cost assessment will need to consider costs that fall outside the scope of the project or the decision making/project development process. Typically these are "external costs" that are not connected to the marketed and can be described as "non-use values". External costs can also be described as "indirect costs." Referring to the sea level rise and wetlands example, the costs associated with flooded wetlands from sea level rise fall could fall outside the scope of the project. This will depend to a large extent on how the cost assessment boundary is defined.

Cost #4

External Cost: "The term external cost is used to define the costs arising from any human activity that is not accounted for by the agent causing the externality." (UNEP, 1998, p. 20). As most economists contend, it is difficult to account for these costs as part of standard market transactions for two reasons: either because they fall outside the jurisdiction of the decision maker, or because they are not directly connected to the market. These costs can also be referred to as "non-market" values and can be quantified on the basis of certain economic valuation approaches. **Non-marketed and non-use values** can also be used to quantify the benefits of adaptation and can be accomplished through the use of surrogate market techniques and contingent valuation. This typically involves hedonic pricing analysis, hedonic wage risk analysis and the use of travel costs to quantify the value of resources that are not directly connected to the economy. Hedonic pricing typically involves determining a willingness to pay or a willingness to accept on the part of local stakeholders; in this case it would be those that would be affected by climate change and could benefit from the implementation of specific adaptation measures particularly those with biodiversity dividends.

Determining the costs of adaptation measures typically involves consideration of a number of other associated costs. These include: financial costs, project costs, and implementation costs. Financial costs are essentially costs that are recoverable through a revenue stream associated with private costs. From a purely financial point of view, the implementation of some measures could accrue costs that are not recoverable. In comparing the implementation of various measures, it is really this last overall category of costs that could influence the decision-making process.

Cost #5

Project Related Costs: This category of costs comprises a number of different project related costs; those that would largely be associated with different measures. Some projects have large up front **investment costs**, while others incur a greater amount of **recurring (operations and maintenance) costs**. A sea wall for example is likely to incur a greater up front investment cost, while drought resistance crops will require more ongoing maintenance. It is these types of costs that may cause the overall financial cost to be greater than private costs; however this will also depend on the severity of impacts.

As far as the mandate of the European Commission is concerned, it could have the greatest impact with respect to offsetting costs associated with the last cost category; **implementation costs**. Addressing implementation costs could help facilitate the implementation of adaptation measures more generally speaking.

Cost #6

Implementation Cost: Implementation costs are associated with the ability of governments and project developers to undertake measures and to finance them. Implementation costs could be associated with a specific project, or they could relate to the cost of adaptation more generally speaking. The EU for example, could determine that there is an implementation cost associated with raising awareness on adaptation in order to encourage member states to develop and implement national adaptation strategies. At the project level, implementation costs could be more precisely defined in relation to barriers delaying project implementation at the local level. Improving local capacity to implement projects can be described as a "barrier removal cost". (UKCIP, Implementation Guidelines, 6-8)

6.3 Uncertainty: a proposal to standardize tolerable thresholds

The issue of data availability and data quality will have implications for the inherent uncertainties of calculations. As a general rule, decision makers working at a higher level of government may work with more default values, and with smaller data sets. Quantifying cost at a higher level of government could tolerate an accepted level of uncertainty, given that it is not directly liable for the measures in question. Some of the more general costs and benefits could be ranked based on a qualitative assessment, but less quantification could be involved. (Although this would depend largely on the measure itself, and whether or not it is a planned or reactive measure.)[37]

Borrowing from the risk analysis of the UKCIP program, calculations made in relation to higher level policy measures could be undertaken based on an uncertainty threshold known as "Tier 1". A Tier 2 categorization would involve less quantification of actual costs and benefits, while simply assigning upper and lower bounds on the risks inherent in cost calculations. A tier 3 categorization would tolerate the least amount of uncertainty, where the majority of both use and non-use values are converted into monetary terms. (HMT Green Book, 2003.) A Tier 3 calculation would be undertaken primarily by local authorities and project developers in the private sector, who would require more regional specific data to reduce their exposure to financial loss and liability. Generally speaking, the more disaggregated bottom up approaches to calculating adaptation cost integrate more data affecting finance and project performance, while the more aggregated, less data intensive approaches are more concerned with the overall costs to the economy.

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37. Indeed, in cases where the EU for example may be dealing with short term decision making requirements, particularly in terms of supplying emergency assistance, it will not have the luxury of considering cost assessment approaches that are more data intensive.

Referring to the literature review undertaken in Chapter 5 (see. p. 61) , a report completed by the UNFCCC in December of 2009 underlined the notion that cost estimates taken using more aggregated approaches (as would typically be the case for policy makers) are inherently uncertain. Less uncertainty is associated with calculations made for measures implemented by local authorities given that disaggregated approaches are more data intensive, although there may often be a lack of data. One could infer, particularly from the literature reviewed for this project, that more aggregated approaches while being uncertain, also result in lower cost estimates. (See Chapter 5, p. 61.)

Given that estimating adaptation is largely a function of context, it is not possible to state that more aggregated costing methodologies categorically result in lower estimates. The actual cost will depend on what is being assessed, the measure under consideration, and the impacts to which they respond. For the purposes of a proposed uncertainty threshold however, it would be accurate to say that in response to more general policy measures typically implemented by the EU government, or even national governments, where aggregated costing methodologies may be more applicable, that a higher uncertainty threshold may be more easily tolerated.

6.4 Adaptation cost methodology: a step-wise approach

The cost assessment methodology proposed in Chapter 7 is based on the completion of seven steps; the most fundamental step comprising the initial project scoping and delineation of the cost assessment boundary as outlined in this chapter. These steps are based on information obtained as a result of the literature review, and as a result of consultation with various stakeholders throughout Europe. They are outlined as follows:

STEP 1: Defining cost assessment boundaries and baselines

STEP 2: Identifying climate change risks and vulnerabilities

STEP 3: Identifying adaptation measures applicable to identified risks

STEP 4: Selecting the applicable valuation approach

STEP 5: Identifying and collecting data needed for evaluation

STEP 6: Estimating costs and benefits of adaptation actions

STEP 7: Prioritising adaption measures and selecting the appropriate level of governance for implementation

As is stated repeatedly throughout this report, it will be challenging to standardize an approach to calculating the cost of adaptation; calculating cost will vary based on the policy context, the impacts under consideration, and the measure being considered for implementation. This complexity is illustrated in Chapter 7, in outlining how different valuation approaches could apply to different measures.

6.5 Conclusions

This chapter provides an overview of some the key issues to consider in undertaking an assessment of adaptation cost, and the need to scope out the assessment boundaries. It emphasizes both the importance of the overall assessment objective, and the need to consider data uncertainties in undertaking assessments. The discussion of data uncertainty illustrated the importance of determining uncertainty thresholds in relation to varying levels of data aggregation. Decision makers at the EU level may need to formalize the determination of precise thresholds, in relation to potential "Tiers", as part of the legislative process perhaps in the form of official guidance. The uncertainties discussion also indicated the importance of improving data availability in relation to climate change impacts at the local level.

The issue of scoping out a cost assessment boundary could consider some of the techniques applied in undertaking an environmental impact assessment (EIA), on a case by case basis or by setting thresholds for standard project parameters. Article 5 of the EIA Directive (85/337/EC), provides the basis for issues to be covered as part of an EIA, and as such forms the basis of EIA project scoping. Further detail on these issues is provided in Annex IV of the Directive. The Directive also indicates how Member States are able to determine the degree of relevant issues to consider. While the issues under consideration are different to those relevant to an applied adaptation cost assessment, harmonizing an approach to cost calculations could be encouraged through the development of legislated guidelines. (Note that unlike EIA legislation, these guidelines may or may not be part of a legislated requirement.)

Typically, system boundaries are an important consideration in the statistical field. However, as stated in Chapter 1 of this report, defining a system boundary in relation to costs, is used purely to define the limits and parameters of a cost calculation. Given the standard statistical principles, the results of cost calculations would be too variable and thus not likely to be collected as part of standard statistical data gathering.

7. A proposal for the assessment of measures and adaptation cost

Summary of findings

It is hard to assess the cost of a measure without looking at the bigger picture. The bigger picture in relation to adaptation cost and the implementation of measures, involves consideration of the different elements of the project cycle. The scope of indirect and direct costs (as outlined in Chapter 6) is largely a function of the stakeholders involved, and the resources needed; for this reason, determining the range of costs that will need to be quantified is at the discretion of the decision maker or project developer. If one considers the OECD definition of adaptation, it is the intention to implement adaptation measures that separates it from business as usual practices associated with day to day resource management. (See p. 23 in Chapter 2) As outlined in Chapter 6, the objective of cost assessment, and the *intention* to address adaptation, not only establishes the boundary of a project but helps to determine whether implemented measures are additional.

Determining the actual cost of measures cannot be separated from either the policy environment or from the physical environment. The costs associated with implementation of the measure are evaluated in relation to actual impacts. Although it will be necessary to obtain as much information on the cost of equipment and general maintenance of applied measures, the formulas presented herein illustrate the fact that decision makers cannot calculate cost without first considering detailed analysis of the state of the environment. We should however, emphasize the fact that the key objective of this project was to calculate the cost of adaptation in relation to measures, and not the cost of climate change. We focus less on the need to determine total damage costs, focussing more on the applicable resource costs.

The approach proposed emphasizes the importance of applying a bottom-up economic valuation approach. The actual cost assessment is preceded by an ex-ante evaluation as described in chapter 6, or "project scoping". This emphasizes the importance of determining project boundaries, and that the scope and overall data needs are defined before embarking on an assessment of measures and the associated adaptation cost estimate. The approach consists of seven steps. The steps are meant to be broadly applied in a range of different contexts, and may require adjustment based on the individual or entity undertaking the assessment. In this project the five-step procedure is to be applied by three different levels of government: EU/National/Local.

The authors anticipate that the seven-step approach will need to be adjusted and improved upon. The ideas and steps outlined herein merely constitute a proposal that could contribute to future discussions in relation to the determination of adaptation cost. In short, the steps proposed are based on the key elements of adaptation as outlined in the IPCC definition outlined in Chapter 2; that adaptation is defined as "adjustment in natural or human systems in response to **actual or expected climate stimuli or their effects**, which moderates harm or exploits beneficial opportunities associated with climate change." (IPCC TAR/AR4 (2001/2007)). This definition underlines the need to consider measures that

apply to actual impacts which we have considered as part of a vulnerability assessment in the second step of the proposed methodology. The IPCC definition also suggests that cost would need to be determined on the basis of the order of effects: the first focus of the measurement should be activities that respond to actual or expected climate stimuli. The second focus of the measurement should be activities that respond to the secondary effects of actual climate change stimuli. (See p.23 of Chapter 2).

7.1 STEP 1: Defining cost assessment boundaries and baselines

Assessment boundaries can be used to define the limits of projects, programmes or policies implemented at different levels of government or by project developers in the private sector. The boundaries will depend on the objectives of the assessment and other factors as outlined in Chapter 6. It would involve defining a geographical boundary in terms of a total area, and determining which particular sector(s), or a particular activity within a sector or sectors, are to be targeted for evaluation.

Defining a cost assessment boundary is also a question of who **bears** the cost. Given this reality, some levels of government will be more directly involved in the determination of costs than others given their mandates. This will also be a function of how governments allocate funding to adaptation, and their authority to pay for certain types of activities based on budgetary practises. At the EU level, roughly 76% of total spending (see Chapter 8) is undertaken through the Common Agricultural Policy and Cohesion Policy. Although the Commission will not be directly involved in the implementation of specific measures, it will need to have a sound understanding of the costs faced by lower levels of government (in regions throughout Europe) in implementing projects in order to accurately allocate funding to different programs. The majority of costs will be more directly borne by national governments, the private sector, and local government. Typically EU funding allocated through various funds is intended to add value to existing funding programmes undertaken by national governments and the private sector.

At the same time, the adaptation challenge under consideration may involve drawing a boundary that includes a greater range of impacts, thus necessitating a range of different responses. In instances where governments may need to respond to a range of impacts based on a list of different measures, it will be necessary to prioritize them. Having drawn a cost assessment boundary, the end-user would need to establish a baseline scenario in order to separate climate change impacts and adaptation actions from background risks and business as usual activities typically undertaken to avoid those risks. This should be based on an evaluation of the current situation considering a defined sample of historical risks, and the corresponding actions taken to address risks that are not associated with climate change.

Despite some of the challenges to undertaking cost projection exercises, determining a baseline as part of a business as usual scenario is crucial in order to determine the incremental cost of climate change, and what additional funds may be required to meet that cost. In the public sector the key challenge will be to determine the justification for public intervention and hence what additional cost can be attributed to adaptation. The key obstacle to determining additionality (as discussed in other sections of this report) is based on the fact that there is no established baseline for existing climate stability and the

associated cost. Determining cost now, at a specific temperature, will set a precedent in terms of establishing a trend in the change of cost relative to temperature over time. The impacts corresponding to cost at specific temperatures will need to be determined based on an established correlation.

Apart from determining the physical boundaries of a cost assessment problem, decision makers will also need to define the temporal boundaries of a cost assessment. This will involve determining both the baseline, and projecting costs over time.

The following sub-steps could be used in establishing a baseline:

Sub-step 1 – Establish the Baseline Year and Time Series: What is the initial reference point? What time frame are we using to compare the business as usual scenario against scenarios that reflect potential changes to economic and climatic variables?

Sub-step 2 – Determine the Business as Usual Scenario: Determining a business as usual scenario however, could simply be a scenario where implementation measures are not implemented. Total adaptation cost is determined based on a comparison between a "with" and a "without measures" scenario.

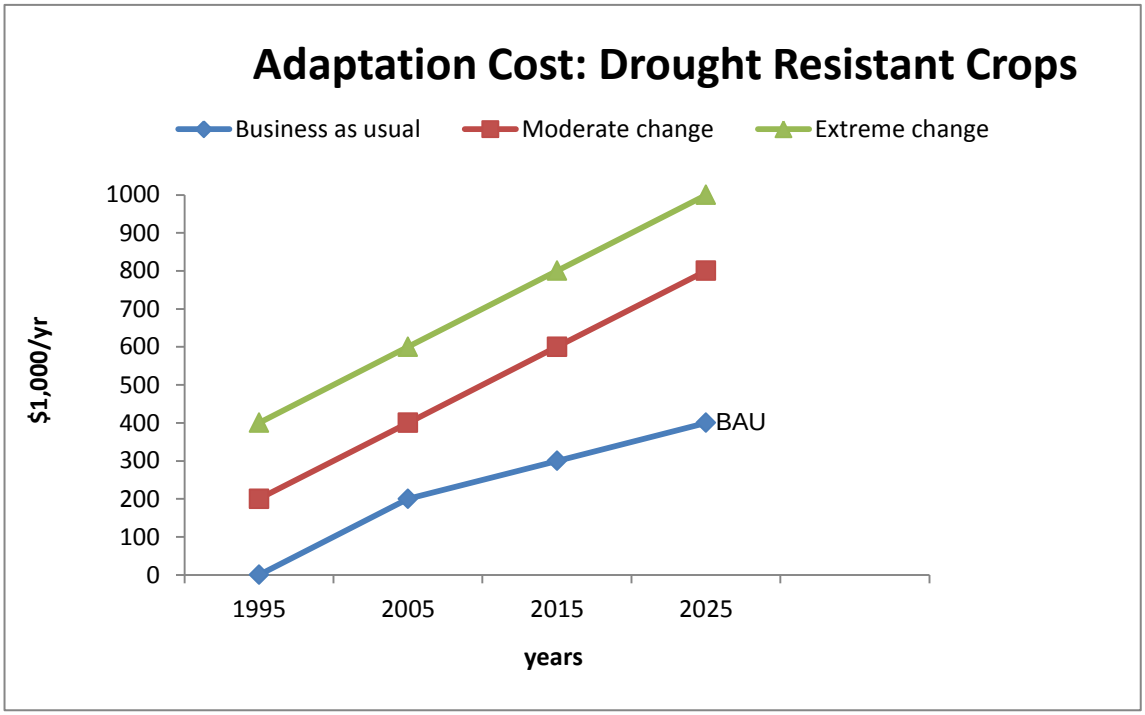
Step 3 - Determining a representative sample size: How much data do we need to get a reliable indication of projected costs? As outlined in Annex 6, projection curves are smoother if more historical data is used.

Step 4 - Plotting temperature change relative to cost increase using different temperature scenarios: It would be possible to compare the business as usual case against the temperature increase scenarios (SRES scenarios) outlined by the IPCC. The IPCC has outlined a number of projected impacts relative to temperature change, referring to different SRES scenarios.[38] (We should be careful not to confuse the need to plot temperature change against cost, with the probability that actual temperatures may increase at a certain pace.) If it is not possible to compare the baseline or business as usual scenario to these scenarios for whatever reason, it will be necessary to compare baseline costs against those for a different scenario associated with a project's lifetime. This will also help define the outer limits of the cost equation.

[38] . See: http://www.ipcc.ch/publications_and_data/ar4/wg2/en/figure-spm-2.html

The example below can be used to illustrate the importance of defining a project's temporal boundary. Assuming the baseline year is 1995, the costs of implementing an adaptation measure in the agricultural sector based on varying temperature change scenarios, could be illustrated as follows:

Figure 5: Example of cost curve for the agriculture sector 1995-2025



The moderate and extreme change scenarios illustrate the increased cost of implementing drought resistant crops over the business as usual scenario. The additional investment required to address the cost of crops would be the difference between the business as usual (BAU) scenario and that of either the year of extreme or moderate climate change. The relevance of baselines and projections are further described as part of step 6 in relation to the calculation of total cost.

The approach described in Step 6 however, uses a comparison between a baseline and an alternate scenario to illustrate the rate of adaptation over time. In essence, in calculating total cost, there is no "business as usual". The need to illustrate a BAU scenario at this stage in the methodology is meant to help illustrate the importance of determining additionality. Calculating total adaptation cost in Step 6, is based on the need to address future cost of adaptation in comparison to a scenario where society is already addressing the impacts of climate change. This has implications particularly in relation to the timing of the measure.

For a more general discussion on the importance of project boundaries and data needs, refer to Chapter 6.

7.2 STEP 2: Identifying climate change risks and vulnerabilities

In allocating funding to adaptation measures, the EU would need to identify which risks posed the greatest threat to the EU's human and economic security. This involves the identification of a huge number of risks with impacts originating from outside the EU's borders. Examples of transboundary impacts attributable to identifiable sources include flooding, forest fires, and species migration. While the risks for threats with trans-boundary impacts could be mitigated through international funding mechanisms, risks found within the EU could also be addressed through the various cohesion funds, the CAP, and LIFE.

There are a number of databases that exist outlining the total cost of damage related to previous extreme weather events (www.cred.be/sites/default/files/ADSR_2009.pdf). These numbers could be applied to EU level estimates while applying a number of applicable correction factors.

The identification of risks throughout Europe would obviously be more general than those identified by national or local governments. Regardless, decision makers and project developers will still need to determine what risks they face based on an assessment of the following (ECA, 2009):

1) What are the hazards facing the area in question? Is the area expected to suffer the impacts of droughts, floods, heat waves, wind or climatic zone shifts?
2) What is the magnitude of those hazards likely to be? Where are they likely to occur, and what sectors of the economy are they likely to affect? This can also be determined by assessing impacts on a range of determined exposure units. (See Chapter 2 for a definition of exposure unit.)
3) How will impacts affect different sectors of the economy?
4) How resilient is the geographic area in question? Does it fall within the jurisdiction of a national or regional government that has experience implementing adaptation measures? Has the corresponding government sought to develop a comprehensive adaptation strategy?

It is possible to assess vulnerability based on an assessment of different economic sectors. Figure 6 illustrates how three different climate change scenarios will result an expected loss of income for a range of sectors up until 2030. Here we make the assumption that more resilient economic sectors would incur fewer economic losses in turn making them less vulnerable.

Here one needs to distinguish between the damage costs associated with climate change and adaptation resource costs. Completing a vulnerability assessment as part of the first step of a proposed cost methodology helps to identify the cost of specific impacts, while the subsequent steps help identify the costs of the resources required to address those impacts. In determining economic loss across different asset classes, one would need to derive the appropriate damage cost function for the area in question. This type of more empirical research is being undertaken as part of the project ClimateCost.[39]

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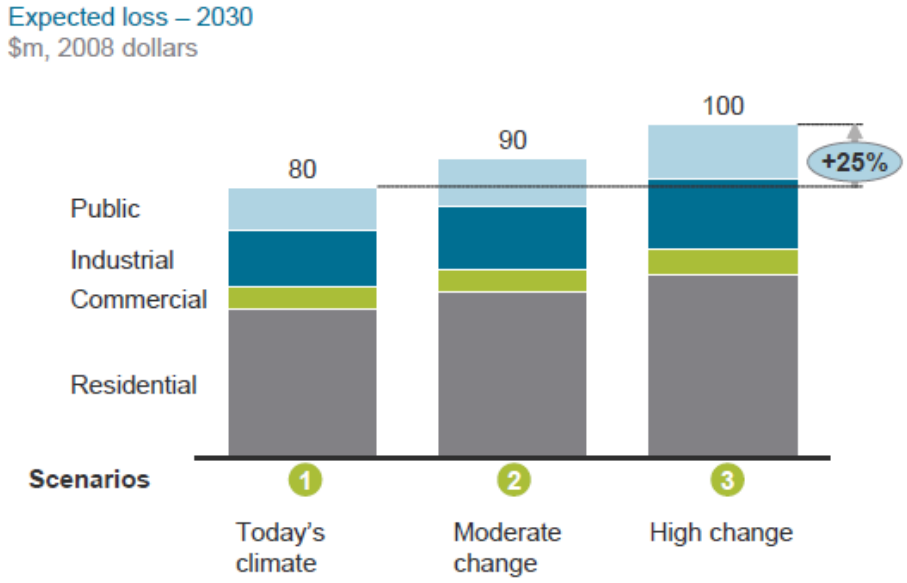
39. For more information on ClimateCost, see: http://www.climatecost.cc/

The methodology proposed in this report, is based largely on the assumption that the application of any given measures will address the damage costs associated with the impacts in question. Any residual damages occurring beyond the baseline year would be addressed through ongoing maintenance and operations cost; thus the total cost of any measure would involve quantifying annual implementation costs throughout the project's lifetime.

Figure 6: Loss across different asset classes for the climate change scenarios – UK test case



Source: ECA 2009

It is hard to provide a standardized approach to the assessment of vulnerability given the variability among different sectors, although we note a few examples:

- In agriculture, it would be possible to determine the vulnerability of soil to climate hazards such as flooding through an assessment of soil conditions under different flooding scenarios. The stability of standard soil properties such as soil productivity and erosion risk would need to be evaluated under different scenarios.
- In the buildings sector, the vulnerability of the building stock would be a function of the hazards it faced relative to the integrity of structures. Information would be required for building materials, building design, building height, and information related to building foundations.
- In the health sector, it would be possible to plot the vulnerability of the local population to certain hazards, based on the standard number of hospital visits, the ability of the sector to respond to health concerns, and the standard mortality rate.

Plotting a standard vulnerability curve involves two steps. The first step requires determining co-efficients that could be used to characterize the extent of vulnerability in the

event of different scenarios.[40] Referring to the agricultural example, one would need to characterize the impacts of certain hazards on soil; a response to flooding for example that would be attributed to different degrees of temperature change. This would involve prior determination of how local soil conditions typically respond to water saturation. In short, you would need to outline the following type of index:

Table 7: Determining the vulnerability of soil in a +2°C by 2050 scenario

Vulnerability co-efficient	State of Soil per Hectare
0: No vulnerability	Standard soil retention properties observed
<=0.2: Low vulnerability	Soil exceeds retention capacity a few times a year
<=0.5: Moderate vulnerability	Soil exceeds retention capacity every few weeks
<=0.8: High vulnerability	Excess water in soil observed on a weekly basis
<= 1: Very High Vulnerability	Soil close to permanent saturation

These values could be plotted against various levels of water saturation in soil for different soil types, based on an independent assessment of how different types of soil respond to flooding under standard weather conditions. Having determined which types of soil are more vulnerable to flooding based on local soil conditions, one could then map vulnerability throughout the area in question. This would be synonymous with determining the total number of receptor units. (See Chapter 2 for a definition.) Referring to the pre-determined vulnerability index, the cost of impacts associated with each vulnerability co-efficient will help determine how the cost of agricultural productivity could increase under different climate change scenarios. Increases in cost associated with the various scenarios would have to consider standard inflation and growth in Gross Domestic Product. This would be as part of a scenario where adaptation measures are not applied.

As outlined in Chapter 6, the project boundary for any given adaptation cost problem needs to be clearly defined. Determining the range of costs applicable to any problem can also be illustrated as part of the soil vulnerability problem. If flooding per hectare of soil is to affect crop yields as part of a first order effect, then one cannot ignore the impact this may have on food prices as part of a second order effect. As such, depending on the person or entity carrying out the cost assessment, one may need to consider to what extent impacts could

[40] . see: http://www.gisdevelopment.net/application/natural_hazards/floods/ma08_145pf.htm)

"leak" in to other areas of the economy. This could be an issue for all levels of government, given the economic importance of the agricultural sector to the local economy, and as part of national and EU trade policies. If one considers the IPCC definition of adaptation, it is the costs associated with the first order effects that would need to be considered prior to the costs associated with the secondary effects.

In practical terms, undertaking vulnerability assessment can be a costly and often futile exercise. This is particularly true for large scale assessments that result in the identification of remote vulnerable areas with few if any direct links to the national or local economy.[41] For larger scale assessments, the cost of undertaking the actual assessment could be minimized by using existing vulnerability maps particularly in terms of assessing first order impacts. Again, the individual or entity undertaking the cost assessment would need to determine the scope of the problem they are solving, and whether it is necessary to consider first and or second order impacts.

7.2.1 Determining the magnitude of risks

Apart from having identified risks in relation to standard physical properties and geographic variability, assessing the magnitude of those risks will involve additional scenario analysis. There are two complexities associated with scenario analysis: while it is possible to assign a probability to certain climate change scenarios, and to make certain assumptions about impacts for economic growth in relation to sectors connected to the market, it is difficult to project adaptation cost without more empirical data relating the actual cost of adaptation to specific temperatures.[42] This will require a more thorough investigation of how cost corresponds to temperature fluctuation over a given time series. Secondly, the IPCC climate change scenarios are based on global mean temperature change. Extrapolating the cost of adaptation will require more local data in relation to weather events and impacts.

Given the uncertainty of climate change, the probability of any climate change scenario is difficult to define, and there are risks associated with the selection of the scenario itself. For analytical purposes, it could be possible to assign probabilities to scenarios on a comparative basis, in order to illustrate the relative probability of climate change impacts and to help define the economic losses associated with them. To define the significance of the climate change impacts, the business as usual scenario (or 0^0 C change scenario) has to be compared against temperature increase scenarios, such as the SRES scenarios outlined by the IPCC. The IPCC has outlined a number of projected impacts relative to temperature change, referring to different SRES scenarios.[43]

Nevertheless, the idea of assigning probabilities to scenarios is merely a proposal; this approach may require further development. The authors of this report are not proposing that an absolute value be considered in relation to one scenario. A range of costs for climate

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[41] . Based on a conversation held with Josef Haider from KfW (German development bank), on November 4, 2010.

[42] . The IPCC has published standard probability functions. See: http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch10s10-5-4-5.html

[43]. See: http://www.ipcc.ch/publications_and_data/ar4/wg2/en/figure-spm-2.html

change impacts would be derived based on a range of different probabilities; this range of costs could be used to help inform the decision making process.

While it is important to consider probabilities in the context of individual cost calculations, they may have limited applicability to higher level decision making. As part of short term budgetary planning in the EU, in relation to the Multiannual Financial Framework (MFF) for example, allocating funding to adaptation measures may be impacted by more current policy considerations. Funding decisions may be made regardless of what the projected impacts. If one considers the longer term policy agenda, the EU may need to look at how the implementation of adaptation measures will correspond to the development of the 2050 roadmap. In the latter case, there would be greater scope to consider a range of costs associated with a range of probabilities, possibly allowing for greater consideration of developments in adaptation technology.

In comparing short term vs. long term funding, the uncertainty associated with longer term impacts in the short term, places more importance on the need to implement no-regrets measures and to avoid mal-adaptation. (Refer to Chapter 2 for definitions of these terms.) The prioritization of measures is discussed in greater detail in Section 7 of this chapter, and the challenges related to the development of probabilities are described in Annex 6.

The application of probabilities to the decision-making process notwithstanding, the notion of assigning probabilities to different cost estimates is based on a premise put forward by Swiss Re where risks are assigned "price tags". Their overall approach to calculating cost is based on an assessment of risk; risk which is assessed based on the probability of different climate change scenarios. If you refer to the calculation outlined below, the terms "expected cost" and risk are used interchangeably in the context of probability analysis to reflect the "actual" or existing cost of climate change, combined with economic growth and future climate change. (ECA, p. 28) We raise this type of analysis at this stage of the overall assessment approach merely in order to help identify the magnitude of risk in relation to the selection of the appropriate measure in step 3.

Referring to risk management approaches applied by the private sector, projecting climate change impact cost would therefore involve applying the following type of equation:

EXPECTED IMPACT COST (or risk magnitude)[1] = actual cost in a given year[2] * probability[3]

(HMT Green Book, 2003)

1: This number could be determined based on existing data, or based on the proposed approach.

2: Determining actual cost of impacts will relate to information available on known impacts in the chosen year.

3: A discussion of probabilities and scenario building is outlined in Annex 6.

This formula is also synonymous with determining the risk magnitude in relation to different impacts on different exposure units. If risks are mapped within a specific geographic boundary in relation to a number of predetermined units, they could then be added up to determine both the total risk and the total cost of impacts. It is worth noting however, that while this approach could be used to asses risk and costs in a given year, that it may not represent the total additional cost of impacts over the life of an entire project. There is the possibility that basing an assessment of risks on one year, may distort the perceived cost of impacts. As the research undertaken for Annex 6 illustrates, it is difficult to assign a probability to a specific year. It would therefore be appropriate to consider adding up risks for different years to provide a total expected cost over the lifetime of the project. (HMT, Green Book, p. 37)

The issue of probabilities as they relate to this particular step, in relation to future impacts, is only meant to help illustrate the severity of risks in response to the selection of the appropriate type of measure(s). Probabilities are also used in order to calculate the total cost of adaptation as part of Step 6.

7.3 STEP 3: Identifying adaptation measures applicable to identified risks

The most fundamental component of the proposed methodology is the identification of appropriate measures. We argue that the methodology should be based on the selection of a measure, or of a group of measures, to respond to the relevant impacts. The entity that would be responsible for the implementation is secondary to the response. As argued under Step 7, the EU and national governments would need to decide on the appropriate level of government that would correspond to the implementation of a measure.

As outlined in section 7.2, it will be crucial for decision makers to consider the range and magnitude of risks. Selecting the applicable measures will depend largely on the discretion of the decision maker or project developer, the overall objective of their adaptation strategy, and the nature of their relationship with project implementation. Those that are more directly implicated in projects are likely to select different types of measures. If the magnitude of the risks in question is likely to pose a significant threat to local livelihoods, measures will need to be resilient enough to cope with future impacts. At the same time, the degree of resilience inherent in chosen measures should also avoid the risk of mal-adaptation.

In selecting the appropriate measure, one may need to consider the "adaptation share" of a measure. In short, the corresponding cost of a measure would not correspond to the business as usual weather variability and impacts, but to the impacts associated with climate change. The latter cost would be known as the “adaptation share” of a measure, and could impact the way in which funding is allocated to adaptation measures. For more information refer to section 2.2 in Chapter 2.

It is difficult to separate measure selection from the quantification of adaptation cost given that on the one hand measures could be selected on the basis of cost effectiveness (requiring more cost effectiveness analysis) without considering local benefits. On the other hand, some measures could be selected for political reasons placing less emphasis on the need for

least cost options instead maximizing the potential to implement no-regrets measures with a vast number of co-benefits. The latter scenario will depend largely on the mandate of developers or decision makers, and could involve a more qualitative assessment of co-benefits that were not considered as part of the original cost equation (requiring more cost benefit or even multi-criteria analysis).

Decision makers will need to consider the following issues:

1) Project lifetime and time horizon: In allocating funds to planned measures, what is the applicable time horizon? Decision makers could select measures with project lifetimes that correspond with their budgetary cycle. This would ensure that the implementation of certain measures is financially viable.[44] This issue may be more of a consideration in relation to planned measures; implementing reactive measures (emergency response for example) or autonomous measures will occur more immediately with fewer project delays. (Stern, p. 406) For a policy question that considers impacts according to a specific time horizon, 2050 for instance, it will be crucial to consider whether the measure in question will be resilient enough to cope with future impacts.
2) Project finance and uncertainty: In allocating funding to specific measures, how will decision makers or project developers choose measures in a way that addresses the uncertainty of climate change impacts? In other words, will no-regrets measures be chosen? Are such measures reversible? Is there justification for using techniques that deal with uncertainty more systematically as part of real options appraisal or portfolio analysis?
3) Local geography and trends in impacts: Are measures capable of addressing existing and forecasted impacts?
4) Degree of vulnerability and adaptive capacity: Are the relevant institutions capable of implementing measures? Is local business capable of changing standard practises to implement new measures? For the EU, assessing this reality will help determine what "softer measures" will need to be implemented to complement existing "hard measures".
5) Cost: Are the actual technical measures or policies available affordable? Will their implementation result in economic losses and what are the alternatives? What are the co-benefits associated with the implementation of measures?
6) The availability of alternative adaptation options: how many measures are feasibly applicable to the impact(s) in question? Is it possible to combine them in response to the identified impacts?

A list of measures for analysis has been compiled through this project as described in chapter 4. This list could be further developed through the addition of information available

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44. One cannot ignore the fact that the decision making process can increase the cost of measures in light of scarce resources. If governments allocate funding to measures with short term horizons that require significant up front capital investment in order to allocate funds within a limited budgetary cycle or planning process, the cost of short term measures relative to longer term measures may appear to be higher. See Tol, 1995, p. 5.

in various information sources such as national databases for example UKCIP[45] (UK) and Routeplanner (NL)[46], research projects such as ADAM (digital compendium)[47] and CLIMSAVE[48] and from 2012 EU adaptation clearinghouse.[49] The example provided for Sweden in Chapter 6, and examples outlined in Annex 5, illustrate how decision makers or project developers could choose measures on the basis of their political or economic priorities. As stated above, either the type of measure or the objective of a particular policy could dictate the application of a particular cost assessment approach.

7.4 STEP 4: Selecting the applicable valuation approach

The approach taken to valuate adaptation measures will be based largely on the overall purpose of a cost assessment. Some decision makers may need to find the most cost effective option to address impacts based on political priorities, while others may be more interested in considering the overall benefits to society. This reality may dictate the type of valuation approach applied. In terms of obtaining the necessary data for a valuation, some measures may be harder to valuate in cases where they are not connected to the economy. In these cases, one would need to identify what needs to be valued and then conduct a literature review to determine whether valuations of similar impacts or values have been undertaken at other locations and if the results could be applied for the current evaluation. For climate change, this would primarily involve looking at how much impacts have cost as a result of similar extreme weather events. One would need to consider what aspects of the policy site make it different from the study site including the magnitude of change, good/service in question, socioeconomic and cultural characteristics of population, availability of substitutes, and the assignment of property rights.

The general approach of step 4 involves three broad components: determining the purpose of the cost assessment, choosing the applicable valuation method such as Cost Effectiveness Analysis (CEA) or Cost Benefit Analysis (CBA), and lastly, evaluating the final output of the exercise. Again, one needs to consider the fact that application of the evaluation methods is based on different objectives: CBA approaches often compare losses against gains while CEA compares the relative costs and outcomes (effects) of two or more actions. To illustrate the complexity involved in applying the right type of cost assessment approach, we have assessed approaches while considering some of the realities or characteristics inherent in different measures as part of the examples provided in Annex 5.

In the majority of cases, assessment approaches are selected by considering the total number of use and non-use values, the nature of investment flow through projects, and the project implementation context. Selecting an economic valuation approach as opposed to outlining an actual quantification methodology is more about determining the use of qualitative vs. quantitative approaches, and the use of bottom-up vs. top-down approaches.

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[45] http://www.ukcip.org.uk/index.php?option=com_content&task=view&id=286&Itemid=423

[46] http://library.wur.nl/desktop/direct/

[47] http://adam-digital-compendium.pik-potsdam.de/adaptation-catalogue/option-database/drought.html

[48] http://www.climsave.eu/climsave/index.html

[49] http://circa.europa.eu/Public/irc/env/cc_impacts/library?l=/public_1/concept_clearinghouse/clearinghouse_finalpdf/_EN_1.0_&a=d

Determining how the different variables valuated as part of cost benefit analysis for example will vary as part of a defined time series, is what constitutes a broader methodology.

As part of this proposed methodology, we argue that an approach to quantify cost cannot be separated from the measure under consideration and from the nature of the impacts it is meant to address. As the examples in Annex 5 demonstrate, the way in which cost is quantified will be a function of the measure, and the resources required to implement any given measure will be determined on the basis of the applied valuation approach. The measures have been categorized using the approach applied as part of the Adaptation White Paper analysis; examples have thus been provided for "green", "gray" and "soft" measures. While this project suggests providing an alternative typology for the classification of adaptation measures more broadly, this approach has been used merely to illustrate the differences between measures.

7.5 STEP 5: Identifying and collecting data needed for evaluation

The following type of data would be required in completing the four previous steps; although more detailed data would be required in relation to steps 3 and 4, in order to undertake the cost calculations in step 6. Again, it is hard to provide specific references for data sources given that the data required will depend on the context as it relates to implementation of a given measure. More sector specific data needs are described in relation to the examples provided in Annex 5.

STEP 1: Defining cost assessment boundaries and baselines
Data needs: Defining overall cost assessment boundaries would involve obtaining generic background data in relation to the area in question. If one is to consider a more localized issue, regional governments could utilize national statistics to characterize the local economy, while referring data gathered by national environmental ministries or agencies to characterize the local geography. Looking specifically at the history of impacts on a region could involve referring to some of the databases outlined in this Chapter (CRED for example), or could involve obtaining data issued by the insurance industry.
STEP 2: Identifying climate change risks and vulnerabilities
Data needs: The data required to complete Step 2 relates primarily to established vulnerabilities. In some cases maps may exist that outline the location of vulnerabilities; this will depend on the sector in question. Looking specifically at future impacts, conducting risk assessments could involve determining probabilities or using established probabilities. Issues related to probabilities are outlined in Annex 6.
STEP 3: Identifying adaptation measures applicable to identified risks
Data needs: The description of Step 3 includes a number of different references related to applicable measures.

STEP 4: Selecting the valuation approach

Data needs: As outlined in Chapter 6, valuating the cost of adaptation measures will largely be a question of using market and non-market values. In some cases, particularly in relation to measures implemented by the private sector at local levels, market values could be gathered on the basis of confidential in-house data. For decision makers, there may a number of secondary data sources that could be consulted such as price indexes, or national statistics related to overall resource productivity and output. Non-market values are harder to obtain through standard data sources, and may only be determined as a result of project specific literature reviews as part of benefit transfer exercises. In some cases, primary valuation of the site in question may be required.

7.6 STEP 6: Estimating costs and benefits of adaptation measures

As outlined in Chapter 6, the cost of adaptation includes the total cost of impacts, and the total costs related to the implementation of measures. If one considers the work of Frankhauser, adaptation cost can also be defined as "the real resource cost required to create net adaptation benefits" and that spending on adaptation represents the overall opportunity cost associated with allocating resources from one timeframe to another. In this sense, opportunity cost is not simply the cost associated with the selection of one measure over another. (UNEP, 1998, p. 107) Referring to Step 1, and to the cost calculations as part of each of the examples in Annex 6, cost is described in terms of damages on a per unit basis, but places less emphasis on the need to allocate resources from one scenario to another. Calculating total adaptation cost on the basis of an established time series is illustrated as follows:

Adaptation cost (AC) = Resource cost (RC) in baseline scenario (BL) with altered climate and adaptation to the current climate - Resource cost in scenario with altered climate and adaptation to altered climate. In this instance, we are assuming that climate is "constant"; it is the rate of adaptation that differs.

Equation no. 1:

AC = (RC for adaptation to BL Scenario) – (RC for adaptation to altered climate)

This is outlined in Step 1 in relation to the identification of the baseline.

Looking at the completion of the other steps in the methodology, costs related to these variables would need to be calculated:

RC in BL: The resource costs as they relate to the actual measure will have been calculated as a result of the analysis undertaken in Step 4. Having undertaken the analysis in steps 1-3, the ensuing calculations rest on the assumption that the measure will be capable of addressing the risks associated with future climate change impacts. Although one could calculate total annual damage costs and factor them in to a baseline scenario (based on an assessment of costs over the lifetime of the project), the extent to which residual impacts

would cause damage even in extreme weather events beyond the baseline year, is a function of the type of measure being undertaken. The consideration of annual damages will be more of a consideration for measures that require significant retrofitting in response to predicted impacts. We propose accounting for operational costs separately; in the context of accumulated implementation costs for the time series under consideration.

Were one to consider resource costs under a business as usual or "without measures scenario", damage costs could be used to illustrate both the avoided cost of a with measures scenario, and to determine what additional funding could be required to address the impacts of climate change.

Based on the measure in question, and on the overall objective of the cost assessment, the following types of costs could apply in the baseline scenario.

Equation no. 2:

RC in BL = Opportunity Cost + Social Cost + Project Cost + Implementation Cost

RC in Altered climate: Based on Frankhauser's approach, calculating the cost of adaptation in an altered climate will essentially involve quantifying the total annual project and implementation costs for the timeframe in question.

The resource costs as they relate to the implementation of a measure as part of a future climate scenario could also be a question of probabilities. What is the likely magnitude of impacts the measure is likely to face? Having calculated the baseline resource costs, we would need to reapply the formula from Step 1:

Equation no. 3:

EXPECTED IMPACT COST (or risk magnitude) = actual cost in a given year * probability

We need to consider the fact that equation no. 3 is not likely to be an issue with respect to the implementation of certain measures such as sea walls or dykes. This would also depend largely on the applied project lifetime; if a decision maker or project developer was looking at the rate of sea level rise two hundred years from now, perhaps it could be more of a consideration.

This calculation would need to be repeated for a series of years throughout a project's lifetime to illustrate the variability in costs and probabilities. The variable expressed Equation no. 4 would need to consider a total expected impact cost for all years considered in the context of the measure's project lifetime.

Calculating the cost of the variable "RC in Altered climate" would then look something like this:

Equation no. 4:

RC in ALTERED CLIMATE = Expected impact cost + accumulation of annual implementation costs for the timeframe in question

Referring to Equation no. 4, one could expect the expected impact cost variable to be very low assuming that measures are implemented successfully. This would mean that overall, the cost in the altered climate year, is likely to be lower, resulting in a negative cost for adaptation which one could interpret to be equivalent to a benefit.

In undertaking the assessment of costs there are a few other cross-cutting issues to consider:

1) What are the benefits? In some cases benefits will be quantifiable, in others they may be associated more with the aesthetic value of a measure, or with their ability to meet other less market driven objectives such as biodiversity. The more quantifiable benefits of adaptation measures could relate to the mitigation of greenhouse gases. If one applies Frankhauser's approach, the costs could be negative in cases where the initial capital outlay exceeds the costs associated with the implementation of measures under future scenarios. This approach will be able to fully account for certain types of benefits in cases where cost is greater under future scenarios.
2) What is the uncertainty associated with the calculation being undertaken. At this stage of the assessment process we are less concerned with the uncertainty as it relates to climate change, but more with the level of uncertainty that could be assigned to the actual methodology. While probabilities may be able to account for the degree of future impacts, Frankhauser's approach fails to account for a number of exogenous factors such as increased prices for measures and outputs used in valuating measures.
3) In cases where measures are capital intensive, there will be issues in relation to the applied discount rate. As outlined in Annex 5, discounting will be an issue for grey measures that relate to infrastructure.

The selection of one type of measure over another may not be a question of standard cost benefit analysis, but could be undertaken as a result of comparative analysis. The issue of prioritizing some measures over others, may not be a question for all decision-makers or project developers and some decision-makers may be mandated to consider relatively few options for financial reasons. (This is illustrated through the Swedish example in Chapter 6.) In cases where the decision maker is drawing a project boundary to include a variety impacts and risks, there may be a need to consider numerous measures based on established priorities.

7.7 STEP 7: Prioritising adaption measures and selecting the appropriate level of governance for implementation

The issue of prioritizing measures for implementation, and selecting the appropriate level of governance, will only be an issue for higher levels of government. If one considers the need to draw a cost assessment boundary, the issue of measure prioritization is a function of the overall boundary; higher levels of government will simply be dealing with a greater numbers of impacts and risks given their jurisdictions. If national or EU governments are allocating funding for measures on a more general level, they would need to determine who would be best suited for its implementation. Presumably this would also involve the private sector, and could have implications for allocations to regional development banks. As discussed in the previous few sections, some measures are categorically implemented by certain levels of government; infrastructure measures in the health sector would be implemented by national governments, green measures would be implemented by local government, and a number of overarching policy measures would be implemented by the EU government.

Prioritizing the selection of measures remains a function of the overall objective of the cost assessment, even in cases where the scope of relevant issues is broader. In the case of the EU, this would relate primarily to its overall mandate in terms of addressing the impacts of climate change, and the corresponding timeframe in which measures would be funded. As described in Step 1, prioritization may be based on shorter term considerations in cases where measures have been identified on the basis of immediate needs. Looking at longer term considerations, prioritizing measures could be based on more projected impacts and the regions in which they are likely to occur.

As discussed in further detail in Chapter 10, the prioritization of measures should be based on established political priorities.

7.8 Conclusions

As stated in Chapter 5, In order for methodologies to become standardized, and easily replicated to a number of different situations, the scientific community and policy makers will need to determine whether it is possible to derive default values and acceptable uncertainty thresholds for climate scenarios as part of calculations. This has been done for the calculation of greenhouse gas inventories by the Intergovernmental Panel on Climate Change. A number of methodologies applied to projects in the developing world have come up with default values for adaptive capacity and resilience to climate change: perhaps this kind of index could be applied to the calculation of adaptation cost in the EU.[50] There is perhaps also scope to establish a particular reference scenario that could be consistently applied as part of any official estimates of adaptation cost. In short, the EU needs to make a

50. The UNDP has established an index known as the Vulnerability Reduction Assessment made up of a number of indicators to determine the adaptive capacity of projects/local stakeholders to implement adaptation measures. This index is used to help allocate funding to communities that receive adaptation funding through the Small Grants Programme of the Global Environmental Facility. See:
http://www.undp-adaptation.org/projects/websites/index.php?option=com_content&task=view&id=204

number of political decisions in relation to its overall priorities as they relate to adaptation. More specific recommendations are provided in the conclusions in Chapter 10.

In addition, while there may be challenges to collecting data as it relates to adaptation cost estimates, it could be possible for member states to report on more general data parameters in relation to cost estimates for both impacts and adaptation measures. The project has developed an interface that could be used as a potential national reporting tool (available in Annex 7). For the basic data to be available it is important for the European Commission to actively work for the development of a common reporting format. The templates build on reporting requirements that could be implemented at the local, national and EU levels.

8. Review of expenditure on adaptation

Summary of findings

The budget of the European Union is established via negotiations between the European Parliament and the Council of Ministers based on a proposal by the European Commission and spending is limited by different treaties. For example, the EU budget for 2011 is in accordance with the Lisbon Treaty[51]. So, depending on the treaty to which the budget is linked, different policies and areas are distinguished.

Analysis of the EU budget reveals that it is highly aggregated, and does not provide a transparent breakdown of climate change expenditure. It is therefore not possible to determine how much of the EU budget has been allocated to adaptation-related projects. Having surveyed national statistical offices throughout the EU, national budgets also provide little detail with respect to adaptation-related expenditure. While Member States have either initiated or implemented adaptation-related policy, accounting for adaptation-related measures has not yet become a reality with the exception of the United Kingdom.

A review of National Communications that countries deliver to the UNFCCC indicates that it is generally measures related to generic "risk prevention" that are reported. Existing reporting relates to the prevention of forest fires, limiting the effects of spring floods or planning for droughts. The National Communications also proved to be the best source of information at the national level despite the fact that data could be used to delineate expenditure on adaptation measures. While it was possible to identify funding to developing countries, the same type of detail for domestic measures was not provided. The analysis quickly revealed that measures aimed at mitigating greenhouse gases such as energy efficiency were commonly reported as adaptation measures proving that the system boundary of adaptation varies from country to country.

The country-specific analysis that was undertaken for a select number of European countries (the UK, Czech Republic, Greece, Spain, Portugal, Germany, Sweden, Denmark and Finland) indicated that the search for relevant data had to be expanded to include specific government ministries. Otherwise, the National Communications served to gather disjointed data as part of one document (in the Czech Republic for example), the information was scattered and the only source for information gathered about all areas was the National Communication. In some cases, as in Greece for example, reporting on adaptation measures had even been delegated to the private sector.

8.1 Introduction

A government will intervene in its national economy only under specific circumstances. Economists have described how government interventions can be justified in three different types of instances: when there is a market failure that threatens the total economy (for

[51] The treaty aims at increasing transparency and the democracy of Europe, Official Journal 17 December 2007, C306, volume 50 http://eur-lex.europa.eu/JOHtml.do?uri=OJ:C:2007:306:SOM:EN:HTML

example with the financial crisis that occurred in the late 2000s); when the equity of society is threatened; or when there is a security issue regarding the supply of basic goods or services. In relation to adaptation, a government will deal with equity issues more than a private company. This means that a government cannot consider a cost/benefit analysis or cost efficiency in the same way as a private company can.

This chapter has taken the form of a review of relevant literature as part of an Internet search in order to determine how, and whether, public intervention related to adaptation has been undertaken. This review helps establish a framework for the collection of data related to adaptation expenditure, referring to a list of measures extracted from the Impact Assessment of the adaptation White Paper and the identified definition of an adaptation measure provided in Chapter 2.

8.2 Data collected by the OECD and European financial institutions (EFIs)

8.2.1 The OECD

The Rio Markers have been developed by the OECD for biodiversity, climate change and desertification. They constitute eligibility criteria for funding projects that contribute to climate change objectives. The Rio marker 'Climate Change' means that a project is eligible for public financing if:

- The project aims to mitigate climate change by limiting anthropogenic emissions of GHGs;
- The project aims to protect / or enhance GHG sinks and reservoirs;
- The projects aims to integrate climate change concerns into the development objectives of recipients' countries (via institutional building, capacity development, strengthening the regulatory and policy frameworks, research, etc.); or
- The project aims to assist countries to meet their obligations under the UNFCCC.

All four of these types of projects, however, do not explicitly address climate adaptation measures up until the next reporting in 2011. This changed in 2009, when the Development Assistance Committee (DAC) approved a new marker on climate change adaptation (OECD 2010) that could be used to measure national spending on adaptation. All national communications for the EU were reviewed for this report.[52] The review showed that some countries refer to the OECD database on Aid. However until now the information has not covered adaptation as previously mentioned. The only information available at the current time, relates primarily to developing countries.

8.2.2 European financial institutions (EFIs)

Our review shows that EFIs will be required to comply with any legislation that affects the implementation of projects. Future policies on adaptation could incentivise consideration of

52 http://unfccc.int/national_reports/items/1408.php

the cost issue but none have been required as of yet. Member States, who are also shareholders of EFIs such as the EBRD could ask them to start reporting more on the amount of funding they are dedicating to adaptation.

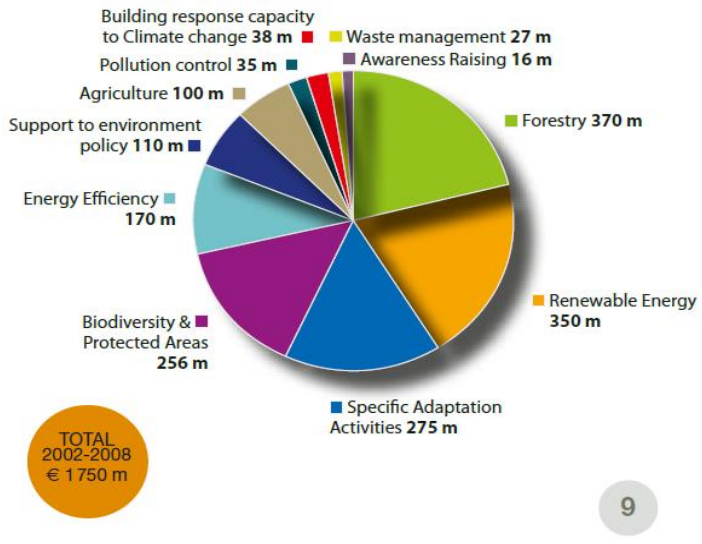
The EBRD in particular, does not have any data indicating how much funding has previously been allocated to adaptation cost. They have dedicated time to mitigation and on the derivation of cost curves for mitigation measures, but have not considered adaptation cost from a similar perspective. Consultation with the EBRD, reveals that some international financial institutions are roughly 3 years behind the Commission in terms of considering the cost of adaptation.

8.3 Expenditure at EU level

The EU as a supranational entity is party to the UNFCCC. As such, the EU has an obligation to report on the implementation of the Convention by preparing a communication report (Articles 4.1 and 12). On 3 December 2010, the EU adopted its 5th communication report under the UNFCCC[53], in preparation for the conference of the parties to the UNFCCC COP15 that took place in Copenhagen between the 7 and 18 December 2009. The EU reports on the allocation of financial resources and technology transfer (Section 1.6), using the Rio Markers (see above discussion regarding Rio Markers).

In 2009, the European Commission published "Supporting a climate for change – The EU and developing countries working together". This report provides an overview of the EU's approach for supporting developing countries in *inter alia* adapting to the effects of climate change and to mitigation. A number of activities have been undertaken under the Global Climate Change Alliance launched in September 2007.

Figure 7: Commitments in Euro on Climate change per main sectors 2002-2008



[53] CEC. 2009. Communication from the Commission: Fifth National Communication from the European Community under the UN Framework Convention on Climate Change (UNFCCC), COM(2009)667, 3 December 2009, http://ec.europa.eu/environment/climat/pdf/fifth_comm_unfccc.pdf

Source: EC 2009c

The Commission's Communication on a European blueprint for international climate finance (COM(2009)475)[54] was issued on 10 September 2009 as part of the preparations for the UN climate summit in Copenhagen in December 2009. It is estimated that 'finance requirements for adaptation and mitigation actions in developing countries could reach roughly €100 billion per year by 2020'. International public funding would play a key role in helping reach this figure and the Commission's best estimate gives figures of €22 to €50 billion per year from international public finance by 2020 alongside the potential €38 billion expected to be generated by a well-designed international carbon market. The EU's share of public funding, depending on criteria used to determine the burden-sharing system that is to be applied between donors, would be between €2 and €15 billion per year in 2020. Given the amount allocated to adaptation, it will be crucial to provide a justification for the allocation of funds in order to ensure a certain level of transparency with respect to the EU decision-making process.

8.3.1 EU Budgetary spending on adaptation to climate change

The budget of the European Union is established via negotiations between the European Parliament and the Council of Ministers on a basis of a proposal by the European Commission and the spending is limited by different Treaties. For example, the EU budget for 2011 is in accordance with the Lisbon Treaty[55]. So, depending on the Treaty under which the budget is linked to, different policies and areas are distinguished.

We reviewed the structure of the EU budget in relation to adaptation expenditure. Until recently, there has been no need for the European Commission to identify and follow-up financial aspects of measures directed at climate change adaptation. The annual EU budget includes rather general headings and adaptation funding is likely to be part of most of these headings (eg under cohesion for growth and employment, rural development, environment, etc.). Therefore, it is very difficult to detect the level of public support from the EU budget for such measures without further information on details.

Table 8: The 2009 EU Budget[56]

Budget heading	Euros billion
1. Sustainable growth	**60.2**
1A. Competitiveness for growth and employment	11.8

[54] Commission of the European Communities, Communication from the Commission on Stepping up international climate finance: A European blueprint for the Copenhagen deal, (COM(2009)475)

[55] The treaty aims at increasing transparency and the democracy of Europe, Official Journal 17 December 2007, C306, volume 50 http://eur-lex.europa.eu/JOHtml.do?uri=OJ:C:2007:306:SOM:EN:HTML

[56] CEC (2009)

1B. Cohesion for growth and employment	48.4
2. Preservation and management of natural resour	**56.1**
2A. Agricultural expenditure including direct aids	41.1
2B. Rural development	13.7
2C. Environment	0.3
2D. Fisheries	0.9
3. Citizenship, freedom, security and justice	**1.5**
4. The EU as a global player	**8.1**
(excludes the extra-budgetary European Developme Fund)	
5. Administrative expenditure	**7.7**
6. Compensation to new EU countries	**0.2**
Total	**133.8**

Table 9: EU structural and cohesion funds 2007-2013[57]

Climate Change				
Objective	Investments	Investments details	Amount (€)	
Convergence	Direct investments	Air quality	959,124,555	2.2%
	Direct investments	Climate change	170,041,176	0.4%
	Direct investments	Energy efficiency	3,319,704,173	7.7%
	Direct investments	Renewable energy	3,584,996,589	8.3%
	Direct investments	Risk prevention	5,055,141,242	11.8%
	Indirect investments	Cycle tracks	509,589,761	1.2%
	Indirect investments	Intelligent systems and clean urban transport	6,207,485,909	14.5%
	Indirect investments	Rail	23,130,341,378	53.9%
Convergence			**42,936,424,783**	**100%**
Regional Competitiveness and Employment	Direct investments	Air quality	20,979,829	0.5%
	Direct investments	Climate change	51,849,174	1.3%
	Direct investments	Energy efficiency	765,105,590	19.5%
	Direct investments	Renewable energy	977,423,449	25.0%
	Direct investments	Risk prevention	519,853,896	13.3%
	Indirect investments	Cycle tracks	36,340,042	0.9%
	Indirect investments	Intelligent systems and clean urban transport	873,925,728	22.3%
	Indirect investments	Rail	668,864,478	17.1%
Regional Competitiveness and Employment			**3,914,342,186**	**100%**
European Territorial Cooperation	Direct investments	Air quality	40,272,181	3.8%
	Direct investments	Climate change	82,837,046	7.9%
	Direct investments	Energy efficiency	107,467,685	10.2%
	Direct investments	Renewable energy	223,347,167	21.2%
	Direct investments	Risk prevention	253,973,572	24.2%
	Indirect investments	Cycle tracks	88,489,487	8.4%
	Indirect investments	Intelligent systems and clean urban transport	175,774,218	16.7%
	Indirect investments	Rail	79,008,551	7.5%
European Territorial Cooperation			**1,051,169,907**	**100%**

[57] http://ec.europa.eu/regional_policy/themes/statistics/2007_environment_climate.pdf

DG Regional policy has published statistics on **EU structural and cohesion fund** spending on environment and climate change for the 2007-2013 financial perspective under the three different objectives underpinning the current cohesion policy of the EU (Convergence, Regional competitiveness and employment and European territorial cooperation). In 2006, when the EU funds' Regulations and Community Strategic Guidelines on Cohesion were adopted, they did not explicitly refer to climate adaptation and gave priority to mitigation measures such as energy efficiency and renewable energy sources while adaptation measures were left to the interpretation of national and regional operational programmes (the key planning documents which determine long term objectives and concrete measures for spending EU funds at the level of Member State or regions). This underlines the importance of considering the implementation of measures at the national level, and the need to review documents produced as part of operational programmes.

It should be noted that around 76 percent of the EU's expenditure is not under the direct control of the Commission. After the publication of the White Paper on climate adaptation in 2009, the DG of Regional policy had to report on the extent to which cohesion policy contributes to spending on climate change adaptation. The approach which they undertook was to group both mitigation and adaptation measures under the broader category 'Climate change' and also to account spending under 'Risk prevention' as adaptation measures.

Referring to financial statistics, it appears that between 2007 and 2013 EU structural and cohesion funds have allocated €304,700 for climate mitigation and adaptation measures and €5,829,000 for risk prevention. Despite this initial breakdown of spending, determining precise amounts of expenditure is complicated by the following issues: 1) in the former category, expenditure on adaptation is combined with that on mitigation; 2) in the latter category, it is also not clear what kind of projects are awarded funding (they might be relevant to extreme disasters but not necessarily targeting climate adaptation); and 3) based on the subsidiarity and shared management principles, it is up the Member States to award funding to whatever projects they deem appropriate. Therefore, one needs to further explore the management of EU Structural Funds at the national level in order to understand the logic of how much 'climate change' funding actually supports adaptation.

Table 10: Categories of EU funds spending on climate adaptation

• **Convergence objective**	• **Environmental measures eligible for co-financing**
• **ERDF**	• **Environment (Article 4.4):** promotion of biodiversity and nature protection (including Natura 2000); • **Prevention of risks (Article 4.5):** development and implementation of plans to prevent and cope with natural and technological risks • **Health (article 4.11):** investments to develop and improve health

	provision which contribute to regional development and quality of life in regions.
• **ESF**	• **Enhancing human capital in environmental measures (Article 3.2a)** Reforming to integrate sustainability in education and training systems; • **Strengthening institutional capacity for environmental measures (Article 3.2b)** Mechanisms to improve policy and programme design, monitoring and evaluation; Managerial and staff training and support to socio-economic and non-governmental actors to improve delivery of policies and programmes.
• **Regional Competitiveness and Employment objective**	• **Environmental measures eligible for co-financing**
• **ERDF**	**Environment and risk prevention (Article 5.2):** development of infrastructure for biodiversity and NATURA2000 sites; plans and measures to tackle natural disasters; protection and enhancement of natural heritage.

The provision of emergency relief to individual regions or Member States in the event of major natural disasters is being made possible under the **EU Solidarity Fund** (EUSF) set up in 2002. It is triggered when the cost of damage exceeds a certain threshold. This fund could have considerable implications in the context of Member States' adaptation to climate change. Article 2 of the EUSF Regulation (2012/2002) states that the fund should be mobilised 'when a natural disaster with serious repercussions on living conditions, the natural environment, or the economy in one or more regions or one or more countries occurs'. Eligible measures include 'the immediate cleaning-up of disaster-stricken areas, including natural zones', which can include ex-post climate adaptation measures. However, a more relevant question is to what extent the EUSF could be deployed to support preventative longer-term adaptation measures.

The European Parliament has called for the definition of 'natural disaster' in Article 2 of the EUSF Regulation (2012/2002) to be extended beyond sudden catastrophic events like floods, to include longer term threats such as droughts, desertification, and to urban 'hot spots'

(caused by localised temperature increase) where the elderly and the very young are particularly vulnerable (European Parliament 2006)[58].

The **EU Rural Development policy** includes actions on climate change under what is known as 'Axis Two: environmental/land management'. The majority of measures found under Axis Two are devoted to 'forestry land' with mention of practices related to afforestation, restoring forestry potential and protection. The latter includes forest fires and other natural disasters. The Regulation on the **European Agriculture and Rural Development Fund** refers to the issue of forest management in relation to climate change by stating that: '*Sustainable land management practices can help reduce risks linked to abandonment, desertification and forest fires, particularly in less-favoured areas…*" and in " .. *combating climate change. ..Appropriate agricultural and forestry practices can contribute to … adapting to the impacts of climate change'.* Particularly, these include:

- Agricultural measures: natural handicap payments to farmers in mountain areas; payments to farmers in areas with handicaps other than mountain areas; Natura 2000 payments and payments linked to Directive 2000/60/EC; agri-environment payments; animal welfare payments; support for non-productive investments.
- Forestry measures: first afforestation of agricultural land; first establishment of agroforestry systems on agricultural land; first afforestation of non-agricultural land; Natura 2000 payments; forest-environment payments; restoring forestry potential and introducing prevention actions; non-productive investments.

Under the cohesion policy there is a common reporting standard for all countries receiving cohesion funding, which is based on the categories of expenditure. (See Annex to the COM after the end of the programming period.)[59] It is actually completed by the managing authorities of the respective Operational programmes.

With regards to CAP, it is possible to find out how much money has been spent on Pillar 1 (through direct payments and, intervention support etc.), and on Pillar 2 (sometimes broken down by measure). Based on an objective interpretation of CAP financial data, it is also possible to identify which measures could be delivering climate benefits, but it is not possible to determine whether these benefits can be separated out from the business as usual benefits as it is not required in the financial follow-up of results. In addition, the annual publication on agricultural statistics (released up until 2009) has not been published

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58. European Parliament (2006) European Parliament (EP) (2006) European Parliament Resolution on Natural Disasters (fires, droughts and floods) - environmental aspects. P6_TA(2006)0224. EP. Strasbourg.

59

http://ec.europa.eu/regional_policy/sources/docoffic/official/communic/negociation/com_2008_301_annex_en.pdf

with an environmental audience in mind and does not allow the reader to determine what percentage of spending could be allocated to adaptation.[60]

More generally, for Pillar 2, it is more common to use the anticipated budget figures for the whole programming period (2007-13). These can be found broken down by measure and by Member State in the annexes to the document on statistical information for Rural Development.[61] Budgetary data is also available on an annual basis for Pillar 1. The only information that directly relates to climate change is data on how Member States are using additional funds that were made available to them under Pillar 2 following the CAP Health Check in 2008 – but this is a very small proportion of the total Pillar 2 budget.

8.4 Expenditure at the Member State level

Based on our review of the 5th National Communication to the UNFCCC, it appears as if most countries use the term "disaster prevention" to characterise adaptation spending. For the purposes of this report, an Excel-template was developed (available in Annex 8) to record specific measures covered by the relevant country, and to record the methodology used to quantify that funding. The template enabled the country reviewers to describe each measure, classify the measure and if possible sum them up. By identifying each measure they could be discussed in groups according to their relevance and applicability to the area. However, our review revealed that most countries have not provided a transparent description of how funding has been quantified.

Country-specific analysis was completed for a select number of European countries using National Communications: the UK, the Czech Republic, Greece, Spain, Portugal, Germany, Sweden, Denmark and Finland, revealed that in general the search for data had to be extended to specific government departments or ministries. In the Czech Republic relevant information was scattered among several ministries, with the National Communication serving as a centralised data repository. The review initially started out with a review of national budgets but this quickly proved futile. Most budgetary allocations are related to broad programmes containing a large variety of headings unrelated to adaptation.

Table 11 shows an overview of European countries that have developed national strategies for adaptation. (Biesbroek et Al, 2010). By early 2009, nine EU Member States had developed a National Adaptation Strategy, whilst several others were in the process of doing so.

Table 11: Overview of National Adaptation Strategies in Europe

60. http://ec.europa.eu/agriculture/agrista/2009/table_en/en34.htm

61. http://ec.europa.eu/agriculture/agrista/rurdev2009/index_en.htm

Country	National Adaptation Strategy (NAS)	Year	Responsible for the development of the NAS
Denmark	Strategi for tilpasning til klimaændringer i Danmark (Danish Energy Agency, 2008)	2008	Ministry of Environment, shifted in 2008 to Ministry of Climate and Energy
Finland	Finland's National Strategy for Adaptation to Climate Change (Marttila et al., 2005)	2005	Working group for preparing the NAS under the Ministry of Agriculture and Forestry
France	Stratégie nationale d'adaptation au changement climatique (ONERC, 2007)	2007	National observatory dedicated to the effects of climate warning (ONERC); Inter-ministerial delegate for sustainable development
Germany	Deutsche Strategie zur Anpassung an den Klimawandel (BMU, 2008)	2008	Environmental Ministry supported by the Federal Environmental Agency
Hungary	Nemzeti Éghajlatváltozási Stratégia	2008	Not included in study
Netherlands	Maak ruimte voor klimaat! (VROM, 2007)	2007	Adaptation to climate change in spatial planning (ARK) programme, co-ordinated by the Ministry of Housing, Spatial Planning and the Environment
Romania	Ghid privind Adaptarea la Efectele Schimbărilor Climatice	2008	Not included in the study
Spain	Plan de nacional de adaptición al cambino climático (PNACC, 2006)	2006	Environmental Ministry; National Office for Climate Change
United Kingdom	Adapting to climate change in England. A framework for action (DEFRA, 2008)	2008	Department for Food, Rural Affairs and the Environment (DEFRA)

Source: Biesbroek et. al 2010

Despite the shortcomings of National Communications, they remain the best source of information related to national adaptation strategies. Despite the fact that this international reporting requirement relates to climate change, the description of what could be considered adaptation expenditure relates primarily to more general "risks" such as forest fires, floods and droughts. The documents provide more detail in relation to spending on international cooperation, and a significant amount of information is provided in relation to specific bilateral adaptation programmes. Although adaptation measures are described for the EU 27, (a full description of the measures found in of the EU27 member states is available in Annex 9), little data in relation to adaptation cost and expenditure is provided. The analysis quickly revealed that some mitigation measures such as energy efficiency was commonly reported as adaptation measures proving that the system boundary of adaptation varies from country to country.

Example 1 below describes what was found for Hungary in its 5th National Communication. Project descriptions are provided, but the Communication does not indicate how project funding has been allocated. Detail is provided in relation to mitigation measures, but not adaptation.

Example 1: Hungary:

Examples of adaptation measures with no expenditure or cost data provided:

1. Impact assessment for water catchment areas and development of indicator system for monitoring changes in the natural waters

2. Examination of autumn and spring type cereals to identify the effect of climatic factors on product quantity.

3. Repeated measuring and assessing of water restraint potentials and surface and under-surface water reserves

With expenditure

- Green Investment Scheme HUF 7.5 billion. 2008-2012
- State aid grants - energy savings HUF 40.2 billion 2002-2006

Source: 5th National Communication

Example 2 below shows a detailed reporting on existing and planned spending for adaptation measures in the UK.

Example 2: United Kingdom:

Type of measure	Amount	Year
Design for Future Climate Change	4,9 million	2010
Capacity building	2 million	Unknown
Flood and coastal erosion risk	394 million	2002-2003
Flood and coastal erosion risk	800 million	2010-2011
Climate change research	100 million	2010-2015
Surface water management plans	15 million	Unknown

Source: Defra

8.5 Conclusions: data on adaptation in its infancy

The literature review searching for data related to climate change adaptation expenditures revealed that discussions on policies and related actions are more commonly developed rather than the economic follow-up of the actions. The exception by far is the details of expenditures available on foreign aid where each project is described in policy documents and to international organisations.

Given the increasing importance of adaptation on the global agenda, statistics are likely to become increasingly important as well. In the context of international negotiations, countries could use reported spending on adaptation to bargain for reductions from larger emitters. In general, very few countries are describing the underlying methodologies or assumptions of their expenditures when reporting adaptation activities internationally. The literature review undertaken in relation to Member States, indicates that information related to implemented measures is anecdotal and random. This makes the system boundaries hard to determine and complicates the classification of new and existing adaptation measures. In terms of support measures to the developing world most countries reported very well on specific projects, the amounts, the time frame and the results of the projects.

One of the key data collection needs identified as a result of undertaking this study, is the need for a more centralised systematic data collection of actual impacts, of weather events exceeding a norm that can be labelled climate change events, and in relation to the implementation of actual measures per Member State. More importantly, while a MS may be reporting on the implementation of measures and outlining the total cost, they do not indicate the type of valuation technique applied as part of cost estimates. More systematic data-gathering on the application of different approaches and the lessons learned would help future cost estimation exercises.

9. A Proposed methodology for adaptation expenditure statistics

Summary of findings

It was anticipated that the data review, would show that specific adaptation measures in state budgets are not easily distinguished today and this proved correct. If annual monitoring of expenditure for adaptation is to be undertaken we propose the establishment of a new data collection system based on sound statistical principles.

This proposal is not for collecting data on cost estimates (future anticipated costs) but for collecting data on expenditure statistics (past events). The proposal only covers data collection for government statistics. However, it is foreseen that it would be important to also collect data on private measures and a path forward in that area is also briefly described. It is based on a proposal that the Eurostat will be the coordinator of any new statistics on adaptation expenditure and that they co-operate with the European Statistical System to collect the data. This will ensure that the data compiled at country level is harmonised, follows the overall guidelines and facilitates the analytical results to be published.

The authors of this report contend that in order to be able to create the right basis for statistical data collection, the definition of an adaptation measure should follow the IPCC definition. This means that the adaptation measure to be selected should consider elements of the IPCC definition. The authors also believe that the classification of COFOG would provide a good start for collecting data on government expenditure while the NACE classification would provide an excellent basis for collecting data on autonomous measures (enterprise statistics). These classifications would be complemented by a specific table presenting the data on adaptation expenditure according to climatic event.

The underlying statistical process for gathering and presenting harmonised adaptation expenditure data could follow the framework of the UNECE/OECD/Eurostat, known as the Generic Statistical Business Process Model (GSBPM) as seen in Figure 8. The model, or nationally adapted versions of the model, has already been implemented in many countries in Europe. It assists the national statistical offices in compiling existing or new statistics according to a certain set of quality criteria.

The System of Integrated Environmental and Economic Accounts (SEEA), a statistical framework, is proposed for use as the content-related framework when compiling new statistics on climate change adaptation expenditures. Today Eurostat collects several statistical modules within the framework, including for air emissions by industry, environmentally-related taxes and environmental protection expenditures.

This year the European Commission has put forward a proposal to the Council and Parliament to include parts of the area of Environmental Accounts in a Council Regulation. This means that a specific data collection routine would be operationalised, harmonised and published by the EU Member States and Eurostat. Thus, preparatory actions for this option should include a dialogue with Member States' management authorities (or potentially

through a dedicated Adaptation Committee), climate experts, exchange of information (maybe through a platform consolidating the information available), training, improved use of existing programme management control and monitoring tools. The process of including a new statistical field under legislation is normally long and new legislative acts benefit from pre-testing by a large number of countries to support the idea of increasing the response burden of countries, enterprises or the public.

9.1 Introduction

There is an abundance of data available today for all and everyone to use, often for free through databases or through published reports. National statistical offices have, as a response to this situation become more aware of the importance of expressing the ideas, theories and applied sciences more transparently than before. As a result single countries have developed programmes and processes to ensure and better describe the process behind the work of producing statistics. Very recently the UNECE[62], the OECD[63] and Eurostat[64] approved a new business model that sets out the path for any statistical process to take. For the statistical community the process model is familiar but nonetheless important to communicate.

It is recognised that there are limits to what statistics can accomplish. We argue that it would not be advisable to standardise data collection in relation to some parameters, including cost estimates, but rather to focus on comparable data inputs. Reporting requirements through the European Commission could be used to help statistical data gathering undertaken by national statistics offices. Underlying data related to cost estimates could be provided by the statistical community to some extent, where confidentiality is not an issue or where there is a mutual cooperation between the research community and the statistical offices.

The proposed methodology in this report is based on existing statistical standards. The overall statistical framework that applies to national statistical offices is the Generic Statistical Business Model (GSBPM). It assists in such a way as to ensure that the compilation of statistics follows certain steps, like a checklist and verifies the quality of published results and is described in chapter 9.2. The second statistical framework, more related to the topic, that could be followed is the System of Integrated Environmental and Economic Accounts (SEEA). This is a statistical system that enables a link between economic statistics and environmental statistics and is explained in Chapter 9.3. Each step of the GSBPM is explained on a theoretical level implementing the SEEA while Chapter 9.11 also presents an example of how the statistical compilation could look based on Sweden.

9.2 A general statistical framework for data collection

Statistical compilations build on a number of principles and processes. Each new survey benefits from the experience of previous knowledge and expertise. In order to systemise the

[62] The United Nations Economic Commission for Europe

[63] Organisation for Economic Co-operation and Development

[64] The Statistical Office of the European Union

work with a global effect, an initiative was taken by the UNECE, the OECD and Eurostat to develop a generic model that could be accepted worldwide. Based on an existing business model from New Zealand's statistical office, a Generic Statistical Business Process Model (GSBPM) has been developed (the full model is available in Annex 10. The Common Metadata Framework was published in 2009.

The model is intended to apply to statistical production regardless of the data source (surveys, administrative records, data integration etc.). It also encompasses data quality and the production of metadata. The model introduces the aspect of agreement on standardised higher levels, but provides freedom for individual organisations to introduce lower levels aligned to their specific needs. This is similar to the way that some international statistical classifications are managed.

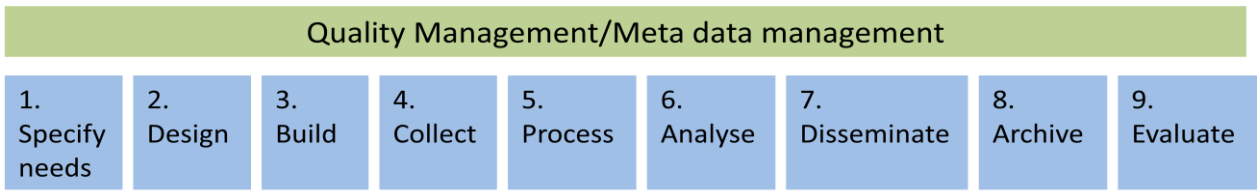
Globally, the model has been adapted or adjusted to existing models around the world. It already provides a basis for the standardisation and benchmarking of production processes, and harmonisation of terminology. (Eurostat 2010).

The GSBPM consists of four levels:

- Level 0, the statistical business process;
- Level 1, the nine phases of the statistical business process;
- Level 2, the sub-processes within each phase;
- Level 3, a description of those sub-processes.

The underlying process modelling theory claims that each sub-process should have a number of clearly identified attributes depending on the issue at hand. These attributes cover e.g. inputs, outputs, purpose, owner, guides, and feedback loops or mechanisms.

Figure 8: The Generic Statistical Business Process Model



Source: The Joint UNECE/Eurostat/OECD Work Session on Statistical Metadata (METIS)

The example of creating new statistics on adaptation expenditure

The GSBPM is not a linear model but a matrix. The matrix allows many possible paths, including iterative loops within and between phases. (UNECE 2009). However, the overall process as seen in Figure 8 shows the intended work process. In the work of creating a new statistical domain of "adaptation" it is important to specify and adhere to the needs of the user community (Process 1). In Process 2, one would thereafter continue to design the method of data collection, might it be a new questionnaire-based survey or to identify other administrative sources. The third component "Build" indicates that the supporting IT systems and the production systems need to be developed. The fourth process would then follow: to actually collect the statistics. Processing the results under the fifth item contains such activities as quality assurance, coding, the derivation of variables and calculating the

end results. The sixth process then contains the work of explaining and validating the final outputs. With statistics it is also important to apply disclosure control which is included under this process. The seventh process contains dissemination of results and promotion activities. Towards the end of the process the results and work process are archived and later on an evaluation of the whole project is conducted. That is when the iterative process becomes important and specific sections are returned to in order to ensure improvements the next time the survey is carried out.

9.3 The System of Integrated Environmental and Economic Accounts (SEEA)

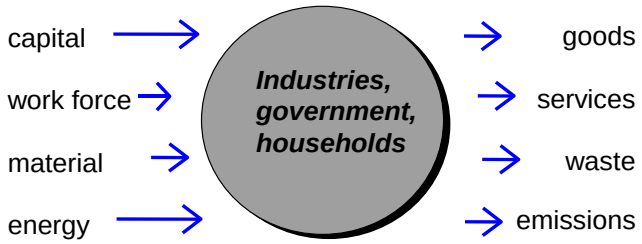
The System of Integrated Environmental and Economic Accounts (SEEA) is a statistical information system that links environmentally relevant data with statistics on economics through the System of the National Accounts (SNA 2008). This means that the definitions, guidelines and practical approaches of the SNA are applied to the SEEA. In broad terms, the system can be described as enabling any user of statistics to compare environmental issues to general economics, knowing that the comparisons are based on the same entities, for example, pollution levels caused by a producing industry can be linked to the specific economics of that industry.

The SEEA has been developed since the early 1990s and has proven to complement normal environmental statistics with policy-relevant economic information. The economic information found in the SNA can be used in many ways: one major indicator from this system is the Gross Domestic Product (GDP).

The SEEA aligns economic and environmental statistics in the same industrial and sectoral breakdowns. This enables the information to be used in environmental economic models, such as CGE-models and econometric models. For climate change, it has mainly been the economy and greenhouse gas emissions that have been the key point of analysis. With this project, the focus is instead on the economic transactions of the state for the purpose of climate adaptation. However, the system allows for expansion to autonomous measures quite easily if this is needed.

The accounts register the structure of production and consumption in society and identify the economic actors and their transactions. One of the economic actors in the accounts is the state. The accounts register how the state spends its money, which economic actors it buys from and for what purposes.

Figure 9: The main statistical components included in the System of Integrated Environmental and Economic Accounts (SEEA).



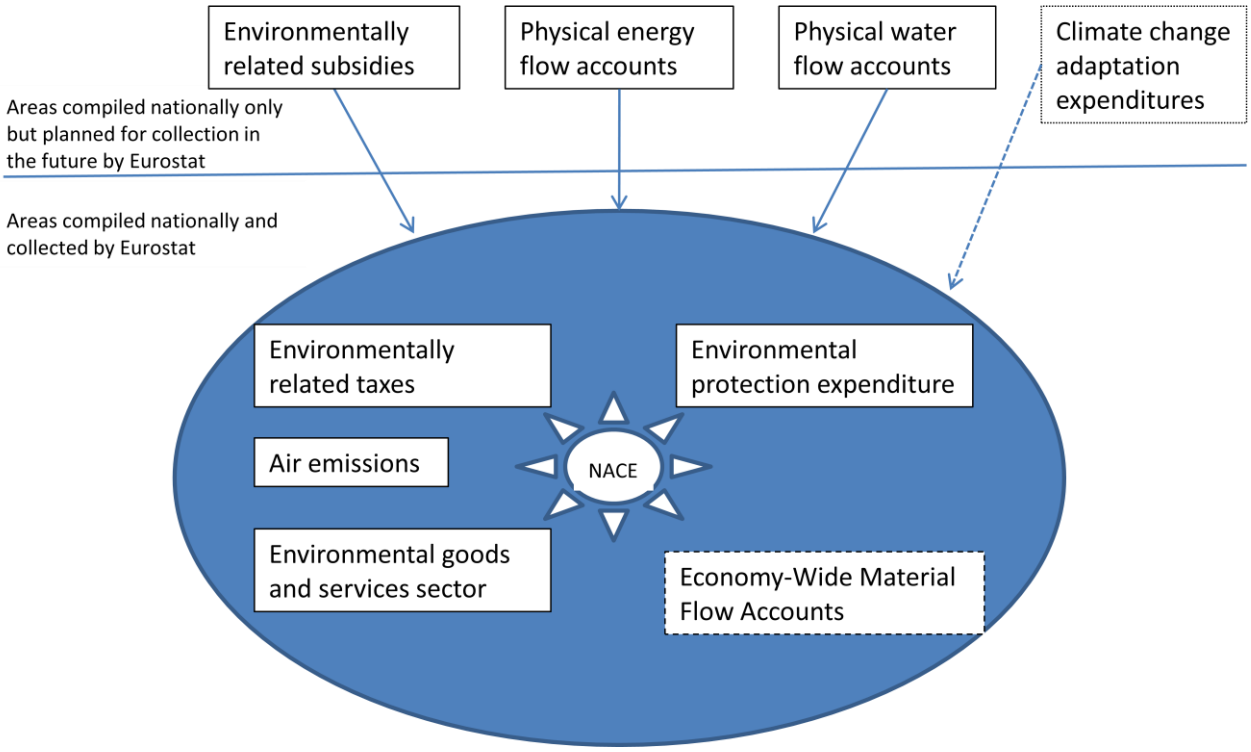
On an EU level, the national developmental work of the SEEA and the SNA is coordinated by Eurostat.

This system is well equipped to incorporate new, environmentally-related expenditure statistics. Under the auspices of Eurostat, a data collection procedure could be developed to suit the European Commission. The first steps have already been taken with the creation of the Reflection Group mentioned above in Chapter 1.

Today Eurostat collects several components of statistical areas under the framework of SEEA. The areas cover both monetary type environmental economic statistic such as taxes and investments but also physical environmental statistics such as air emissions as seen in figure 10. The common denominator for all different components is that they are broken down by industry (NACE) with the exception of economy-wide material flow accounts that focus on the economy as a whole.

Certain components of the SEEA are only compiled at national level. However, Eurostat is currently working on increasing the data collection at EU level and data on climate change adaptation expenditures could be one such component in the future.

Figure 10: Statistics already collected by Eurostat or planned for collection in the future



Below follows a theoretical application of the two systems, the GSBPM and the SEEA.

9.4 Step 1: Specifying the needs

Through the constant flow of questionnaires, data collections and interviews, it has become increasingly important to provide solid reasoning when establishing new statistics. Response burdens should not be increased but reduced, the use of existing data sources are encouraged and each proposal to create something new undergoes close scrutiny by authorities, organisations and the respondents.

In order to establish new statistics on adaptation it is therefore important to specify the needs of the organisation requesting the data. For this specific topic one would say that the European Commission has a need to follow up the strategies set up at EU level. But this might not always be sufficient to ensure that national statistical authorities are provided with the necessary resources. It is therefore important to follow the national developments in strategising the field. In most strategies there is often room for improvements when it comes to indicators and ex-post evaluations.

Besides the needs of the user, this step also includes identifying the scope, concepts and output objectives.

The specific framework under which adaptation expenditure could fit

The overarching concept under which new statistics on climate change adaptation expenditure could fit would be the System of Integrated Environmental and Economic Accounts. By following the different approaches, guidelines and the existing international cooperation in the area statistics of international comparability would be ensured.

With respect to adaptation expenditures, one would have to focus on the measures and activities on the existing system boundaries of, in particular, the residential principle. This means that the economic actor who is performing the activity or is financing the activity should be measured. Within economic statistics this is not difficult, the enterprise or establishment located in a specific nation is also the entity on which the statistics are based.

Things are rather different if one turns to traditional environmental statistics where it is more common to follow the national boundaries rather than the economic actor.

It would be expected that the national statistical offices would implement the developed methodology for adaptation expenditures within their work on SEEA and that Eurostat would then collect the published statistics on aggregate levels.

Defining the scope based on the IPCC definition of an adaptation measure.

The term "Adaptation" must be defined in order to conceptualise this new statistical field. The decision to choose a particular existing definition must be clear and acceptable for the community working on the topic area as well as understandable by the end-user community.

In our opinion, the preferred definition would be that of the IPCC. To recapitulate the definition: "Adaptation is defined as "adjustment in natural or human systems in response to actual or expected climate stimuli or their effects, which moderates harm or exploits beneficial opportunities associated with climate change."

In previous work with other environmental economic statistics it has been argued that compiling statistics based on effect is actually a second step in the analytical chain. First one needs to know how much has been invested as an intended measurement. Thereafter, researchers are able, on the basis of available information, to compare actual outlays with impacts or effects of the measurement (Palm et.al 2009). This is one reason why the scope is a good candidate for future data collection. Another reason for this definition to be applicable is that it is widely used in reference literature and understood by most actors. However, it is still needed for the definition to be tested more broadly on statistical compilations and not only within a specific research study.

By testing the definition, guidelines can be further developed in order for the compilation to become more streamlined and comparable across countries. The testing would be done at country level and assessed by the statistical community and thereby provide good examples and ideas on how to apply the definition. It is important that the measures are not arbitrarily assigned to the adaptation area.

One topic/boundary issue is related to whether or not expenditures for occurred damages could be seen to be included in the definition. The definition describes adjustments to actual

or expected events. One could see expenditures for damage or remediation as an acceptance rather than an adjustment and would therefore not be included.

9.5 Step 2: Design

The second building block according to the GSBPM is to start designing the questions/variables of interest for the data collection and the data collection methodology itself.

The production of government-based statistics is currently based on administrative data. Very few countries perform questionnaire-based surveys but instead rely on official documents and registers to compile statistics. However, if autonomous measures (private actions) had been part of this project, this section would have described alternative ways of constructing sample-based surveys.

This project has however only looked at planned measures and therefore been constructed following the approach of collecting relevant variables and then examining how a new set of tables could be constructed. The idea is that national statistical offices or another relevant authority should compile the necessary information based on the details they can retrieve from their statistical sources. After which the European Commission, namely Eurostat, would send out the proposed tables below to the national counterparts and thereby collect the statistics to be analysed at an EU level.

Proposing a hierarchy of statistical tables

Based on the first evaluation of the list of measures, the data collection exercise and our discussion with the Eurostat Reflection Group, three different types of tables are proposed. They could be used as a data collection tool by the European Commission to be sent to the Member States and the European Statistical System. The individual countries would have the basic data and aggregate the information to suit the tables.

In general all financial flow within the government would be recorded that has bearing on adaptation. This also means that funding mechanisms to the third world would be included in the data. With regards to in-flow to the economy through different EU funds, this would not be captured by the proposed tables as it is not considered an expenditure by the government. In case the European Commission also wants to follow revenues on adaptation, specific tables would have to be developed. However, it can sometimes be the case that the subsidy or investment grant reported is actually financed through different EU programmes. It would be important to clarify this in the event of an actual reporting mechanism in the area.

First level: Total expenditure on adaptation by government level

The first level of data would be the most aggregated level. It is constructed to calculate total governmental expenditure for adaptation. The idea is that countries report the statistics they have gathered that fit in Table A below, issued by Eurostat. Table A consists of the basic variables collected through governmental finances statistics and would be fully

comparable to other macroeconomic aggregates such as GDP, output or similar. The table is also broken down by institutional sector (see Section 2.2.3 and Section 3.2.3). It is anticipated that certain variables would be of minor significance such as property income or that even Social security funds would have very little to do with adaptation measures but it is nonetheless part of the total calculation.

Table A: Total expenditure for adaptation, Year X

Type of financial flow	State	Central	Local	Social security funds
Gross capital formation + Acquisitions less disposals of non-financial non-produced assets (transaction OP5AK2)				
Subsidies (D3)				
Property income (D4)				
Intermediate consumption (P2)				
Other taxes on production + Current taxes on income, wealth, etc.+ Adjustment for the change in net equity of households in pension funds reserves (OEB)				
Total expenditure of functions of government				

Second level: Expenditure for adaptation by COFOG and government level

Table A1 would be in addition to Table A, providing additional information presented a little differently. The total sums would be equal to those of Table A. The reason for creating such a table as seen in A1 is that different analytical conclusions can be drawn from the tables even though the basic information is the same. Normally the data collected by Eurostat from the European countries through COFOG are divided into institutional sector **and** type of financial flow **and** by type of function. However, as adaptation expenditures are in their infancy, it is not expected that the statistics could actually be this detailed so soon. To separate them would enable a country to fill in at least one of the two tables.

It is important to note that only the adaptation expenditure for adjusting behaviour is included but not damage and remediation expenditure (see discussion in Chapter 9.3)

The table only shows an extract of the domains available. Under Category 04, Economic affairs, more sub-categories are available such as e.g. communication, or R&D. The same applies to, for example, Category 06 where Water supply is included as a separate sub-section. See annex 4 for a full list of sub-categories that are included in the COFOG.

Table A1: Expenditure for climate change adaptation. Part of table A (COFOG), Year X

Government functions	State	Central	Local	Social security funds
01 General public services				
02 Defence				
03 Public order and safety				
04 Economic affairs				
Of which:				
04.2 - Agriculture, forestry, fishing and hunting				
04.3 - Fuel and energy				
04.4 - Mining, manufacturing and construction				
04.5 – Transport				
05 Environmental protection				
Of which				
05.1 - Waste management				
05.2 - Waste water management				
05.3 - Pollution abatement				
05.4 - Protection of biodiversity and landscape				
06 Housing and community amenities				
07 Health				
08 Recreation, culture and religion				
Total				

Third level: Expenditure on adaptation by type of weather event

The third level of tables would break each specific topic down into special analysis depending on climatic events and type of financial flow. From the design point of view Table A1.1 is a hybrid of Tables A and A1 as it combines type of event with type of financial flow rather than by institutional sector. It is of course possible to develop two different sets of tables just like the one above. However, the main finances for disaster prevention measures by the public sector would go through the state and a total would probably suffice. Table A1.1 is a sub-set of information to Tables A and A1. This means that only measures directed at disaster prevention would be recorded. In Tables A and A1 other types of measures like green corridors or diversification of crops would be recorded as well

as disaster prevention measures. As the data collection review revealed, most countries consider adaptation to be directly linked to weather types and report data by type of event rather than by sector of the economy, e.g. building dikes to prevent flooding or changing irrigation practices because of water scarcity. It would therefore be important to be able to follow this scenario as well as being prepared for the fact that this table might be the one where most information is available today.

Table A1.1: The direct disaster prevention expenditure. Part of table A and A1. → reduction of impact, Year X, general government

Type of economic flow / Type of weather event	Investment	Intermediate consumption	Subsidies/ investment grants	Co-operation funding
DDP.1. Storms				
DDP.2. Floods				
DDP.3. Extreme temperature *Of which*				
DDP.3.1 Heatwave				
DDP.3.2 Cold wave (Frost)				
DDP.3.3 Extreme winter conditions (Snow, icing, rain, avalanches etc.)				
DDP.4. Drought				
DDP.5. Wild fires (forest, grass, shrub etc.)				
DDP. Epidemic (viral-, bacterial-, parasitic infectious diseases etc)				
DDP7. Other				
Total				

9.6 Step 3: Build

The third step is more related to constructing an internal workflow for effective data collection. The building component also includes testing of the production system.

As mentioned above, the idea is that Eurostat should continue to develop the design of the proposed tables, to further develop the guidelines on how to apply the concepts, definitions and classifications. This would enable the European countries and the national statistical offices to compile statistics ensuring international harmonisation of results and statistics of good quality.

Eurostat and the national statistical offices equally, would have to develop a work process that enables efficient and expedient handling of the data gathering. This involves establishing a process for the handling of incoming data, i.e. how can data be stored and be validated, another process for how to best apply the information gathered to the

appropriate means of transforming data to the tables and finally how to transfer data from the national statistical offices to Eurostat.

9.7 Step 4: Identify and collect

Step four relates to setting up the sample (if the statistics are compiled according to questionnaire-based approaches), setting up the data collection and performing the data collection.

In relation to government finance statistics the procedure would rather be to identify the existing administrative source, i.e. government budgets or specific database containing governmental outlays in which to identify adaptation measures and thereafter collect the data.

With regard to pinpointing how much extra is spent on adapting to climate events it is proposed to follow the approach already set up by Eurostat in the field of environmental protection expenditures. This project proposes an adjusted model that is mostly applicable to enterprise-based statistics but could be a guideline even for planned measures as seen in Figure 11. This proposal was also recommended by the Eurostat Reflection Group as an initial step forward.

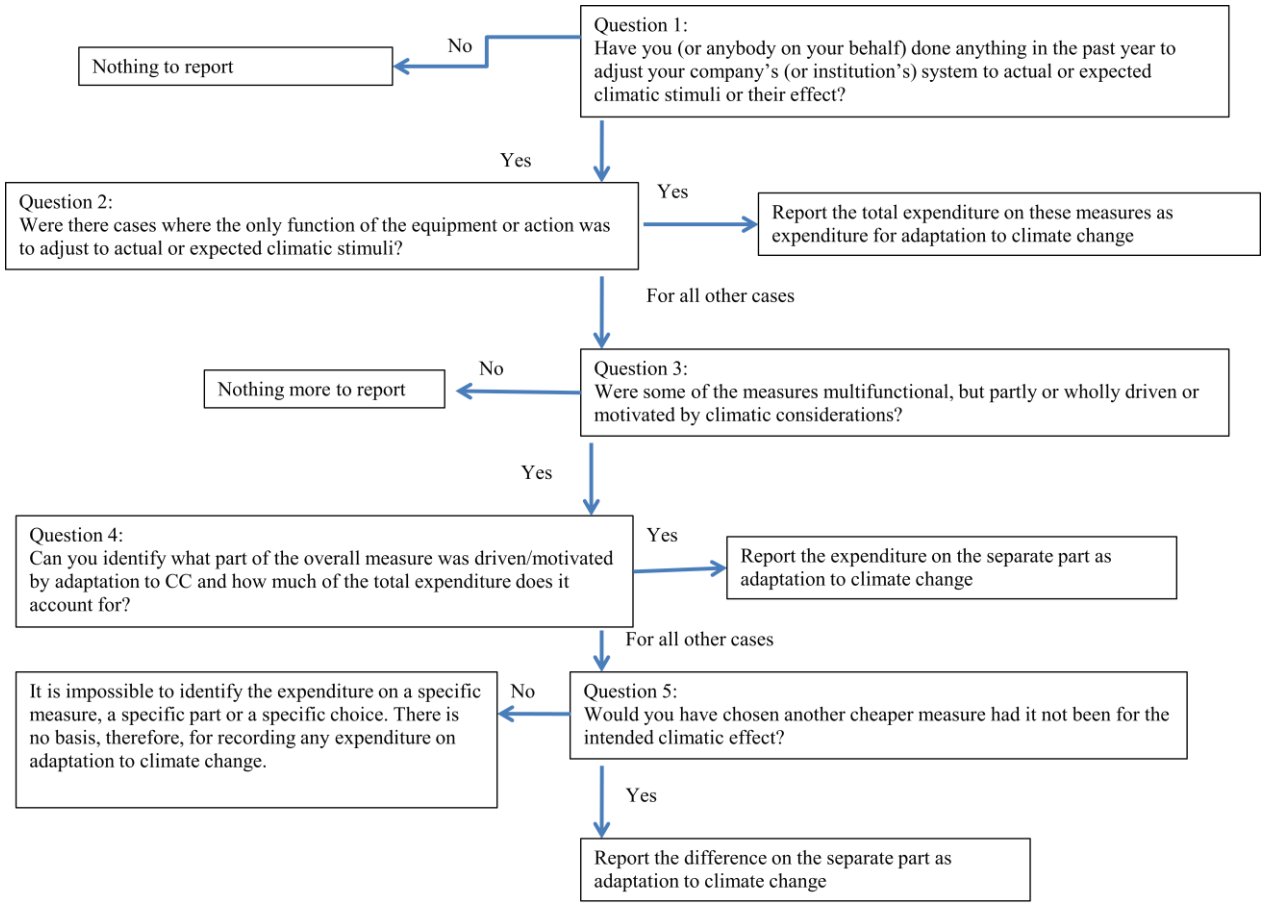
The following text is adapted from Eurostat 2005 publication on environmental protection expenditures – industry data collection handbook. The approach builds on a series of questions where the answer is either yes/no/all other cases. The aim is to try and think of what type of measures have been carried out during the past year to adjust to climate change. This will produce a rough list of measures to be considered when filling in the tables (Question 1 in the tree). The purpose of the following questions is to identify different types of measure involving different types of cost estimations

The second aim is to identify measures where the main function is adaptation to climate change and the total expenditure would be reported regardless of the driving force.
The third aim is to ensure that the remaining measures on the list, i.e. multifunctional activities need to be identified. There are three possibilities for evaluating adaptation expenditure for such measures.
- The first is to identify a separate part that accounts for the adaptation effects and to estimate the expenditure for this separate part (Question 4).
- The second is to identify an extra amount spent related to a specific choice. In this case the extra cost compared to the alternative without the intended adaptation effects would be reported as adaptation expenditure (Question 5).

There will inevitably be some measures that have improved the adaptation capacity but where no climate change adaptation expenditure can be reported. It is important to avoid giving the impression that we would like an adaptation component for all types of activities. That would result either in too high figures, mostly based on a rule of thumb, or a refusal to answer because the response burden was thought to be unacceptable. It is also important to get the point over that the reason for not including these measures is not that they are unimportant, but rather that they are so fully integrated into the normal operating

activity of the business or government agency that it is impossible to speak of and identify climate change adaptation expenditure.

Figure 11: Proposed guideline for determining the part of expenditures specifically dedicated to adaptation measures



9.8 Step 5: Process

The process of the resulting data collection would then follow. This would entail ensuring the correct coding and classification allocation. It would also include validating the basic data. Normally the approach is to look at the previous year's data for the same measure (if it exists on an annual basis) to ensure that no typing errors or erratic behaviour of the data are present in the micro-data material.

The process step also includes summarising the material into selected aggregates. This is when the tables developed for Step 2 would enter into force.

9.9 Step 6: Analyse

The sixth step includes the process of preparing the draft outputs, explaining the results as seen, and validating the aggregates.

The basic results would be validated through other macro-aggregates. For example; if the tables are constructed by COFOG, other COFOG data could be applied, creating new indicators that would both validate the results (i.e. adaptation expenditure are not larger than total government finances) and provide interesting indicators that would enhance the analytical possibilities.

If times series are developed, the analysis would describe changes over time and how the data relates to other expenditure in the same area.

9.10 Steps 7-9: Disseminate, archive and evaluate

The final three steps relate to how the statistical office would proceed in order to publish the information, how it would archive and manage documentation of the area as well as evaluating the entire procedure, from Step 1 once again for the following data collection cycle.

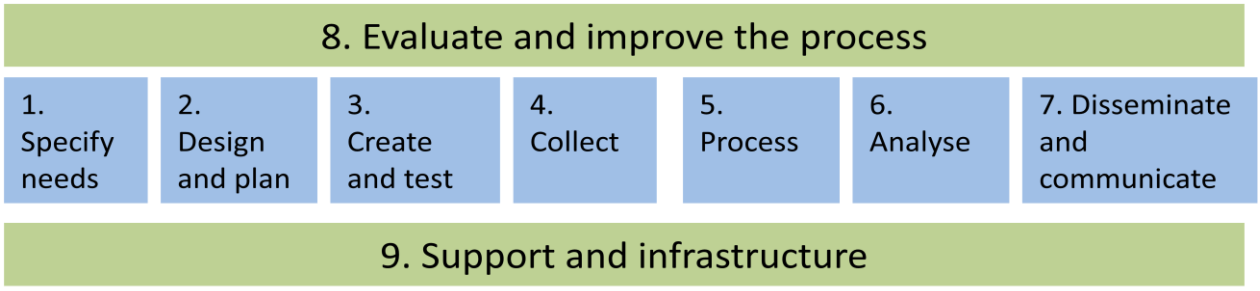
9.11 An example of how a country could implement the proposed methodology

Two aspects facilitate this example. The proposed model builds on two frameworks, the GSBPM model and the SEEA. Statistics Sweden has implemented a national version of the GSBPM model as seen in figure 12. The content does not deviate from the international model however is visualised slightly differently. Statistics Sweden has worked on SEEA since 1993 thus knowing the system from a European perspective very well.

The model at Statistics Sweden focuses mainly on survey sample statistics and quite a few of the sub-steps are not applicable to the approach taken in this proposal. As only the public sector is to be evaluated there would be no need to create such things as population frames, samples, enumeration methodologies or statistical confidentiality checks.

The following example follows each of the first 7 steps of figure 12. Steps 8 and 9 are iterative processes throughout the work flow and mentioned where appropriate.

Figure 12: the GSBPM model at Statistics Sweden



Step 1: Specify needs

The Swedish government has expressed an understanding of the regional and local impacts of global climate change in Sweden and articulated in the 5th National Communication to the UNFCCC that work on climate change adaptation has been identified in Sweden since 2005. There is no national follow-up of the actions taken other than the UNFCCC report and the possibility exists that the government would be interested in compiling annual statistics in the field. Contacts would be taken to identify the national needs in order to compile as much relevant information as possible.

The other user of the future statistics would be Eurostat through the data requirement at EU level. It is not likely that national statistics would be compiled without the expressed request from Eurostat to do so.

Step 2: Design and plan

If Eurostat applies the proposed tables A, A1 and A1.1, some work has already been done that helps the data-gathering process. However, certain additional tools need to be designed as along with the setting up a plan related to the entire production flow.

As the tables proposed only relates to government expenditures there will be no need to design a population or a sample survey. As a result of this there will be no need to establish methods for estimating missing data or national weights to enumerate survey results. The important aspects are to identify the correct source of administrative information, design the validation procedure to ensure the quality of incoming data, design the analysis to be performed and design the output with regards to publishing and communication.

Data sources

In Sweden the Swedish National Financial Management Authority (ESV) coordinates and has the responsibility to collect and disseminate government based statistics. The data they produce is processed according to SNA principles and according to the COFOG classification. The data in its processed form also serves as input data for the calculation of national economic statistics.

With regards to other environmental economic information, such as environmentally motivated subsidies published by Statistics Sweden, the data is processed based on data from the ESV authority directly. The SEEA-group which is responsible for statistics on environmentally motivated subsidies cannot use the processed data from the national accounts group as the level of detail is lost after their aggregations and extra processes.

Designing validation procedures

The data from ESV is generally of good quality, but nevertheless certain checks need to be established to verify the information. A simple check is to find the corresponding appropriation in the national budget and verify the calculations. Additional validation could be achieved through establishing contact with the respective government

departments and authorities for their input into the extracted data. The procedure would also include comparing the statistics with previous cycles (if applicable).

Designing the analysis and dissemination

The analysis of the expected data output would be based on existing approaches in terms of shares and indicators. The tables would be published by COFOG category and totals. In addition, indicators would be created such as total adaptation expenditure as a percentage of total government expenditure. Another indicator that would be interesting to compile would be to use the data on disaster prevention expenditure (table A1.1) and link it to weather events.

Designing the production flow

The entire production flow would be planned according to when the basic data is made available and how often Eurostat would require data to be sent to them. Certain milestones would be:

- The availability of basic data from ESV (T-1 year is usually available in XX),
- The availability of experts in the field,
- The availability of technical support (to build databases or programmes for calculating the results)
- The availability of related data on which indicators can be based on.

Step 3: Create and test

It is not expected that the amount of incoming data will be large in terms of number of rows in a work sheet. It is highly likely that the SEEA group at Statistics Sweden would choose Excel as the preferred way of compiling the statistics. A pilot project would have to be launched to test the scoping, the data manipulation and the output results. If the pilot revealed that the data collection procedure could be based on other statistical programmes, such as SAS then a new instrument would be created that provides a more efficient production system.

Step 4: Collect

It is probable that data on adaptation expenditure would, in a similar fashion, use the data from the ESV directly as for environmentally motivated subsidies. Relevant COFOG classes would be extracted and further operations would follow. Each line in the budget (i.e. each appropriation) would be examined based on the existing text but also by means of the budget document connected to the data. From previous experience it's known that government budget documents are not detailed enough. On such occasions contacts will be necessary with the relevant authority to establish where the spending has been allocated and to what.

Care must also be taken that no double counting is made with regards to the flow of transfers between central government and local government. The data used within the

SEEA-group today from ESV only looks at central government and there might be situations where funding elsewhere has been made.

Step 5: Process

Step 5 mainly relates to sample surveys and as this data compilation would not fall under that category this process is fairly simple. As mentioned, there would be a plan for how to validate the data extracted from ESV, see Step 2. The validation would verify the quality of the data and thereby enable robust results.

Step 6: Analyse

In this phase, statistics are produced, examined in detail and made ready for dissemination. This phase enables statistical analysts to understand the statistics produced. Analysing the results would entail constructing the tables, indicators and explanations of the relevant aspects of the data.

It would be important to interpret the data, explaining the particulars of adaptation expenditures.

Step 7: Disseminate and communicate

This would be the last phase of the production process (besides the evaluation process that follows each new release of statistics). This involves formatting and loading data and metadata (documentation) for publication in the available databases on-line. In addition to the explanatory texts, tables and graphs will be prepared along with press releases to promote the new results.

Statistics Sweden will publish all results on-line free of charge. Data on adaptation expenditure would therefore be available in the Swedish Statistical Database, and have its own place on the website in connection to other SEEA-type statistics.

9.12 Conclusions: standard tables and standardised calculations

The EU budget itself is at the moment not adapted to include new statistics related to adaptation expenditure. It requires the attention of Commission officials to suggest changes in the budget layout before adaptation components can be visualised. Until recently there has not been an interest in highlighting adaptation activities and as a result new ways to accomplish this goal need to be considered.

The proposed tables for data collection on expenditure statistics are mainly directed at the national level budgets but the higher aggregated tables could apply also to the EU budget programmes or projects.

With regards to collecting new statistics on adaptation expenditures, it is proposed that Eurostat, as the coordinator of SEEA in Europe, should take the lead in the further work. Eurosat have already established work processes and mechanisms for co-opting national

experts in statistics and policy related areas for discussions. They also have the systems developed to handle data collection, validation of results and dissemination.

In return the national statistical offices or equivalent have already established the same type of routines to handle new data requests from Eurostat and balance them with national requirements.

It is seen that standardised tools are required to gather new information on adaptation to climate events. The proposal is therefore that either DG Clima themselves propose a new data collection in the field or provide Eurostat with the incentive to carry out the work.

10. Conclusions and possible ways forward

This project focussed on government measures for adapting to climate change. The goal was to propose a system to standardise data flows for the measurement and ex-post monitoring of economic data of adaptation as well as how to calculate adaptation costs. The report focuses on two relevant aspects: quantifying the cost of adaptation, and expenditure on adaptation. Regarding cost estimates of adaptation projects and measures, the report provides a proposal for the assessment of cost estimates based on what economic data is currently being compiled, what different approaches are available to do this, and what the differences are between the approaches. Regarding expenditure on adaptation, the report proposes a new methodology to quantify adaptation expenditure through the compilation of new statistics. It describes how the EU is currently accounting for past spending on adaptation in its budget, examines whether EU Member States hold any statistics on how much they have spent on adaptation, and if this is the case, what types of measures are included as part of these statistics.

The project has only looked at planned measures (i.e. government activities). Aspects related to autonomous measures (i.e. private activities) are not covered as part of this report.

10.1 Project results – specifics

Defining the scope, checkpoints and typologies

In order to establish the scope and boundaries for adaptation expenditures and adaptation costs, the project investigated the available literature for guidance. Several definitions, approaches and practical applications were identified and added to this report. The combination of collected expertise into a standardised framework worked well for the development of a proposed methodology both concerning creating a new statistical field for climate change adaptation expenditures and to develop a stepwise approach to calculating cost estimates. The IPCC definition to be applied when scoping the area out is already internationally recognised. What is missing is a widespread testing of the definition involving a critical appraisal as to the kinds of measures and activities that can be considered as falling under the definition.

In order to guide the person who will compile either the statistics or make estimations based on an identified set of measures or projects with a bearing on adaptation a checklist developed by Eurostat is proposed. The checklist is adjusted to adaptation and it guides the compiler with a set of questions to determine the applicability of a specific measure to adaptation.

The project also investigated existing typologies and ways of categorising the final results of the different calculations. The work has revealed that there is an abundance of studies in the field of cost estimates but that the typologies are often lacking in description or transparency in allocation techniques. Throughout available studies certain sectors were always studied: agriculture, biodiversity, forestry, water and health among others. It did

not appear impossible to apply standard statistical classifications to the area and for this project. Considering that the public sector was the targeted sector for investigation here, the Classification of Functions of Government (COFOG) is proposed for use as the future typology.

From a statistical point of view the typology aims at consistently categorising items so that adaptation measures do not blend into one another. But more than that, it provides a framework to which additional information can be added to enhance a specific study or project, if applied correctly.

Identifying the current situation on data availability

The review initially started out with a review of international and national budgets but this quickly proved futile. Most budgetary allocations are related to broad programmes containing a large variety of headings unrelated to adaptation. This was not unexpected. Even though discussions at policy levels are increasing it is generally the case that the development of indicators and data is of secondary concern and tends to follow a few years behind policy developments.

This said, with the correct application of the definition and access to detailed records of actions, implemented measures and distributed resources data could be made available. If, for example, a country is establishing a climate change adaptation policy with instructions on what type of measures should be dealt with, it is possible to investigate the actual implementation of said actions and, hopefully, financial records are kept that can be used.

Proposing a methodology to assess cost estimates of adaptation

Given the importance of context in assessing the cost of adaptation, determining a replicable methodology was not straightforward. Nevertheless, a seven step approach has been developed based on discussions with the Commission, with industry and on insights from the literature review, in an attempt to provide a consistent approach to cost assessments. The methodology evaluates a number of different cost criteria crucial in determining the costs of adaptation to climate change. For the public sector to be able to systematically determine adaptation cost in response to broader policy questions, the methodology would require the standardization of a number of key data parameters subject to consultation with the public and with industry. This is particularly true in terms of choosing a particular baseline year to allow for a meaningful comparison of potential measures.

From a bigger picture policy perspective, the importance of looking at adaptation cost in the context of a defined time series could help determine the pace of cost increases or decreases, thus illustrating how temperature change correlates to fluctuations in the cost of adaptation. It will be crucial for policy makers and project developers to have a clear understanding of how quickly cost will increase in terms of allocating budgets to future periods in time. Although it may be possible to plot this correlation on the basis of existing data, the most

relevant information available to date is based on global temperature means and does not account for regional, seasonal and inter-annual differences in climate.[65]

The time series issue is however, complicated by the need to consider the timing of implementation. If measures are being compared over a given time series based on a theoretical exercise for the purposes of policy planning then issues related to the timing of measures may be less relevant. However, on a project basis, it would be difficult to determine resource costs in a baseline year without considering the ideal date of implementation. If the Commission is considering the implementation of a series of measures in relation to a budgetary timeframe, timing could coincide with that planning period.

Identifying the current situation on data availability in relation to cost estimates

One of the key data collection needs identified as a result of undertaking this study, is the need for a more centralized systematic data collection of actual impacts, of weather events at the local level. The examples provided in Annex 5, and the probabilities methodology in Annex 6, both illustrate the need for more local temperature and impacts data.

The literature review undertaken in relation to member states, indicates that information related to implemented measures is anecdotal and random. More importantly, while MS may be reporting on the implementation of measures and outlining the total cost, they do not indicate the type of valuation technique applied as part of cost estimates. More systematic data gathering on the application of different approaches and the lessons learned would help future cost estimation exercises.

Proposing a methodology to compile statistics on adaptation expenditure

Public sector expenditures are today compiled statistically through the System of National Accounts (SNA) to capture one nation's commitment in a wide range of issues. Specific governmental expenditures on environmental protection are compiled according to the System of Integrated Environmental and Economic Accounts (SEEA), a sub-set of the SNA and both systems are co-ordinated in Europe by Eurostat.

For government spending on adaptation the proposed methodology follows the SEEA in concept, boundary issues and applications. This will ensure international harmonisation of the compiled statistics as well working with a platform that already has channels and mechanisms established to work on improvements of the proposed methodology. The added benefit of following the SEEA is that the framework enables traditional economic statistics to be linked to the new information and it is possible to analyse adaptation expenditures against other economic commitments. This enables the reader of the final results to grasp the proportions (are the expenditures on adaptation reasonable or very high or very low?) and compare them to other fields of interests.

In brief, the methodology follows a work process model, the Generic Statistical Business Process Model (GSBPM). This model supports the development of new statistics from

[65] . See Tol, 1995, http://www.fnu.zmaw.de/fileadmin/fnu-files/publication/tol/RM23.pdf

design of tables and questionnaires to processing incoming data and presenting the results. It can be applied to both national organisations as well as supranational organisations.

10.2 The proposed path forward

The project emphasises the need for testing the developed proposals of this study. Even though the work builds fully on existing approaches and methodologies, the standardisation process always takes time. By testing the proposals, adjustments and improvements can be made in order to provide the maximum possible benefits in the form of reliable results and credible platforms.

The report does not advise gathering cost estimates as part of a standardised statistical data gathering exercise given the variability in cost calculation outputs, and the impact of different contextual factors. It would be possible however, to use a register such as the Adaptation Clearinghouse to track estimates for analytical and comparative purposes

The project proposes that Eurostat continues the work on establishing a new statistical area on adaptation expenditure in cooperation with DG Clima and relevant experts at other DGs. By doing so the policy relevance of the compiled statistics would be ensured.

A result of their efforts would be that harmonised guidelines and approaches can be established for the national statistical offices to apply in their part of this process. From the literature review it was clear that detailed access to national information is needed to create statistics of good quality. For that reason it is not feasible for the European Commission to gather the data themselves without assistance from national organisations. As such, Eurostat has the responsibility to coordinate this need and work.

DG Clima could lobby for the area of expenditure on adaptation to become part of the future statistical EU regulation on Environmental Accounts. With respect to adaptation cost, DG Clima could consider developing a set of cost assessment guidelines that could be used by stakeholders throughout the EU.

Annexes 1-10

Annex 1. Literature Review Methodology

Annex 2: Typologies in literature

Annex 3: Typology of the White Paper

Annex 4: Classification of Functions of Government

Annex 5. Application of proposed cost methodology to examples of adaptation measures

Annex 6: Using scenarios and probabilities to determine a range of projected adaptation costs

Annex 7: Cost Assessment Templates

Annex 8: Template for collecting measures on adaptation

Annex 9: National spending in relation to adaptation

Annex 10: Levels 1 and 2 of the Generic Statistical Business Process Model

See separate document

Identification and elaboration of methodology to be used in the classification and costing of projects and programmes for adaptation to climate change

- **Annexes 1-10 of the final report**

Final report 2011-02-07: contract SI2.550218

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Date	Publication	Description	Organisation
Computable General Equilibrium modelling (CGE)			
2007	Economy-Wide Estimates of the Implications of Climate Change: Sea Level Rise	Study related to cost estimates for sea level rise and the corresponding measures using a static CGE	FEEM: Francesco Bosell, Marco Lazzarin, Roberto Roson, and Richard S.J. Tol
2001	Economic Impact of Climate Change: Simulations with a Regionalized Climate-Economy Model	Study that analyse adaptation to climate change in different regions of the world using a dynamic CGE model, DART and an Ocean- Atmosphere model (investments in coastal protection)	Kiel Working Paper No. 1065: Oliver Deke, Kurt Georg Hooss, Christiane Kasten, Gernot Klepper, and Katrin Springer.
2001	Estimates of the Economic Effects of Sea Level Rise	Study comparing model investments in coastal protection through static CGE model FUND	Environmental and Resource Economics 19: 113–129, 2001: Roy F. Darwin and Richard S. J. Tol

Date	Publication	Description	Organisation
Investment and Financial Flow and I&FF/Impact assessment studies			
2009	The Costs to Developing Countries of Adapting to Climate Change: New Methods and Estimates. The Global Report of the Economics of Adaptation to Climate Change Study	Provides clear information about the methodology behind the calculations. It deals with planned measures only. The study chose to include adaptation deficits a part of the development baseline.	World Bank.
2009	The Economics of Adaptation to Climate Change – Final methodology report	Clear information on methodologies to cost estimating adaptation, but considers cost in the context of a project portfolio.	World Bank
2007	Sweden facing climate change - threats and opportunities SOU 2007:60	Costs of adaptation estimated as fixed % increase against future climate sensitive baseline capital investment, typically at national/regional scale.	Swedish Commission on Climate and Vulnerability (2007)
2007	Investment and financial flows relevant to the development of an effective and appropriate international response to Climate Change	Includes investments and ongoing current expenditure. Emission scenarios were applied to project investment flows and current expenditure. The report points out weaknesses of the estimation approaches today.	United Nations Framework Convention on Climate Change (UNFCCC).
2007	Fighting Climate Change: Human Solidarity in a Divided World. Human Development Report 2007/2008	The report is an extensive review of the impact of climate change to society. It discusses vulnerability and risks and highlight equity issues. It provides information of various measures and its anticipated cost.	United Nations Development Programme (UNDP).
2006	The Stern Review on the Economics of Climate Change.	Chapter 18 sets out the methodology approach to adaptation. The review follows the idea of the economy is at the core and any loss of income introduces constraints to output. The review also includes descriptions of how to handle benefits of adaptation.	Stern Review

Date	**Publication**	**Description**	**Organisation**
Economic Integrated Assessment Model studies			
2009	Analysis of Adaptation as a Response to Climate Change.	The report uses the AD-WITCH model which is a joint mitigation-adaptation model. The importance of the discount rates is discussed. The report also provide a cost-benefit analysis	te Change. (Carraro et al, 2009)
2009	Economic Aspects of Adaptation to Climate Change: Integrated Assessment Modelling of Adaptation Costs and Benefits	The report emphasises the importance of sound information for decision makers but points out the embedded difficulties of cost/benefit analysis for adaptation. it also describes how price signals and environmental markets can be used but points out the issue of internalisation.	Organisation for Economic Co-Operation and Development (OECD) (de Bruin et al, 2009)
2002	An Integrated Assessment Model of Economy-Energy-Climate – The Model Wiagem	Its core is an intertemporal general equilibrium model WIAGEM which includes all world regions and main economic sectors. The economic model is paired with a model of the ocean carbon cycle and climate.	Integrated Assessment 2002, Vol. 3, No. 4, pp. 281–298, Claudia Kemfert
Review studies			
2010	Review of adaptation costs and benefits estimates in Europe for SOER 2010	A review of major methodologies - but no real proposal for a methodology. Overlooks the importance of including data on the natural environment.	European Environment Agency: Paul Watkiss and Associates
2010	The Costs of Adaptation.	A review of cost estimates for adaptation and concludes among other things that Important knowledge gaps remain both in terms of scope (whether all relevant impacts are covered) and depth (whether for a given impact all relevant adaptation	Fankhauser, S. Published by Wiley WIREs Climate Change 2010 (1). 23–30.

		options have been considered).	
2010	Modelling impacts and adaptation in global IAMs	Reviews the modelling of climate impacts and adaptation in global IAMs, including both models with an economic focus and models with a science focus	Wiley Interscience, Focus article Volume 1, March/Apr i l 2010, Hans-Martin Füssel
2009	White Paper: Adapting to climate change: Towards a European framework for action	Starting point for analysis of measures, typologies and definitions	European Commission
2009	Potential costs and benefits of adaptation options: A review of existing literature	A lot of excellent information on the variables required to calculate cost - a lot of the conclusions here form the basis of the proposed methodology	United Nations Framework Convention on Climate Change (UNFCCC).
2009	Assessing the Costs of Adaptation to Climate Change: A Review of the UNFCCC and Other Recent Estimates.	Looks at actual cost calculations - not methodologies. More emphasis on global aggregate cost.	International Institute for Environment and Development and Grantham Institute for Climate Change (Parry et al)
2009	Shaping Climate-Resilient Development: a framework for decision-making	Outlines a framework for assessing risks and costs of adaptation	Global Environment Facility, McKinsey & Company, Swiss Re, the Rockfeller Foundation, Climate Works Foundation, the European Commission, and Standard Chartered Bank
2008	Economic Aspects of Adaptation to Climate Change: Costs, Benefits and Policy Instruments.	Special focus have been made on chapter one and two where the authors conducts a critical assessment of different estimation approaches to adaptation	Organisation for Economic Co-Operation and Development (OECD)
2007	Climate change: the cost of inaction and the cost of adaptation	Outlines some of the challenges to assessing the cost of adaptation	European Environment Agency
2007	Climate Change 2007: Synthesis Report	Important information of potential scenarios	IPCC
2007	Investment and Financial Flows to	An overview of international	United Nations Framework Convention

	Address Climate Change	approaches to calculating adaptation cost - more of a macro level analysis	on Climate Change (UNFCCC).
***Other studies* – vulnerability, typologies**			
2009	Catastrophic risks	Outlines methodology and statistics on how to account for unknown risks, how to process data outliers	International Journal of Green Economics, 2009. Vol 3, No 2: Graciela Chichilnisky
2010	Document on the accounting of adaptation projects	Working document on typology and type of measures	French Development Agency (unpublished)
2006	Adaptation to climate change: Key terms	The document outlines several key terms and concepts in relation to adaptation to climate change.	OECD, Ellina Levina and Dennis Tirpak

The table builds on Watkiss et al for EEA 2010:

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