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OVERVIEW OF ACCESSIBILITY OF THE CLIMATE CHANGE ADAPTATION FINANCE DATA IN EUROPE

FINAL REPORT

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OVERVIEW OF ACCESSIBILTY OF THE CLIMATE CHANGE ADAPTATION FINANCE DATA IN EUROPE
FINAL REPORT

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1. INTRODUCTION

1.1. Overall Context

Background

A new *EU Adaptation Strategy*, first evaluated in 2018, is expected to be published in early 2021. It aims to enhance resilience and preparedness to current and future climate impacts by better integrating adaptation actions into key sectors of the EU. Consistent measurement, accounting and reporting capabilities are critical to track, analyse, and overcome barriers, risks but also to identify climate change and green growth (investment) opportunities. This leads, for example, to a key concept in adaptation finance – measurement and reporting of adaptation finance and climate risks. Without measuring adaptation risks and understanding the existing investment deployed to address them, it is difficult to develop strategies to overcome barriers to investment in adaptation. Therefore, data, information and knowledge on adaptation finance is fundamental to underpin adaptation policies and strategies.

Reflecting sustainability criteria, especially climate change, in financial markets is increasingly gaining attention as opportunities and risks arising in this context are changing business practices. Among a wealth of publications on this topic, understanding the major drivers and constraints of transforming the financial system to a more sustainable one is key.

The European Commission has resolved to become a global sustainable finance leader, anticipating concrete action and major regulatory changes in its *Action Plan: Financing Sustainable Growth* (2018). The Commission committed to a timeline for implementation of 10 reform areas contained in the *Action Plan*. These fall under three areas: re-orient capital flows towards sustainable investment, in order to achieve sustainable and inclusive growth; mainstream sustainability into risk management; and foster transparency and long-termism in financial and economic activity. Following this, in 2020 the *Taxonomy Regulation* was adopted, helping to create a common language for investors to re-orient investments. This regulation establishes the conditions and the framework to gradually create a unified classification system ('taxonomy') on what can be considered an environmentally sustainable economic activity. This is a first and essential step in the efforts to channel investments into sustainable activities. The Principles for Responsible Investment, Principles for Responsible Banking and the Principles for Sustainable Insurance also drive climate-related disclosures.

These frameworks have ramifications for the whole investment chain, led by governments as all EU policies must contribute to the goal of achieving net zero GhGs, investing in green technologies and protecting the natural environment. All sectors within the economy and society play a role, and governments and decision-makers must provide predictability for investors and other economic actors.

Across the globe, monitoring and tracking of climate finance and green growth needs to be more streamlined and effective. Moreover, the accounting of natural capital and ecosystems – at the public sector level (e.g. mainstreaming the accounting of resources into development planning and national economic accounts), but also at the private sector level (incl. integration of natural capital considerations into financial sector reporting) – needs to be strengthened.

1.2. Objectives

The aim of this Report is to support the EEA in creating a succinct package of information compiling a literature review and responses from a questionnaire, which was designed to collect national adaptation finance information. This will provide input to the briefing and background information planned by the EEA for 2021 addressing the cost, efficiency, and effectiveness of adaptation measures.

This Report is structured as follows. Chapter 2 presents the findings from work on identifying and collating relevant country information on domestic adaptation finance, with a focus on the national level. The starting point is the EEA briefing Financing Europe's Low Carbon, Climate Resilient Future, and the methodology to prepare overview maps on adaptation finance.

Chapter 3 provides an understanding of the availability (rather than the purpose and use itself) of adaptation finance data. This is conducted through an analysis of the results of a questionnaire distributed to EEA's National Focal Points and national reference centres on climate impacts and adaptation in direct collaboration with the EEA.

Chapter 4 provides an overview (mapping) of the different types of adaptation costs distinguished in different studies, their applicability for different adaptation actions, their applicability at national and European level. This includes understanding the different approaches to the mapping of costs and benefits in order to support the EEA in developing a classification of key type adaptation measures, by elaborating further methodological developments, including:

- The types of costs of adaptation (including direct costs and transition costs);
- The ancillary benefits of adaptation; and
- The efficiency of adaptation measures versus the cost of inaction.

The work focuses on reviewing the information base to assess the current state-of-play on domestic adaptation finance among EU countries, the different types of cost distinguished, their applicability for different adaptation actions, and their applicability at national and European level.

It is important to note that this Report does not set out to deliver a full picture of the quantitative European climate finance landscape as such, but rather to carefully review the existing publicly accessible data and information on the various aspects of the European domestic climate finance landscape (e.g. different sources of finance, different climate action areas, etc.).

2. METHODOLOGICAL FRAMEWORK TO COLLECT INFORMATION ON DOMESTIC ADAPTATION FINANCE

2.1. Introduction

Task 1 focuses on identifying and collating relevant country information on domestic adaptation finance, with a focus on the national level. The starting point is the EEA briefing *Financing Europe's Low Carbon, Climate Resilient Future*, and the methodology to prepare overview maps on adaptation finance.

In an initial step, a short methodological note was prepared, to guide the subsequent data gathering and review. This can be found in Chapter 2.2.

The team then conducted a review of the types of data collected previously (actual adaptation spending, planned expenditure and total investment need), and how these categories help the collection of metadata to understand domestic adaptation finance. A simple classification matrix was developed, and is presented in Chapter 2.3.

Annexes:

Annex I: Kick-Off Meeting Minutes

Annex II: Amended Work Plan

Annex III: Annotated Report Outline

Task 1_simple classification literature review (Excel file)

2.2. Methodology

Introduction

This Chapter presents the Methodology Note developed to provide an outline of how the team organised the project and collect country information on domestic adaptation finance. It provides an

overview of the whole project and how the consortium aim to bring the individual tasks together to review the information base to assess the current state-of-play on domestic adaptation finance among EU countries, the different types of cost distinguished, their applicability for different adaptation actions, and their applicability at national and European level.

Analytical Framework

In this project, the definition of adaptation activities is left open, particularly considering the questionnaire, reflecting the more dispersed character of adaptation measures and to allow for national concepts, definitions and interpretations to be included. In general, domestic adaptation finance is defined as public spending on activities that aim to increase climate resilience, and includes investment needs, actual spending and planned expenditure on national projects. Domestic adaptation finance includes spending at the national level, as well as the respective metadata from geographical and sectoral plans and strategies. Therefore, a top-down approach is used.

However, it is essential that adaptation is defined in practical terms, in order to assess, for example, domestic climate spending not earmarked as adaptation. Therefore, a simple classification matrix has been developed considering the answers to **guiding questions**:

- What is defined as (domestic) adaptation spending at the national level?
- Are the subcategories "investment needs", "actual spending", and "planned expenditure" the right categories and how to provide clear definitions for the chosen subcategories?
- Which information besides national adaptation strategies and plans (NAS and NAP) can be used to provide information on domestic adaptation finance?
- Which information on adaptation spending by local authorities is suggested to be included?
- Do investments taking into account future impacts due to climate change count 100% as adaptation finance, and if not which rules of thumb that can be used to estimate share of climate/adaptation finance in total investment? Can the assumption stay that this mainly an issue for investments in disaster risk reduction measures as to cope with the impact of chronic/slow-onset events can be counted 100% of adaptation finance?

A literature review to explore these questions is presented in a classification matrix (Chapter 2.3), and used to inform the development of the questionnaire (Chapter 3). The responses given to the questionnaire were further supported by gathering and presenting metadata (conducting a meta-assessment) on mapping adaptation cost and benefit categories.

Using the EU Taxonomy

The Methodological Note provided a short analysis of how the EU Taxonomy Directive may be used by EEA Member States in the future to report on adaptation finance spending, including investment needs, actual spending (nationally), and planned expenditure. The Directive could prove a useful guideline on how to track, monitor and report domestic adaptation finance and how to systematically assess expenditure. This is presented in detail in Chapter 2.4.

Data Collection

A preliminary **literature review** has been conducted by the team with broad literature covering journal articles and grey literature, with the aim of guiding the consortium with input for their ongoing work. The starting point is the EEA briefing *Financing Europe's Low Carbon, Climate Resilient Future*, and the methodology to prepare overview maps on adaptation finance.

The literature review was used to help the consortium to understand the type of data being sought and where it might be found. For example, there may be common documents such as the NAP that identifies adaptation actions and corresponding spending; however, there may be information pertaining to adaptation in the agriculture sector contained in the National Agricultural Plan, or infrastructure expenditure that has different documentation behind it but all of which are not covered in the NAP.

The literature review is kept brief as its main purpose is to inform the other activities of the consortium. It is not within the scope of activities to analyse the national adaptation plans and strategies of all EEA-32 member countries[1]; and the team proposes to take a relevant sample of national climate policies and priorities. The consortium conducted a brief review of budgetary documents to understand the level of data contained, in order to understand in a further step how the information is typically reported in budgetary documents as part of the questionnaire (see below).

To understand further how adaptation finance data is collected and used at the national level, the consortium contacted three selected National Reference Centres[2] (NRCs) for a **preliminary interview**. Through this feedback process, the consortium improved the structure and content of the questionnaire.

In order to design a more efficient questionnaire to be distributed to the National Reference Centres and Country Representatives in direct collaboration with the EEA, the Ramboll team plans to conduct preliminary meetings with three French institutions, including the NRC, the National observatory on the effects of global warming (ONERC), and two Country Representatives, notably the Agency for ecological transition (ADEME) and the Institute for climate economics (I4CE). Frankfurt School plans to conduct preliminary meetings with Country Representatives from Czechia, and Ecologic Institute conducted preliminary meetings with Country Representatives from Germany, in order to gather additional input.

These interviews aim to better define the scope and the content of the questionnaire, in particular, collecting meta-data on climate finance at the national level. Discussed topics include the current status of climate change adaptation objectives, initiatives, and policy documents at the national, regional, and local levels; relevant references on climate finance and adaptation finance to be consulted, with a focus on the additionality; current and future approaches to monitoring climate adaptation finance and the type of collected and reported data; data sources and providers on adaptation finance; categories of adaptation finance regularly reported to understand whether the three subcategories – investment needs, actual spending, and planned expenditure – can still be considered the right categories and identify "who bears these costs"; the completeness of the national-level data; and recommendations for the questionnaire.

Following these preliminary interviews, a **questionnaire** was developed by the consortium, asking NRCs to provide information about their country in relation to adaptation finance by EEA.

To limit the risk of questionnaire fatigue, the questionnaire was designed in a way to focus on the "must have" data while the "nice to have" was be developed further as part of the examples. It was noted by the EEA that it is not the fault of the consortium in the case of a low response rate, and if the subsequent analysis is therefore only partial. One element of the questionnaire considered whether there are overlays between the adaptation cost and benefit categories and the EU Taxonomy, or whether they are completely separate. This is something that could be monitored in future years to see how they align going forward.

Other recommendations collected during the interviews include the need to well define the perimeter of the questionnaire (i.e. specific questions per type of issue, years of reference, data type, etc.) and to provide definitions of some key terms (e.g. additionality).[3] It is also recommended to develop a section that is equal for all NFPs and NCRs, and a second optional section with more "open questions". Generally, the questionnaire was designed so as to capture the diverse methods and levels of progress related to adaptation finance across the respondent countries.

The EEA informed all NRCs about the project and formally contacted NFPs and NRCs with a letter from the Head of Group. The consortium developed a letter and instructions (see Annexes VI, VII and VIII). The EEA coordinated the delivery of the questionnaire directly from their mailbox.

As responses came in, they were forwarded to the consortium Team Leader who allocated the questionnaire responses to different consortium partners, ensuring an equal number (or as close as possible) among the team, with allocation according to the strongest networks/language capacities. The respective consortium partner reviewed, input into the metadata table (see below) and verified the information where necessary. In this way, each consortium partner reviewed the same questions and answers in a horizontal approach. Following the first email invitation, a follow-up email was

[1] The EU-27, 4 EFTA countries and Turkey
[2] France, Germany and Czechia
[3] Key terms including additionality and incremental costs are defined in the preliminary literature review

drafted by FS and sent to the EEA on 15 December 2020, with the EEA sending the reminder email to all EEA member states on 16 December 2020. A final follow-up request for responses was sent on 7 January 2021, and upon request, EEA member states were given until 14 January 2021 to submit their completed questionnaire.

Links to documents were requested to 'verify' the statements in the first place (as this project focuses on the metadata). Other sources to be used for verification included the country scoreboards prepared during the evaluation of the EU adaptation strategy; the country reporting on adaptation actions under the Monitoring Mechanism Regulation (Art. 15), and made available via the country pages on Climate-ADAPT; and where needed, if insufficient information could be found in the sources above, in the national communications submitted to the UNFCCC, in the Nationally determined contributions (NDCs), or in the National and regional adaptation strategies and plans (NAS and NAPs), as inventoried by CLIMATE-ADAPT; and information sources such as the Covenant of Mayors for Climate and Energy.

In parallel to these activities, the consortium reviewed literature and existing practice to map how these different adaptation cost and benefit categories are currently applied, if and how the non-included costs can be estimated, and the general pros and cons of the different types of cost classifications. The consortium conducted a brief complementary literature review to understand and assess how the comparability between countries and case studies is handled in the literature.

Tasks were coordinated by Frankfurt School, and each consortium partner focused on summarising methodological and practical developments in understanding the costs and benefits of adaptation related to three themes:

- The types of costs of adaptation (including direct costs and transition costs);
- The ancillary benefits of adaptation; and
- The efficiency of adaptation measures versus the cost of inaction.

Compiling Metadata and Limitations

A simple template to structure the responses by country representatives was developed by the consortium (see separate file "Task 1_simple classification literature review (Excel file)".

The availability of national-level data is challenging. Datasets do not cover all sectors of the economy comprehensively; underlying definitions, particularly for adaptation, are not consistent, and data availability regarding adaptation finance is generally less developed than finance information for mitigation. As the analysis can only be as good as the input data, the availability of data for the preparation of climate investment maps remains a challenge. An analysis of the data is considered for a future project and is outside the scope of work.

Mapping adaptation cost and benefit categories is a meta-assessment, and it is out of the scope of work to consider conceptual developments. Rather, an overview is provided of the most relevant information (without being comprehensive on all aspects) based on the expertise of the consortium. Therefore, no final answers on the questions (or some sub-questions) described in this task are given; however the limitations will be highlighted.

It is considered important by the team to focus on improving the methodology for data collection and to improve the methodological framework for future data collection and subsequent analysis, and extending data and sectors, rather than collecting as much data as possible.

Two important caveats to keep in mind are that in general, the metadata presented is not exhaustive but is the result of questionnaire responses and verification based on publicly available documents.

Scope and Boundaries

As explained above, domestic adaptation finance is defined as public spending on national projects. Therefore, spending for adaptation projects in developing and emerging countries is deemed out of the scope of the project. It is also out of the scope of work to collate lower level data such as local and regional, although no distinction will be made on where the money is spent.

This project aims to identify domestic adaptation finance as:

- Estimation of total investments on adaptation
- Planned adaptation expenditures
- Actual adaptation expenditures

For the project, climate-specific investment in full and climate-related investment in part have been included where possible[4]; for example by extracting the climate-specific components of a climate-related budget line or investment. A scoring strategy, such as the use of climate markers recommended as part of the common methodology for tracking and monitoring climate expenditure in 2014–2020 for the European Structural and Investment Funds (the Rio Markers) might make sense to consider in future research, but is not applied here.

Our collection of metadata aims to create a strong base for further data collection and analysis (such as for follow-up projects). Therefore, the analytical framework and methodology used for the similar data collection exercise in 2016 was not applied.

2.3. Simple Classification

First, a preliminary literature review was conducted by the team with broad literature covering journal articles and grey literature, with the aim of guiding the consortium with input for their ongoing work. Given the limited amount of time for this Task, the overview is not exhaustive and not a (full) 'review' as such: it does not compare literature in a comprehensive manner in order to provide final answers to the research questions below, but rather provides an overview of the most relevant literature and its key outcomes and gaps.

The literature review was conducted primarily using Google Scholar and relevant literature given in the bibliographies of those initial sources. An overview of each source is provided in Annex II, including a short summary on how the papers relate to and/or address the Guiding Questions.

The literature review, including a short review of the national adaptation context among EEA Member States, helped to refine the methodology as, for example, it provided an overview of the information available at the national level (or lack thereof), and provided initial ideas as to what needs to be included in the questionnaire.

Guiding Questions

- What is defined as (domestic) adaptation spending at the national level?
- Are the subcategories "investment needs", "actual spending", and "planned expenditure" the right categories and how to provide clear definitions for the chosen subcategories?
- Which information besides national adaptation strategies and plans (NAS and NAP) can be used to provide information on domestic adaptation finance?
- Which information on adaptation spending by local authorities is suggested to be included?
- Do investments taking into account future impacts due to climate change count 100% as adaptation finance, and if not which rules of thumb that can be used to estimate share of climate/adaptation finance in total investment? Can the assumption stay that this mainly an issue for investments in disaster risk reduction measures as to cope with the impact of chronic/slow-onset events can be counted 100% of adaptation finance?
- Who bears the costs?

Review of Types of Data

The previous study compiled for domestic adaptation finance in the EEA used three different types of data, and below we summarise their findings.

Total investment needs

[4] This relates to incremental cost, also defined in the literature review. Climate-specific investment in full refers to investments with adaptation or climate resilience as its primary objectives, including related targets or results. Climate-related investment in part refers to investments that do not have adaptation or climate resilience as its primary objective or effect, but targets activities that deliver adaptation co-benefits.

Estimated total investment requires additional information. However, estimated investment needs figures for adaptation are already advanced in some cases – namely Estonia and Czechia – covering detailed total investment needs associated with the established National Adaptation Plans.

Actual spending

As for investment needs, information on actual spending trends is more readily accessible for mitigation than adaptation. However, most of the reported data – both for mitigation as well as for adaptation – is rather patchy and most often does not portray a comprehensive picture. The exceptions were Germany, Belgium and France, all of whom had initiated successful domestic climate finance landscaping exercises tracking actual spending trends. These provide best practice benchmarks and elements that could be replicated and built on for increasing the knowledge base on climate finance tracking across Europe.

Planned expenditure

From a bottom-up country approach, very limited and patchy data was available regarding planned future expenditure levels for both mitigation and adaptation. A notable exception here is the comprehensive development of planned adaptation expenditure data available for Estonia and Germany. These planned public budget expenditures were based on what it will cost to implement the actions specified in their national adaptation plans.

Nevertheless, the consortium believe that these remain important categories with which to compile metadata to understand domestic adaptation finance in EEA member countries. This Report does not include mitigation but focuses on adaptation, where spending is more difficult to define, track and monitor.

Results of Literature Review

The assessed literature includes a variety of literature types including EEA reports on adaptation finance, national adaptation strategies (NASs) and plans (NAPs), journal publications, grey literature, knowledge platforms and databases, technical reports etc. There is a considerable body of literature on the discussion of climate adaptation in general. More specifically, the covered topics include various types of funding options for adaptation projects, which funding option to choose, the costs and benefits of adaption finance, and the (national and EU) contributions to climate adaptation finance in developing and emerging countries (also with regard to the UNFCCC and the Paris Agreement obligations). However, the availability of information and data on adaptation spending on EU Member State level is quite low (based on assessed literature). Furthermore, it is difficult to find relevant information regarding the definition of adaptation at national level and specification of subcategories in order to conduct stocktaking of national adaptation finance flows. It seems that the availability of information on adaptation spending on regional and local level (e.g. Dutch Delta Programme Report), specific adaptation project-level (e.g. report on German NAP: Aktionsplan II Anpassung der Deutschen Anpassungsstrategie an den Klimawandel) or on sectoral level is better.

- What is defined as (domestic) adaptation spending at national level?

  As is the case at European level, it is expected that countries might have information on climate spending in general, but not specifically earmarked for adaptation. Moreover, for some sectors, e.g. agriculture, it is also difficult to make a distinction between mitigation and adaptation spending.

This is a very relevant question to be asked as the assessed literature does not provide comprehensive information on the definition of adaptation finance and spending at national level. Generally, the assessed literature refers to domestic adaptation strategies, plans and activities (NASs; NAPs etc.). Several documents contain information on budgets for specific adaptation projects and activities, but rarely on the national level. Therefore, it is important to ask this question in order to get a better understanding of the definitions of (domestic) adaptation spending.

The most commonly accepted definition of adaptation today, i.e. the most widely cited in the literature, is that given by the Intergovernmental Panel on Climate Change (IPCC), which defines adaptation as "the adjustment in ecological, economic or social systems in response to actual or expected climate stimuli and their effects or impacts. This term refers to changes in processes, practices or structures to moderate potential damage or to benefit from opportunities associated with climate change" (Climate Change & Comité 21, 2019).

- Are the subcategories "investment needs", "actual spending" and "planned expenditure" the right categories and how to provide clear definitions for the chosen subcategories?

  Besides information on the different subcategories, we would like to see a simple classification on "who bears these costs". A first distinction is between public and private spending (and PPPs), with further details that can include a dedicated budget for adaptation, (regular) budgets from different ministries/agencies, different types of grants or project funding, etc.

The question is closely related to the first guiding question. The chosen subcategories were applied in several EEA reports but not many other reports refer to these subcategories (but also not to other definitions of subcategories as a result of the general lack of information on the definition of adaptation finance). However, these are the categories typically given in national adaptation plans and budgetary documents, although not used systematically, and provide a good starting point for the metadata collection.

- Which information besides national adaptation strategies and plans (NAS and NAP) can be used to provide information on domestic adaptation finance?

  As adaptation is often mainstreamed into sectoral plans, examples can be river basin management plans, rural development plans or various sectoral action plans. When other plans than NAS and NAP are used, double counting of measures appearing in different plans should be avoided.

As reported in the literature, the sample of assessed NASs, NAP etc. do not provide many indications about domestic adaptation finance. It is a very important question as it is key to define the key sources where to find the data on domestic adaptation finance.

- Which information on adaptation spending by local authorities is suggested to be included?

  While it is clear that adaptation is a multilevel governance issue, it is it suggested to focus the search for information to those measures described in national (sectoral) adaptation plans and to use regional and local policy documents only when of a significant magnitude. Incomparable scattered information within a country and across countries should be avoided. For the local level adaptation finance, it is suggested to explore information reported to movements like the EU Covenant of Mayors.

Platforms such as the EU Covenant of Mayors, provide literature and case studies of local authorities, but these documents also do not contribute a lot to the overall understanding of the national adaptation finance as these projects and activities focus more on the regional and local level. However, the identification of relevant sources on adaptation spending information by local authorities would be helpful as well.

- Do investments taking into account future impacts due to climate change count 100% as adaptation finance, and if not which rules of thumb that can be used to estimate share of climate/adaptation finance in total investment? Can the assumption stay that this mainly an issue for investments in disaster risk reduction measures as to cope with the impact of chronic/slow-onset events can be counted 100% of adaptation finance?

Additionality

The additionality of an adaptation project is the portion of finance required in addition to, or separate from, the cost of development. It is the amount of finance required to include the impacts of climate change (Church and Hammill, 2019).

There are considerable overlaps, including geographical and sectoral, between development and climate change, and the integration of respective activities is important for effectiveness and efficiency (Duwe, 2012). Tracking and monitoring domestic adaptation finance must ensure that the geographical and sectoral allocation of finance considers traditional development objectives, where activities focus on vulnerability issues, with climate resilience and adaptation allocations additionally. For example, at city level, if an activity is planned that includes costs to climate proof the investment, that share would be accounted as additional adaptation.

Incremental Costs

Incremental costs are the additional expenses incurred with respect to a baseline to produce a new output or an equivalent output in a way that results in an adaptation impact. Therefore, the adaptation increment is the part of the project dedicated to tackling climate change. For example, MDBs track adaptation investments by only considering those activities specifically designed to address climate vulnerability on an increment or component basis.

Multilateral Development Banks

In developing their Joint Report on Tracking Climate Finance, the MDBs use three steps to identify a project for adaptation finance:

1. Set out the project's context of vulnerability to climate change
2. Make an explicit statement of intent to address this vulnerability
3. Articulate a clear and direct link between vulnerability and the proposed project.

This demonstrates that although a broad range of activities may contribute to adaptation and resilience, only those with the explicit aim to do so will be measured. The report states the methodology captures "only the value of those activities within the project that are aimed at addressing specific climate vulnerabilities. It is not intended to capture the value of the entire project that is made more climate resilient" (MDBs, 2019).

The Climate Rationale

The climate rationale should clarify the causality between specific climate risks, impacts and vulnerabilities and the proposed activity. The Green Climate Fund, for example, does not require an exact calculation of the cost of additionality or increment, but requires a funding proposal to articulate a climate rationale.

2.4. EU Taxonomy Regulation

This section provides a short analysis of how the EU Taxonomy Regulation may be used by EEA member countries in the future to report on adaptation finance spending, including investment needs, actual spending (nationally), and planned expenditure. The Regulation (EU) 2020/852 and its subsequent Delegated Acts could prove a useful guideline on how to track, monitor and report domestic adaptation finance and how to systematically assess expenditure.

Using the EU Taxonomy in classifying adaptation

The EU Taxonomy will become an integral part of the environmental classification at the European level (at least for finance). As such, ways will need to elaborated on how to use the EU Taxonomy in classifying (public) adaptation spending. The EEA has already recognised the potential role of the EU Taxonomy, e.g. in its Key Type of Measures (KTM) for adaptation methodology (EEA, 2020). The methodology proposes ensuring linkages between the EU Taxonomy and the creation of new funding schemes as well as a revision of existing funding schemes.[5]

This sub-chapter discusses further potential applications of the EU Taxonomy to classifying and measuring adaptation spending.

Background

The EU Taxonomy classifies environmentally sustainable economic activities along the six EU environmental objectives.6 According to the Taxonomy Regulation (TR), technical screening criteria for the environmental objectives climate change mitigation and adaptation should be stipulated in a Delegated Act (DA), which was due by 31 December 2020. The publication of the final DAs are repeatedly delayed. Draft DAs were published for consultation on 20 November 2020.

[5] The EEA would be amongst many public institutions who are currently considering similar approaches for using the EU Taxonomy in its processes and schemes.

[6] They are mitigation, adaptation, sustainable and protection of water and marine resources, transition to a circular economy, pollution prevention and control, and protection and restoration of biodiversity and ecosystems.

The EU Taxonomy is structured along screening criteria for (i) substantial contribution to at least one environmental objective, (ii) do no significant harm (DNSH) to other five environmental objectives, and (iii) minimum social safeguards. While substantial contribution ensures a strongly positive impact by an activity, DNSH and social safeguards aim to minimise negative impacts to other sustainability goals.

The EU Taxonomy has three main use cases (EU Technical Expert Group on Sustainable Finance, 2020):

1. Financial market participants[i] offering financial products[ii] in the EU, including occupational pension providers;
2. Large companies who are already required to provide a non-financial statement under the Non-Financial Reporting Directive; and
3. The EU and Member States, when setting public measures, standards or labels for green financial products or green (corporate) bonds.[28]

Data requirements

Use case three indicates that the EU Taxonomy could and should become a reference framework for classifying public spending on adaptation measures. In theory, an application of the EU Taxonomy for adaptation would be possible if sufficiently detailed and comprehensive data was available. Data requirements include:

- **Type of public expenditure:** are public financial resources spent as expenses (OpEx) or as investments (CapEx)? (Highly unlikely but still possible: do public authorities generate (tax) income from adaptation?) Public agencies would need to differentiate their spending according to this category in order to map their spending to the EU Taxonomy.
- **"Asset" level data:** what are the use of proceeds of public financial resources? Project-specific data would need to be collected by public authorities in order to measure performance against the technical screening criteria. The data collection should include collecting data relevant to the assessment of substantial contribution to climate change adaptation as well as to the assessment of DNSH to the other five EU environmental objectives. Collecting information on Social Safeguards seems irrelevant in the EU as EU legislation matches or exceeds those requirements.

Lack of data persists for the moment

The questionnaire responses have shown that the implementation of the EU Taxonomy is still in early discussions, if at all. 47% of respondents indicated that related discussions are ongoing, while 1 respondent (5%) answered that discussions have not started and 47% did not provide answers to related questions.[7] Therefore, an analysis of the availability of relevant data seems to be mostly outstanding and a confirmation of availability of data is not currently possible. Moreover, the questionnaire has shown that a general lack of adaptation-related data seems to exist throughout Member States jurisdictions. This indicates that a lack of data availability relevant for an EU Taxonomy assessment persists.

Further research and cooperation between European and national authorities should be sought in order to develop a joint understanding of the current data availability and methodological approaches

[7] The responses to the questionnaire could be interpreted as a window of opportunity for harmonised action. The EEA should take swift action if it wishes to utilise this opportunity.

to close the data gap. Such a process will mostly likely take several years to yield decision-useful information. The EEA could act as an initiator and a steering organisation of such a process and in this role ensure harmonisation and comparability of data between Member States.

Potential applications of the EU Taxonomy

The relevance of the EU Taxonomy for the classification of public adaptation spending will increase over the coming years. As of today, a full application seems difficult. The following suggestions for an application of the EU Taxonomy should (i) provide an idea of how to apply the EU Taxonomy and (ii) highlight ways to apply the EU Taxonomy in a reduced scope so that its uptake accelerates.

- **Classification of budget lines**: the EU has already (rudimentarily) classified the contribution of budget lines of the current multiannual financial framework towards climate action using the Rio Markers. The Rio Marker system mostly does not distinguish between mitigation and adaptation. Discussions are ongoing as to whether this approach might be (partially) enhanced by applying the EU Taxonomy instead. A mapping between the EU Taxonomy mitigation criteria and the Rio Makers for the EU budget shows that this approach is viable (Sweatman and Hessenius, 2020). Such a mapping should be repeated for adaptation criteria, with a view to national public spending. It is important to note that **the EU Taxonomy does not cover many adaptation activities financed by public institutions yet.**[8] Hence, a further development of the EU Taxonomy should be sought on the Platform on Sustainable Finance for this purpose, which covers Nature-based Services (NbS), environmental approaches and emergency services. The EEA could initiate and lead both processes.
- **Applying the adaptation principles of the EU Taxonomy**: The Draft Delegated Act[9] of the EU Taxonomy's mitigation and adaptation activities sets out five principles adaptation activities (European Commission, 2020). The activities are considered under the EU Taxonomy if they:
    - (i) do not adversely affect the adaptation efforts or the level of resilience to physical climate risks of other people, of nature, of assets and of other economic activities;
    - (ii) favour nature-based solutions or rely on blue or green infrastructure21 to the extent possible;
    - (iii) are consistent with local, sectoral, regional or national adaptation efforts;
    - (iv) are monitored and measured against pre-defined indicators and remedial action is considered where those indicators are not met;
    - (v) where the solution implemented is physical and consists in an activity for which technical screening criteria have been specified in this Annex, the solution complies with the do no significant harm technical screening criteria for that activity.

The principles could be a useful guide for the formulation of key adaptation measures in case the full rollout of the EU Taxonomy is not possible. The EEA may apply the principles in the process of finalising the KTM. An Adaptation Principle Marker (APM) could be introduced by developing a short guiding document that sets out conditions under which the principles could be regarded as being fulfilled. The APM would feature AND / OR conditions and would be specified at the project as well as the public budget line level. E.g. APM50 could be awarded to a budget line, in which half of all funding flows demonstrably to activities in line with the EU Taxonomy adaptation principles. Future work should elaborate how to design an efficient testing mechanism.

- **Adapted and enabling activities**: The EU Taxonomy distinguishes between adapted activities, i.e. activities directly increasing the level of adaptation, and enabling adaptation activities, i.e. activities reduces physical risks in other economic activities or reduces systemic barriers to adaptation. Due to the limited amount of data available on adaptation related parts of the EU Taxonomy at the national level, it is currently hard to make a distinction between adapted and enabling activities. In the future, such a distinction might help identify spending directly dedicated to adaptation (i.e. through data on adapted activities) as compared to indirect effects.

[8] The work by the Technical Expert Group on Sustainable Finance (TEG) was largely focused on EU Taxonomy use cases one and two.

[9] See: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12302-Climate-change-mitigation-and-adaptation-taxonomy#ISC_WORKFLOW

This will further increase transparency on adaptation spending. However, it remains to be seen if data granularity will ever allow such an analysis.

3. COLLECTING NATIONAL INFORMATION ON CLIMATE AND ADAPTATION FINANCE

3.1. Introduction

In order to understand the availability of adaptation finance data, a questionnaire was distributed to EEA national focal points and national reference centres on climate impacts and adaptation in direct collaboration with the EEA. This included developing and distributing the questionnaire, collecting the responses and verifying the information through qualitative desktop research. The process was initiated though preliminary interviews held with representatives from France, Germany and Czechia in November 2020.

The following sections provide the methodology and an overview of the preliminary results of the questionnaire and subsequent information verification process.

Annexes:

Annex VI: Preliminary Interview Guide

Annex V: Preliminary Interview Minutes

Annex VI: Letter and Instructions to NRC CCIVA

Annex VII: Questionnaire Instructions

Annex VIII: Questionnaire Template

Annex IX: Questionnaire Responses

Task 2_Overview of Responses (Excel file)

3.2. Collecting National Information on Adaptation Finance

Preliminary Interviews

To gain insights into how adaptation finance data is collected and used at the national (European) level, the consortium conducted preliminary interviews with three French institutions: the NFP, the National observatory on the effects of global warming (ONERC), and two Country Representatives, notably the Agency for ecological transition (ADEME) and the Institute for climate economics (I4CE). In Czechia, a preliminary interview was conducted with Representatives from the Department of Environmental Policy and Strategies and the State Administration Department of Energy and Climate Protection. In Germany, the preliminary interview was conducted with the German Environment Agency (UBA).

The preliminary interviews with demonstrated that while the three countries are making progress in considering climate impacts, there are major challenges in collecting and tracking adaptation finance data. This includes definitions, particularly around for example additionality or concrete or also softer measures, as well as tracking adaptation finance flows at different governance levels. The different countries are at different stages of developing and implementing adaptation finance reporting. This suggests that it would be beneficial to develop a methodological framework, and provide a platform for countries to exchange information, share experiences, learn lessons from benchmark countries or initiatives, or have access to a summary of approaches applied in a report or briefing. Many countries focus on specific adaptation actions or projects, rather than having a methodological framework in place to collect data on overall (national) adaptation finance spending.

A synthesis of each meeting can be found in Annex V. Recommendations collected during the preliminary interviews were reported in the Inception Report. The results were discussed in a Project Team call on 30 November 2020 and provided the basis for developing the questionnaire.

Compiling Metadata

A questionnaire was developed covering two Parts, in order to focus on the "must have" data (Part I) and the "nice to have" (Part II). The questionnaire is included in Annex VIII.

Respondents were asked to submit their questionnaires by 31 December 2020. A reminder email was sent on 16 December, with a second follow-up email with the extended deadline sent on 7 January 2021.

The team received a total of 19 responses, which can be found in Annex IX. The other 13 countries received "no data" for all items in the analysis. The responses were added to an overview template in Excel, in order to support the data analysis (attached as a separate document). The template was divided into Questionnaire Parts I and II, with a 'long version' including all responses taken directly from the Questionnaire itself, and a 'short' version, where only "yes, no, other, or –" were included. This enabled the team to perform a quick comparison between countries. An overview tab has also been added, with metadata on each data source (description of data, location, time period, source, etc.). An information verification tab provides the results of the information verification exercise as well as the sources used. The links and documents provided by the respondents were prioritised, and supported by additional analysis, where necessary, from sources including ClimAdapt, the EC country scoreboards report as well as from the reports provided on the websites of country's NAS/NAP. Where information was not available in English, the analysis was conducted by a colleague who speaks that language (where possible), and supported by Google Translate. The overview is provided in the separate Excel file "Task 2: Overview of Responses".

3.3. Interpretation of Results

There is a range of information available in the responses. Fifteen countries report including adaptation finance information in either their NAS or NAP. The level of granularity is, however, more varied – in the case of Poland for example, the information included is on cost of inaction, rather than adaptation financing, while in Spain the NAS identifies possible funding instruments with a planned budget. Financial monitoring of the NAS/NAP is only present in seven countries. In terms of additional sources of information, eleven countries responded that there are other public sources of information on adaptation financing. The issue of additionality in monitoring mostly unclear, with only one countries reporting it as being handled with a specific method. There are a range of difficulties mentioned for tracking adaptation finance, with data availability, definitions and methods, governance structure, and additionality all being mentioned multiple times.

Country summaries

Austria

Adaptation finance information can be found in the NAS. This includes information on costs of inaction (i.e. potential damage costs/benefits up to 2050 from climate change without adaptation, assuming global warming of 2 degrees) and actual spending. The NAP includes cost for each adaptation measure that is to be implemented. Both the current NAS and NAP use information from the COIN research project.10 Further information on adaptation finance can be found from the PACINAS project (Public Adaptation to Climate Change), a more recent Austrian adaptation cost research project; the revised NAS and NAP (to be published in 2022) will be based on the PACINAS project.11

Climate change adaptation is coordinated and implemented at all levels of governance (national, regional, and local). The Austrian Environment Agency has some idea of local/regional adaptation finance but do not include this in national adaptation finance reporting. They report that the issue of

10 More information about the COIN (Cost of Inaction – Assessing Costs of Climate Change for Austria) can be found here: https://coin.ccca.ac.at/sites/coin.ccca.ac.at/files/factsheets/Coin_overview_en_v4_02112015.pdf
11 More information about the PACINAS project can be found here: http://anpassung.ccca.at/pacinas/en/ergebnisse/index.html

local and regional policies (strategies and plans) including more information on adaptation finance is becoming increasingly more relevant.

Austria identified that the key challenge for tracking adaptation finance was data availability. They noted that so far, only two research projects had looked into costs of inaction and adaptation expenditure (COIN and PACINAS). The PACINAS project uses two methods to assess adaptation finance and has a clear discussion of how to identify the adaptation component of sectoral spending[12].

Belgium

Adaptation finance information can be retrieved in the NAP, including insights over the total planned expenditure, actual spending and costs of individual actions. No adaptation pathways nor trajectories have been discussed. Besides, a study on the socio-economic impact of climate change in Belgium, based on different scenarios and discussing the costs of inaction, has been presented in the NAP. Other adaptation finance information can be found in the multi-annual budget 2020-2024 released by the Flemish Government (report in Dutch).

Climate adaptation coordination takes place mainly at the national and regional levels of governance, while implementation occurs at the regional and local level. Whether there is not a good understanding of adaptation finance at the national level, it becomes clearer at the regional and local level where estimates on adaptation costs are available in adaptation plans. However, regional policies do not contain information on adaptation finance.

Adaptation finance information is only available for the following sectors: Agriculture and Food, Building and Infrastructure, and Water Management. Therefore, the need consists of increasing data availability related to other sectors.

Main difficulties encountered when tracking adaptation finance include the data availability and conflicts. In particular, the decision-making process involves many entities and adaptation measures are implemented at the regional and local level. Therefore, it is a challenging task that to follow all adaptation costs undertaken by the different actors. Furthermore, some adaptation measures are multi-purposes.

Bulgaria

Both the NAS and NAP include information and evaluations on adaptation finance. The reports also include financial needs and cost of action/inactions. There are several pathways (scenarios) and financial estimations according to these pathways. Both adaptation coordination and implementation are conducted at the national, regional and local levels. The representative also mentions that some regions provide information on adaptation finance. However, no overview is given on local strategies and policies on this topic. No sectoral data was provided.

The main difficulties in tracking adaptation finance in Bulgaria are the governance structure and data availability.

France

France has only adopted a NAP wherein information on adaptation finance is available for total planned expenditure, actual spending and the costs of individual actions, along with other topics such as development aid. No adaptation pathway however is described. Other qualitative information on adaptation finance can be retrieved in the French Climate Plan, in the six French water agencies website and in the "Climat – Bilan d'Activité 2019" report.

The NAP is monitored annually. The monitoring report, which include finance information, is assessed by a specialised committee of the National Council for Ecological Transition (CNTE) that regularly reports to the CNTE, and therefore to the Minister for an Ecological Transition, on the progress of the actions included in the PNACC-2.

Adaptation finance is coordinated and implemented at all levels, i.e. national, regional and local. The National Observatory on the effects of Climate Change is the responsible institution at the national level via the Ministry for an ecological transition. The Adaptation Strategy of the six French Water Agencies together with 13 regional land planning and sustainable development schemes are used at the regional level. At the local level, local authorities are responsible for proposing action plans,

12 See http://anpassung.ccca.at/pacinas/en/index.html for study results (in English and in German)

including both mitigation and adaptation, to combat climate change via territorial climate plans. Overall, there is a good understanding of adaptation finance at decentralized levels of governance but information is not included in the national adaptation finance reporting. Additionally, it is not known whether regional and local policies, strategies or plans contain information on adaptation finance.

Definitions and methods and data availability are the main difficulties encountered in tracking adaptation finance data. This data is available for the following sectors: Agriculture and Food, Forestry, Building and Infrastructure, Water management, Tourism. On the other hand, data related to Energy, Health and Transport sectors is not available. By and large, it is very important to increase data availability for all these sectors.

France is at the forefront of adaptation finance initiatives notably with the new "Green Budgeting: proposition de méthode pour une budgétisation environnementale" aiming at assessing the compatibility of national budgets with environmental objectives, in particular climate objectives.

Germany

The German NAS contains of a whole process of progress reports on the NAS/NAP, updates of the NAPs, monitoring reports, evaluation reports, etc. The documents prepared within the process include Total investment needs, Total planned expenditure, Actual spending, Costs of individual actions and Cost of inaction. The information are described in a qualitative or quantitative form. Partially, information is also estimated and published within German research projects, e.g. estimation of cost of inaction (damage cost-study).

The latest NAP was published at the end of 2020. It includes adaptation action and their costs. The NAP is regularly updated every 5 years and every 2.5 years a mid-term evaluation is implemented. The process is not including an evaluation of finance information in a comprehensive way.

No information is given on the level of coordination and implementation of climate adaptation actions and sectoral data.

The main difficulties mentioned are governance structures, definition of additionality and conflicts. Interesting is that the problem of additionally is highlighted as one important issue and is planned to be tackled in the next years.

Greece

According to the 2011 report by Bank of Greece, the NAS includes quantitative information on adaptation finance. The report explains the consequences of adaptation inaction and how much in total is requested to cover the costs from climate change. The NAP is yet to be developed, and is being labelled as 13 Regional Adaptation Action Plans (RAAPs). All the required financial supports will be evaluated in the report. All information is publicly available as reports provided by Ministry of Development and Investments.

Climate adaptation is coordinated at the national level. And implemented at the regional level. At the regional level, data is collected through the Managing Authorities of the Regional Operational Programmes.

The sectors that include adaptation finance information are: Agriculture and Food, Forestry, and Water Management, although they all received a low score suggesting sector level data is not given priority.

The main difficulties in tracking adaptation finance are the governance structure, definitions and methods, data availability and additionality.

Hungary

Adaptation finance information cannot be found in the NAS. The country respondents reported that this information can be found in the NAP (which in Hungary is part of the Climate Change Action Plan, CCAP 1), however, this could not be confirmed as while this documents has been finalised, as it had not been published publicly at the time of report drafting. The Hungary respondents reported that the NAP includes costs of individual actions, with each proposed action costed by the responsible ministries and their background institutes, who have more detailed costs of actions than those reported in the NAP. In addition to potentially more detailed information held by each ministry, respondents reported that more information was available in individual sectoral plans, such as the

Environmental and Energy Efficiency Operative Programme2 and the forthcoming Clean National Development Strategy.

Hungary's climate change adaptation activities are coordinated at the national level and then implemented at the national, regional, and local level by Ministries, county municipalities and local municipalities. The Hungarian government reports having some information on local and regional adaptation finance but do not include this in national reporting. Some additional information may be found in climate strategies (called SECAPS) prepared by some municipalities.

Hungary identified five key challenges for tracking adaptation finance: governance, definitions and methods, data availability, additionality, and conflicts.

Ireland

Ireland has not provided a detailed answer regarding the information availability in the NAS or NAP. Besides these two reports, information is publicly available, including in the Climate Action plan; however it is not sufficient to determine national adaptation finance data.

Climate adaptation coordination takes place at the national level, although it is implemented at the national, regional and local levels. The Ministry of Environment, Climate and Communications is responsible for the coordination of adaptation policy and has established several committees and offices for better coordination on all three levels of governance. At the local level, there are several approved Actions for monitoring and recording costs from extreme weather events. However, no information is provided for regional policies.

All sectors were scored as 5 in terms of importance, where 5 is "very important"; however, Forestry and Water Management are the only sectors with available information. This suggests that there is a need to increase data availability related to other sectors.

The main difficulties encountered in tracking adaptation finance included definitions and methods, data availability, and additionality.

Italy

Quantitative or qualitative information on adaptation finance is available in the NAS, specifically the costs of inaction, but no adaptation pathway is described and a financial monitoring is not performed. The Italian NAP has not been approved yet. However, the draft of the NAP identifies the available funding sources at all the governance levels as well as general information about actual and future expenditure for adaptation to climate change. Also, the overall finance needed to adapt in the future was assessed via the PESETA project, the EU Adaptation Strategy, the COPA-COGECA report that assessed the impact of the heat wave and drought of the summer 2003 on agriculture and forestry in Europe, Bosello et al. (2012) in "Economic impacts of climate change in Europe: sea-level rise.", Spano et al. (2020) in "Analisi del rischio. I cambiamenti climatici in Italia", the SESAME project and the CIRCE project.

Climate adaptation coordination takes place at the national while the implementation occurs at the regional and local levels. In Italy, the Ministry for the Environment, Land and Sea is responsible for both the mitigation and the adaptation climate policies. However, it is not known whether regional policies, strategies and plan contain information on adaptation finance.

No information has been provided regarding the availability and the importance of adaptation finance data but data availability has been referred being the main obstacle encountered in tracking adaptation finance in Italy.

Luxembourg

Information on adaptation finance is not available in the NAS nor in the NAP. On the other hand, various adaptation actions are put in place to cope with and to adapt to the effects of climate change, but they are not accounted as adaptation measures. Also, these measures are not implemented by a single entity but a number of stakeholders involved in the process and, as a result, adaptation finance information is not centralized.

Adaptation is coordinated at the national level and measures are implemented both at the national and local level but since they represent only a small fraction of the of the budgetary means allocated to the project, they are not quantified nor accounted as such. However, with the new climate pact

(Pacte Climat 2.0), which has been set up in 2020, municipalities will have to put in place local adaptation plans.

Major difficulties encountered include definitions and methods, data availability, additionality and conflicts.

Netherlands

Both the NAS and NAP includes information on adaptation finance. The NAS is sector specific and only provides qualitative information. However, it also contains detailed information on the major national adaptation project, the Delta Programme, including the finance required to cover specific adaptation actions and total planned expenditure until 2034. This information is quantitative and refers to the Delta Fund. The information on the Delta Programme is updated annually. Additional data on adaptation finance is not available from other public or non-public sources.

Adaptation coordination is conducted at the national level, while implementation is organised at the national, regional and local levels. As a result, at the national level there is no overview whether regional policies and local strategies include information on adaptation finance. The most prominent sector in the Netherlands regarding adaptation action and adaptation finance information is water management, as flooding is a major issue. Health, Buildings and Infrastructure were also deemed very important topics for adaptation finance. The other sectors highlighted are Transport (important), Agriculture & Food, Energy, and Forestry (average importance).

The main difficulties in tracking adaptation finance are definitions and methods, data availability, additionality, and conflicts (e.g. with other types of finance flows, double counting, etc.).

Norway

In Norway, no information on adaptation finance is included in the NAP or NAS. In general, adaptation finance is the responsibility of sectoral ministries, and integrated in their activities. All government agencies and local and regional authorities carry a responsibility for climate change adaptation within their field. The Norwegian Environment Agency supports the Ministry of Climate and Environment in the work on climate change adaptation, and is the coordinating agency.

The county governors are responsible for delegating the government's policy on the regional and local level, with municipalities playing an important role in terms of guidance and coordination of adaptation planning. There is some knowledge about financing at this level, but it is not included in national reporting.

Poland

According to the answers provided, the Polish NAS includes information and evaluation on adaptation finance. No information was provided regarding the NAP report. Information is publicly available through the MPA (Development of Urban Adaptation Plans) project. This project is implemented at the national level, by Ministry of Environment, supporting 44 major Polish cities.

Overall, the costs of adaptation measures have not been estimated, although the losses resulting from the lack of adaptation were estimated, as well as costs that will be generated in the case of non-adaptation.

Climate adaptation is coordinated at the national level, although it is implemented at the national and local levels. The responsible institution for coordination and implementation at the national level is the Ministry of Climate and Environment. At the local level this responsibility lies with municipalities and communities. Both regional and local policies and strategies cover information on adaptation finance.

The main sectors covering adaptation finance information are: Agriculture & Food, Forestry, Building and Infrastructure (all scored '4') and Urban (scored '5') adaptation.

The main difficulties in tracking adaptation finance were given as governance structure, definitions and methods, and data availability.

Portugal

The NAP identifies adaptation action lines, along with goals and indicators to monitor progress but financial estimates are only available for short-term planned adaptation action expenditures. Other adaptation finance information is available in the Resolution of the Council of Ministers no. 130/2019,

at the annual "Activities and Management Report" of the Portuguese Environmental Fund, at the PO SEUR's internet portal where data is provided concerning three investment axes programs, and in the "Annual Implementation Report" of the Portuguese Rural Development Program (PDR2020).

Climate change adaptation coordination takes place at the national level while implementation happens at the national and local level. The Portuguese Environment Agency, together with public institutions and regional authorities, are in charge of coordinating adaptation policies, which are then translated into adaptation actions by the municipalities. However, there is not a good understanding of decentralised adaptation finance since regional entities do not communicate information.

Adaptation finance information is available for most sectors but data availability needs to be increased overall. Main issues concerning the tracking of adaptation finance flows include definitions and methods, additionality and conflicts.

Romania

Both the NAP and the NAS are including quantitative and qualitative information on finance. Both documents are currently under revision. So far the total investment needs, total planned expenditure, costs of individual actions are included. The NAS presents adaptation actions in 12 sectors respectively, agriculture, water resources, infrastructure and urbanism, transport, industry, energy, tourism, forestry, biodiversity, public health and disaster management, education and insurances. The costs for the proposed actions are roughly presented in the NAS but are presented in more detailed in the NAP.

No information on level of coordination and implementation and sectoral data is given.

The main difficulties are described as governance structure and data availability. Two additional points are mentioned: the lack of project funding and the lack of means of control regarding the implementation of certain projects by other institutions

Spain

The Spanish NAS together implemented by means of two Work Programmes (NAPs) identifies adaptation priorities, lines of work and possible funding instruments. Furthermore, adaptation actions planned in the NAPs are budgeted. Other adaptation finance information can be retrieved in the evaluation report of the First Spanish National Climate Change Adaptation Plan released by the Ministry for the Ecological Transition and Demographic Challenge in 2019 and in the Spanish National Adaptation Plan (PNACC). Also, the enabling condition applicable to ERDF, ESF+ and the Cohesion Fund (Annex IV COM (2018) 375 final) for the Specific Objective 2.4 (Promoting climate change adaptation, risk prevention and disaster resilience) includes information on financing resources and mechanisms available for climate change adaptation. Additionally, the Spanish Climate Change Office is promoting a detailed analysis of public expenditure on climate change adaptation with the intent to increase data availability.

Coordination and implementation of take place at all governance level. In fact, there exist numerous institutions responsible for climate change adaptation and management that are coordinated by governmental bodies. Adaptation finance information is available at the regional and local level in most regions and for all sectors.

The main difficulties encountered when tracking adaptation finance are the governance structure, data availability and additionality.

Sweden

The central national document on climate adaptation is the NAS approved in 2017. It includes information on total investment needs, cost of inaction and other or additional information. Cost of inaction are presented by sectors and the information are mainly based on Sweden's vulnerability assessment. The NAPs are prepared as sectoral and regional plans and the information they are containing varies.

The coordination and implementation of climate adaptation happens at all three level: national, regional and local. The Ministry of the Environment is leading the activities on national level, including also the sectoral National agencies which are responsible for vulnerability assessments, preparing and evaluation of actions plans for the sectors. Regional agencies are responsible for adaptation in certain geographical areas. Local authorities are responsible for adaptation planning issues. Information on sectoral data was not provided.

The main issues encountered are definitions and methods, additionality and conflicts.

Switzerland

In Switzerland, information on adaptation finance is available in the NAP, but it is stated that financing for climate adaptation measures is not available, and rather financed by the budgets of corresponding sectors. The Swiss Adaptation Action Plan estimates the costs and human resources of adaptation measures and so is connected to total planned expenditure and actual spending. Multiple adaptation pathways are included in the plan, but there is only one adaptation finance estimate based on a strong climate change scenario.

The coordination at the national level is the responsibility of the Federal Office of the Environment, with further regional coordination handled by an adaptation coordinator in each canton. Some regions provide information on adaptation finance, but it is a small minority. There is no overview of adaptation at the local level.

Data availability was the only challenge highlighted in tracking adaptation finance in Switzerland.

Turkey

No detailed answers were provided on the NAS and NAP reports, and it was reported that this is due to the lack of data available. However, it was mentioned that information is evaluated in both NAS and NAP. The information publicly available is accessible through the National Communications and Biennial Reports. According to additional research, there is no budget or cost estimation for the adaptation actions. Cost-benefit adaptation accounting is not conducted at the national, regional or sectoral levels, and municipalities have their own climate finance resources.

Based on the availability of data, the representative mentioned that the data is coordinated at the national level while being implemented at all levels of governance: national, regional and local. There is very little information on regional policies / local strategies, including information on adaptation finance. Forestry is specified as the only sector having the adaptation finance information.

Data availability was the only challenge highlighted in tracking adaptation finance in Turkey.

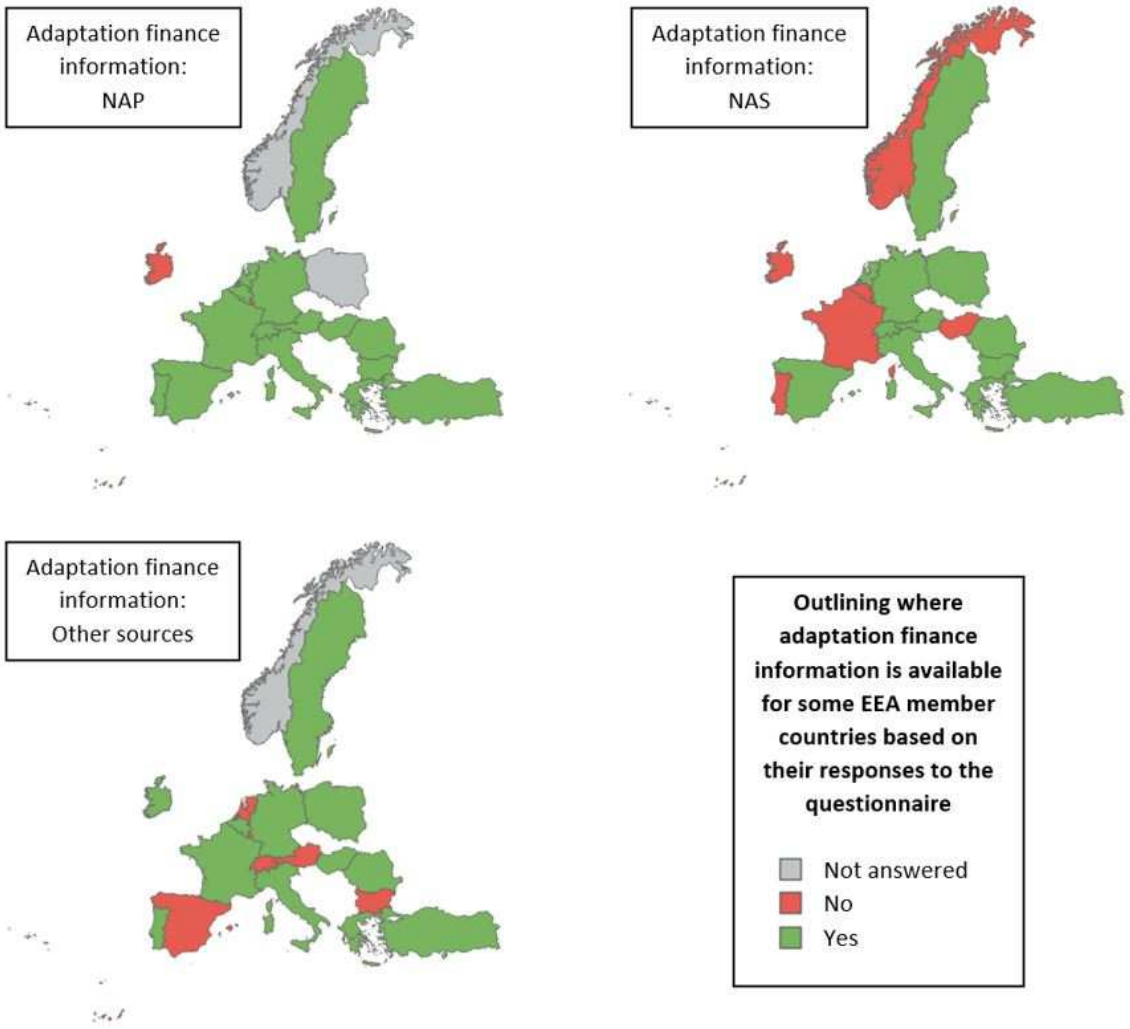
3.4. Cross-cutting evaluation

In addition to the summary of individual country responses to the questionnaire, in this section we summarise key insights across countries.

Adaptation finance information: where can it be found?

The map below shows where national adaptation finance information can be found, notably in the National Adaptation Plan (NAP), National Adaptation Strategy (NAS), or any other publicly available source, as reported in the questionnaire responses from the 19 EEA Member State respondents.

Map 1: Availability of Adaptation Finance Information



Source: Questionnaire Responses input into Tableau Tool

Adaptation finance information that is not included in the specified document (NAP, NAS or other sources as indicated in the questionnaire), is indicated by 'No' in Map 1.

As shown in the figure, two countries did not include adaptation finance information in their national reports, namely Luxembourg and Norway. Ireland did not include adaptation finance information in its NAP and NAS, but in other documents. Poland included information in its NAS and other documents. Belgium, France, Hungary and Portugal included information in their NAP and other documents. Austria, Bulgaria, the Netherlands, Spain and Switzerland included it in their NAP and NAS, while only Germany, Greece, Italy, Romania, Sweden and Turkey included information in all above-mentioned documents.

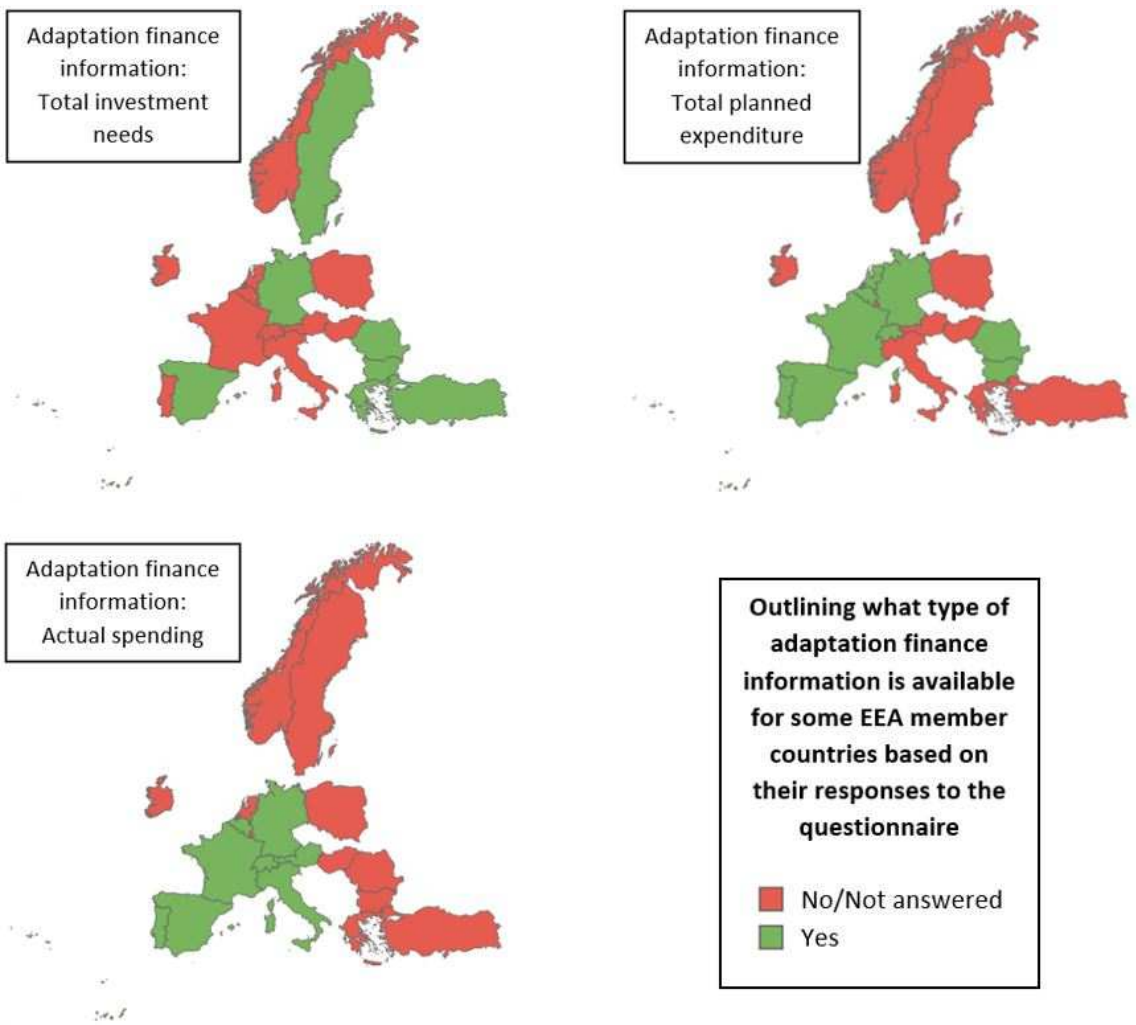
The same information combined into one overall map can be found in Annex X.

Based on these maps, we will discuss differences across Europe.

Adaptation finance information: what type of data is available?

The map below shows what type of adaptation finance information can be found in both the NAP, the NAS or other publicly available sources.

Map 2: The Type of Data Available



Source: Questionnaire Responses input into Tableau Tool

As shown in Map 2, Hungary, Ireland, Luxembourg, Norway and Poland did not include any type of information in their national documents. Austria and Italy only included actual spending information in their national documents. The Netherlands included only total planned expenditure in its national documents. Belgium, France, Portugal and Switzerland included both total planned expenditure and actual spending information. Greece, Sweden and Turkey only included total investment needs data. Bulgaria and Romania included both total investment needs and total planned expenditure information, while only Germany and Spain included all above-mentioned adaptation finance information.

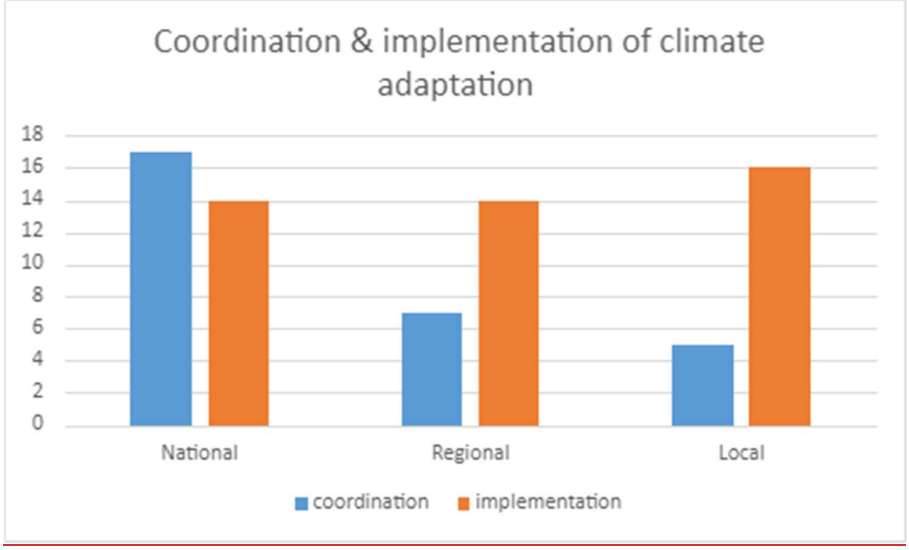
These maps can then be compared with the previous set of EEA-produced maps that illustrated data availability in 2016.

National/regional/local adaptation finance

Coordination of adaptation actions is carried out at the national level in all countries, except Romania and Germany, who provided no response. Seven countries noted additional coordination at the regional level and five others at the local level. In terms of implementation of adaptation, the

responses were more evenly distributed, with 14 countries reporting implementation at the national and regional levels and 16 countries at the local level.

Figure 1: Coordination and implementation of climate adaptation



Source: Questionnaire Responses

As shown in Figure 1, in most countries, the institutions responsible for adaptation are the national environment/climate ministries. In some instances, this body is not a ministry, but rather an environment agency (Portugal), or an observatory (France, Belgium). There are some cases where the responsibility for adaptation is delegated to sectoral ministries, such as in Norway and Sweden. At the regional and local level, adaptation is generally the responsibility of municipalities or local authorities.

Countries were also asked to report on the understanding of adaptation finance at decentralised levels of government (i.e. regional, local). Ten countries reported having some knowledge of local/regional adaptation finance, but it is generally not included in national reporting. Only in the Netherlands and Greece is local/regional expenditure tracked in national adaptation finance reporting.

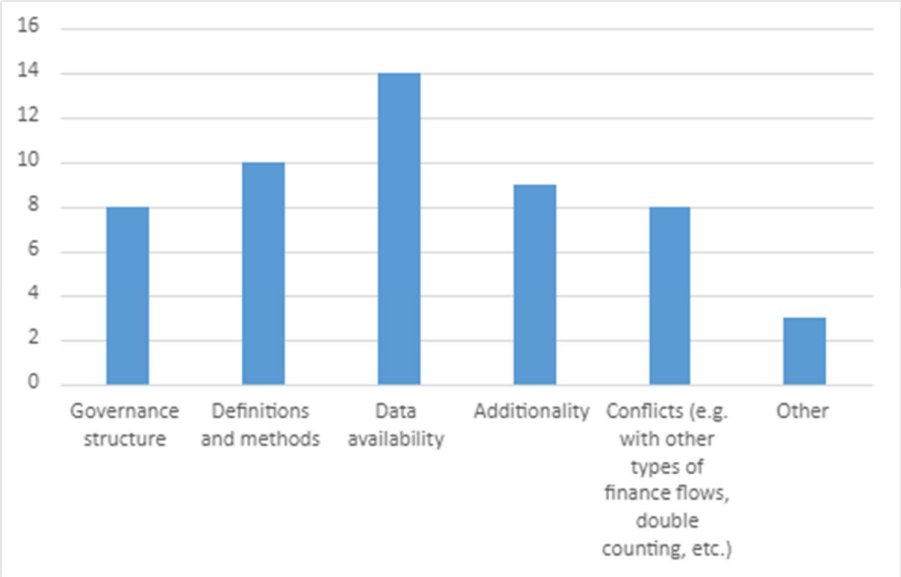
In general, the knowledge of regional adaptation finance is limited at the national level, about half of the countries report having no overview of the situation, and the other half report that a selection of regions provide data or the issue is slowly becoming more relevant. At the local level, only four countries reported that some strategies and policies may contain information on adaptation finance.

Main difficulties

The survey asked country respondents to identify the major difficulties that they faced when it came to collecting adaptation finance information. Country respondents were asked to select the main difficulties they encounter from a multi-choice list of six options (with one option being 'other'). Respondents could select as many or few difficulties as they wanted.

As shown in Figure 2, the biggest challenge is data availability; of the nineteen respondents, fourteen countries listed this as a challenge. Definitions and methods was second most commonly identified challenge (ten countries), followed by additionality (nine countries). Governance structure and the challenge of conflicts with other types of financing flows were both listed by eight countries.

Figure 2: Main difficulties to track adaptation finance encountered by countries



Source: Questionnaire Responses

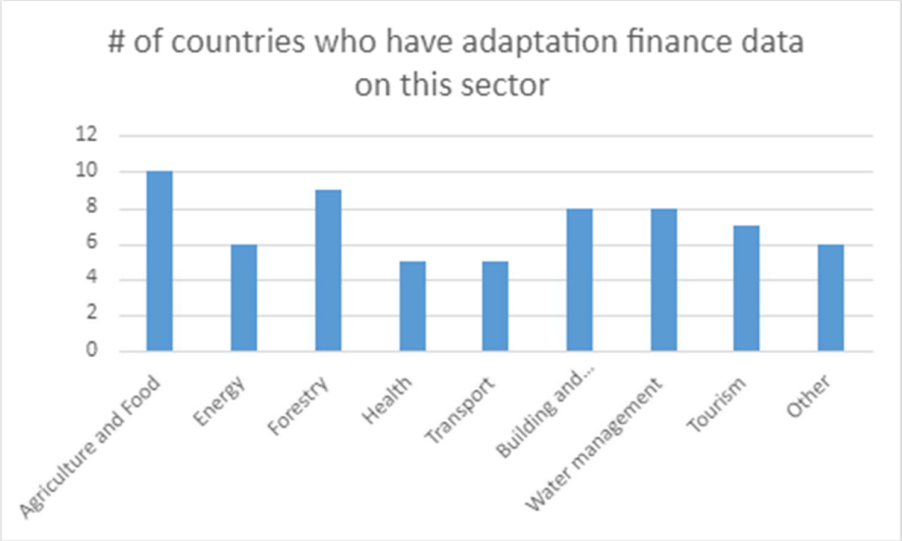
In a follow-up question, we asked whether countries had a specific methodology for dealing with additionality. Fifteen countries out of the nineteen reported that they had no specific approach for dealing with additionality. Of the four other respondents, Portugal reported that most of the projects related to adaptation are allocated at 100% to adaptation with only a few projects assessed in more detail. Sweden reported that in some contexts they have specific approaches. Germany and Austria identified that recent research or future research projects aimed to clarify approaches for additionality of adaptation finance.

Sectoral data: Availability and importance of adaptation finance data

In this section, we include draft figures summarising country responses regarding the availability of adaptation finance data per sector. At time of drafting, there were twelve partial or fully completed responses for these questions.

Figure 3 shows the number of countries who reported having some adaptation finance data for the listed sectors, out of 12 countries who responded to this question. Most common was Agriculture and Food (10/12), followed by Forestry (9/12), and then Building and Infrastructure and Water Management (8/12). A number of countries also listed other sectors for which they had finance adaptation data, including "coastal areas", "disaster risk reduction"/"protection from natural hazards, "urban areas", among others.

Figure 3: Number of countries who reported having adaptation finance data, by sector



Source: Questionnaire Responses

Figure 4 shows average country responses regarding the importance of increasing data availability in the listed sectors. There were eleven partial or fully complete responses. Respondents had to score the importance out of five points. Agriculture and Food was the highest priority, followed by Forestry, Water Management, and Health. Building and Infrastructure was also considered important, while Tourism and Transport were lowest priorities. Interestingly, there does not appear to be a relationship between existing availability of sectoral adaptation data and the need to increase data availability; rather, those sectors where data was most likely to already be available were also the same sectors where respondents most wanted to increase data availability. This could indicate that these sectors are generally highest priority, and that there is a general dearth of data.

Figure 4: Average score given regarding importance of increasing adaptation finance data, per sector

Source: Questionnaire Responses

Best practice and future plans

The questionnaire responses and subsequent analysis demonstrates that there is no standard method to track and report adaptation finance data. However, there are some interesting examples from various countries, presented here.

Austria has implemented a more advanced process on estimation of cost of inaction and adaptation expenditures. In Austria two studies have been implemented during the last years. The study on the rough initial estimation of the "cost of inaction" until 2050 which can be expected as a result of climate change in Austria was completed (COIN-project; Steininger et al. 2015). The purpose of the study was to estimate potential damage costs and quantifiable benefits resulting from climate change (without adaptation). A second study addresses current adaptation-relevant public expenditures and a indicative scenario for future expenditures for climate change adaptation until 2050 (PACINAS (Public Adaptation to Climate Change) project, 2017). The results of the COIN project are already included in the NAS and NAP. The PACINA results will be integrated in the revision of the NAS and NAP in 2022.

A number of countries mention planned further improvements of their adaptation finance data collection and monitoring.

Some countries are working at their classification of adaptation investments. Poland, for example, is planning a harmonisation of their used definitions and the climate expenditure tracking system which should not only be used by the responsible climate and environment ministry but also by other public institutions and ministries. A suitable taxonomy for adaptation financing will be developed in Germany. Basis are existing taxonomies and the focus is on the federal level but the method should be replicable by other institutions, e.g. federal states.

Other countries are working on a better estimation of their actual and planned adaptation costs or cost of inaction, e.g. Flemish Region of Belgium is implementing cost-benefit analyses for considered adaptation measures. In Germany, a study on costs of inaction and total adaptation investment needs started during the last months, commissioned by the environment ministry. Efforts to estimate investment needs by sectors started in Portugal. A National Roadmap including costs of adaptation until 2100 for three different climate scenarios is currently implemented.

An improved financial monitoring is mentioned. In Luxembourg, the financial monitoring will be further discussed in the NAS/NAP update. Germany aims to improve monitoring systems on public adaptation finance by developing a methodology to capture climate change-related damage and costs systematically (esp. from extreme weather events). The issues of additionality of adaptation is one major issue for the analysis.

Further research ideas

The survey shows a very diverse picture for adaptation finance data, evaluation and monitoring in the EEA member countries. A full picture cannot be drawn but the implemented analysis shows that there is still a demand for clear definitions on adaptation finance terminology. Methodological issues consist for a number of issues. The estimation of costs of inaction and adaptation expenditures could need more emphasis, e.g. most countries have not emphasised so far or only starting to look into tracking of adaptation finance and the issue of additionally of adaptation. Most countries do not have different adaptation pathways and if national pathways exist the estimation of the adaptation costs or expenditures is not linked to them.

4. TYPES OF COSTS AND BENEFITS OF ADAPTATION ACTIONS

4.1. Introduction

In order to understand the cost, efficiency and effectiveness of adaptation measures, it is important to understand the different types of cost distinguished in different studies, their applicability for different adaptation actions, and their applicability at national and European level. This section focuses on summarising methodological and practical developments in understanding the costs and benefits of adaption related to three themes:

- the types of costs of adaptation (including direct costs and transition costs);
- the ancillary benefits of adaptation; and
- the efficiency of adaptation measures versus the cost of inaction.

Annexes:

Annex X: Ancillary Benefits of Climate Adaptation – Annotated Outline / Proposed Approach

Annex XI: Economic Evidence on Efficiency of Adaptation Action vs Inaction – Annotated Outline / Proposed Approach

4.2. Adaptation cost types (including direct costs and transition costs)

Introduction

In its Fifth Assessment Report (AR5), the IPCC defines adaptation as "the process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects" (IPCC, 2014a).

The costs of adaptation have been defined in several ways. The IPCC defines adaptation costs as "the costs of planning, preparing for, facilitating, and implementing adaptation measures, including transition costs" (IPCC, 2007). The UNFCCC defines the cost of adaptation as the cost of any additional investment needed to adapt to or exploit future climate change (Chambwera et al., 2014). The costs of adaptation are also defined as "the value of the resources society uses to adapt to climate change" or as "the costs of avoiding climate change damages" (Callaway, 2003).

It was not possible to find any clear definition of costs of adaptation in previous EEA reports and documents even if the term is widely used, particularly in the EEA Technical report No 13/2007 (EEA, 2007).

Broadly speaking, it is important to appraise the costs of adaptation in order to identify the most appropriate interventions for reducing vulnerability, enhancing adaptive capacity and building resilience. Moreover, it is important for effective decision support and making processes in broader development and sectoral planning contexts. It also helps to determine the costs of the residual damages that remain after adaptation measures are implemented, since they will not completely cancel out the adverse impacts of climate change. Finally, tracking the costs of adaptation is necessary for a better monitoring and evaluation of adaptation policies.

When addressing the different types of costs of adaptation, there are several challenges. First, it is necessary to define the boundaries and the scope of the analysis for understanding the societal costs and benefits of adaptation actions. Second, thematic priorities exist, resulting from adaptation costs being mainly sector-specific and accessible via technical reports and scientific papers (ECONADAPT, 2015). Third, it is important to understand the synergies, trade-offs and conflicts between the different types of costs of adaptation. In fact, economic analyses tend to focus on incremental adaptation costs therefore neglecting that adaptation costs usually overlap between categories. Additionally, adaptation costs represent only one type of cost, i.e. those that reduce the impacts of climate change, while the overall response to climate change also includes the costs of mitigation,

i.e. those to reduce the extent of climate change, and the costs of residual damages that cannot be mitigated nor adapted to (Fankhauser, 2009).

Another challenge is related to the mainstreaming of adaptation costs, which are likely to be integrated with existing policies, programmes and operations (Li et al., 2014), and therefore less visible in budgetary and financial documents. Furthermore, economic analyses naturally present uncertainties associated with climate change; neglecting uncertainties would lead to a potentially substantial underestimation of costs (see chapter 4).

Generalities about the adaptation actions types and approaches

Adaptation actions are intended to enhance protection capacity against adverse climate change effects, improve resilience, reduce vulnerability or take some sort of benefit from the consequences of climatic events. The European Environment Agency defines four types of adaptation actions (EEA, 2016a):

- **Green actions** refer to nature-based solutions (e.g. introduction of plant species in urban developments to limit runoff and avoid heat islands, new crop and tree varieties, or wetland restoration that allows rivers to naturally flood floodplains).
- **Grey (or hard) actions** include the development of artificial infrastructures (e.g. seawalls, beach restoration to cope with coastal erosion, etc.).
- **Soft actions** include managerial, legal or policy approaches intended to produce changes in behaviour and governance methods (e.g. early warning systems, insurance against climate-related damages).
- **Combined actions** are those implementing simultaneously different types of actions.

Hard measures are sometimes preferred to soft measures because their benefits and costs are easier to quantify. However, critical soft measures tend to be more relevant to facilitate adaptation (Li et al., 2014) and are more frequently used than the structural/physical ones (EEA, 2020b). Economic analysis and tools must be adequate for the scale of the problem and the practical applicability. Qualitative screening assessments or cost-benefit analysis, cost-effectiveness analysis, multi-criteria analysis, expert judgment and robust decision-making frameworks may be used for analytical consideration. Empirical methods and techniques can be used to inform the costs and benefits of soft measures. Such tools and frameworks are discussed in more detail in chapter 4.

Adaptation actions may be implemented at different levels: national, regional (NUTS2) and local (NUTS3) respectively. Those belonging to the second and third groups are more difficult to monitor and track due to a lack of governance structure.

Another categorisation is provided by Agrawala et al. (2008) and Chambwera et al. (2014), which state that adaptation action costs, as well as many ancillary benefits as disclosed in chapter 3, may occur:

- At the **sectoral level**, where local-scale costs are limited to a particularly vulnerable economic sector and therefore are more precise (EEA, 2007); and
- At the **national and global levels**, where assessments of the overall need for adaptation finance and the cost of priority actions are taken into account (figures are less precise but more relevant for country's decision-makers).

ECONADAPT (2015) state that adaptation costs are available but are unevenly distributed among sectors (i.e. good coverage for coastal zones, medium coverage for agriculture and water sectors, flood infrastructure and over-heating (energy, built environment) and limited sectoral data for energy, transport infrastructure, tourism, biodiversity, industry and public health sectors).

The EEA (2016) recognises the existence of different approaches to adaptation:

- The **coping approach** consists of measures taken to cope with the immediate impacts of extreme events, or once they appear or when stresses become obvious.
- **Incremental adaptation** occurs when adaptation planners and decision-makers build on existing adaptation measures and knowledge acquired via disaster risk management by

incrementally improving them and increasing their efficiency. Incremental adaptation is intended to maintain the essence and integrity of a system or process at a given scale.

- **Transformational adaptation** happens when radical changes are implemented to transform the adaptation approach and attributes of a system in response to climate and its effects. For example, establishing new and innovative solutions aiming to transform the city to be resilient and sustainable. This makes use of behaviour and technology to change the biophysical, social or economic components of a system.

When it comes to the types of adaptation, two main categories are generally identified (Li et al., 2014). The first considers exclusively spontaneous adaptation, which occurs in the absence of public adaptation policies but is difficult to isolate. The second examines major adaptation options that can be planned, i.e. adaptation that is anticipated and organised in relation to public decisions. Public planned adaptation may be in the form of investments in major infrastructures (such as strengthening sea defences), as well as in changes in standards and regulations that will give private actors the freedom and incentives to adapt. Spontaneous adaptation is not typically considered in the cost estimates of adaptation.

- **Spontaneous (or autonomous) adaptation** is defined as "adaptation that does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems" (IPCC, 2014b). It is mainly undertaken by private parties acting on their own without public intervention but within an existing public policy framework (UNEP, 2016).
- **Planned adaptation** results from deliberate policy decisions taken in response to evidence that conditions are changing or have changed (e.g. via climate change impact and vulnerability (CCIV) assessments, national risk assessments (NRAs)) and that action is needed to re-establish, maintain, or achieve a desired state. It can be undertaken by public authors to address current vulnerability and builds adaptive capacity.

Another categorisation distinguishes adaptation as:

- **Reactive**, when it takes place after the impacts of climate change are observed; it can be spontaneous, when it occurs within the ecosystem in reaction to climate change, or planned.
- **Anticipatory**, when it takes place before impacts of climate change are observed and is likely to tackle longer-term challenges.
- **Silent**, when adaptation includes all adaptation actions that are not recognised as such, are not quantified nor accounted for in the adaptation component of some projects. Whether it is possible to get an estimate of the financial funds related to silent adaptation, it is very challenging to specifically determine their destination and their contribution to the improvement of climate change adaptation capacity (Climate Change & Comité 21, 2019) (see also chapter 4). This is particularly true in the field of disaster risk reduction (DRR), which has mobilised important funding for decades, without explicitly linking it to climate adaptation.

When adaptation actions lead to current or future increased risk of adverse climate-related outcomes, increased vulnerability to climate change, or diminished welfare, they are defined as **maladaptation**. By and large, maladaptation can affect the implementing/targeted actors, an identified external actor, and/or a number of resources resulting in indirect effects for all or several actors (Juhola et al., 2016).

Overview of investments types, costs types and categories

Adaptation actions may be undertaken in two broad sectors (Li et al., 2014).

- The **public sector** is the main driver of adaptation finance at the international and domestic levels. International adaptation finance flows are earmarked because they follow certain rules and data is relatively complete, while domestic adaptation finance flows are seldom earmarked since mostly managed by ministries and data is limited (UNEP, 2016).
- The **private sector**, where adaptation actions are mostly integrated into development interventions or business activities (UNEP, 2016) and therefore are difficult to track because adaptation actions rarely stand-alone (e.g. payments for ecosystem services, product labelling and certification, bio-carbon markets or biodiversity compensation funds).

Both public and private adaptation finance can be classified as either international or domestic.

Investments may also be grouped into three broad categories:

- **Total investment needs**. This corresponds to the definitive cost of adaptation but are very difficult and almost impossible to estimate as they depend on scientific elements, ethical and subjective decisions, and are related to the balance between adaptation costs/benefits and residual impacts (ECONADAPT, 2015).
- **Actual spending**, which involves up-front costs incurred today to build resilience to future climate risks over the lifetime of the investment (UNEP, 2018).
- **Planned expenditure**, corresponding to the costs envisaged for investments.

The "finance gap" is defined as the difference between the costs, i.e. the finance required, for meeting a given adaptation target and the amount of resources available to do so. Since the total investment needs are usually unknown, especially at the beginning of a project, the finance gap could be difficult to estimate. Therefore, one possible method to overcome the issue consists of defining intermediate goals and to proceed step by step such to determine the economic amount needed to reach the following objective.

The costs of adaptation actions may be incurred by a pool of entities and/or programmes, including:

- **Public administrations and institutions**, including but not limited to different ministries (e.g. the Ministry of the Environment, etc.), adaptation committees, environment agencies, hence often included into national funds and plans (e.g. NAS, NAP, etc.).
- **Other funding** related to adaptation but not necessarily earmarked as such, mainly in NAPs, or clearly included in adaptation finance flows. As such, expenses may be explicit, when they relate to broader programmes (e.g. Common Agriculture Policy climate-related spending), or implicit (or silent), when financing contributes to adaptation even if it is not the principal reason of it (e.g. coastal protection spending, flood mitigation spending, etc.).

Adaptation actions may be associated with different types of costs. Both the academic and the institutional literature assert that two types of costs categories are often considered (EEA, 2007).

- **Direct costs** are those incurred for implementing adaptation options related to the immediate investment in physical or administrative measures.
- **Transition costs** are those consequential to the investment and correspond to adjustments, hence additional expenses, triggered by adaptive responses (e.g. monitoring, maintenance and management costs).

However, a third type of cost may also be identified – the general or overall cost – for strengthening the general adaptive capacity of an impacted system (the cost of facilitative adaptation).

Fankhauser (2009) notes that cost estimates only include investment costs rather than the lifetime costs of adaptation measures (e.g. operating and decommissioning costs), which can be higher. In fact, direct costs can be specified in monetary terms while indirect costs such as transition, environmental, institutional and social costs are likely to be excluded due to methodological issues and complexity (Asplund and Hjerpe, 2020). Most of these non-assessed costs relate to the intangible impacts (non-market, such as environmental services and human health) of adaptation actions (Li et al., 2014). Indeed, these impacts cannot be directly translated into monetary terms; they require more complex economic evaluation methods (contingent valuation, hedonic prices, etc.).

Only for a limited number of adaptation options and impact categories the costs of adaptation are assessed using different methodologies and scenarios (climate scenarios and time frames), which make comparison and aggregation challenging (Li et al., 2014).

Another categorisation groups the types of costs of adaptation into sub-categories:

- **Total costs**, necessary to implement identified adaptation actions. It is very complex to estimate this value because cost estimates vary according to assumptions and conditions, scenarios, impacts and adaptation options considered, methodologies applied and vary strongly between regions and countries (IPCC, 2014a). Globally, adaptation costs may range from USD 25 to more

than USD 100 billion between 2015 and 2030 (UNEP, 2021) but extreme events, a potential source of large adaptation costs, are not properly covered, and these studies take into account a limited set of adaptation options.

- **Additional costs** (e.g. accounting for the additional effect/costs of climate change), which may rise due to the costs of design (e.g. safeguards) and implementation (e.g. capacity-building, project management, reporting, monitoring and evaluation, and oversight); these costs may range between 10 and 20% of the total finance. Higher adaptation costs may also be triggered by higher insurance premiums or increased investment in disaster risk response and reduction (UNEP, 2018). This concept of additionality is central in international finance, since large funding sources like the Global Environment Facility (GEF), the Green Climate Fund (GCF) or the Adaptation Fund (AF) have to report their added value compared to a "no climate change" baseline.
- **Cost of inaction**, corresponding to the financial implications if nothing is done.
- **Transaction costs**, i.e. the costs to access markets and information and to reach an agreement and enforcement costs (Chambwera et al., 2014).
- **Information acquisition costs** to access climate and weather data (Chambwera et al., 2014).
- **Adjustment costs**, which consist of early capital replacement to adapt to a different climate (Chambwera et al., 2014).
- **Cost of residual damage**, remaining after the implementation of adaptation actions (UNFCCC, 2011).

In most instances at the European level, only the total costs of adaptation and the costs of inaction are assessed. The other type of costs of adaptation are well defined in the literature but do not exist at the practical level because are difficult to track as data and methods are not available.

When addressing adaptation costs, socio-economic development should be taken into consideration, as such development can change adaptation costs and opportunities. For example, if economic activities expand into areas vulnerable to coastal flooding, costs will increase, while improvements in infrastructure quality may reduce costs (UNEP, 2021). Most studies focus on the technical (engineering) costs of adaptation and exclude opportunity and transaction costs. Implementing adaptation includes design, management and execution, as well as the need for monitoring and reporting. These all contribute to transaction costs and should be included in cost estimates (UNEP, 2021).

"The Economic Cost of Climate Change in Europe - Synthesis Report on State of Knowledge and Key Research Gaps" report (COACCH, 2018) can be used to appraise the coverage of economic analysis and costs estimates of climate impacts and adaptation at the sectoral level. The report monetises impacts in terms of social welfare and provides information related to methods used to conduct economic costs analyses. Additionally, the report highlights some key gaps to effective cost assessment. These are provided in detail in chapter 4.

Proposed matrix to inventory the types of costs of adaptation by adaptation type

In this section, a framework to inventory the types of costs of adaptation by adaptation type is put forward. The proposed matrix is intended for future use by the EEA.

The matrix shown in the page below uses the key type measures (KTMs) identified by the EEA (2020a), which are based on the IPCC (2014a), but in a slightly more granular manner and aligned with EU priorities. This proposes dividing adaptation actions into five KTMs, which are then broken down into sub-KTMs:

- A – Governance and Institutional
  - A1: Policy
  - A2: Management and Planning

    - A3: Coordination, cooperation and networking
- B – Economic and Financing
    - B1: Financing and incentive instruments
    - B2: Insurance and transfer instruments
- C – Physical and technological
    - C1: Physical
    - C2: Technological
- D – Nature-based solutions and ecosystem-based approaches
    - D1: Green options
    - D2: Blue options
- E – Knowledge and behavioural change
    - E1: Information and awareness raising
    - E2: Capacity building and empowering
    - E3: Adopted Practice and Behavioural change

Starting with the sectoral breakdown used by the EEA (2007), EEA (2014) and Climate-ADAPT (2020), the following sectoral categorisation for the costs of adaptation is proposed:

- Agriculture
- Biodiversity
- Built environment (i.e. buildings)
- Coastal management
- Energy
- Forestry
- Human health
- Industry/business
- Marine and fisheries
- Tourism
- Transport
- Water management

This sectoral approach has been combined with the KTMs C and D.

Finally, it is proposed to specify if the types of costs of adaptation used by the EEA (2007) are planned or autonomous, and if they are anticipatory or reactive:

- Direct costs
- Transition costs
- General costs

A colour code (green or blue) could be used to specify whether adaptation costs are in the form of planned or autonomous adaptation.

Matrix: Types of costs of adaptation by adaptation type

Adaptation type description/examples					**Types of costs**		
KTM/Sector		**Sub-KTM**	**Description**	**Examples**	**Direct**	**Transition**	**General**
KTM A: Governance and Institutional		(grey as KTM A is high-level / abstract, so unlikely to be clear cost / benefits as too general / context specific)	i.e. describe adaptation option	Examples of adaptation option (from IPCC (2014a), KTM document)	i.e. describe costs of adaptation	Colour green if costs are in the form of planned adaptation, specifying if adaptation is anticipatory or reactive	Colour blue if costs are in the form of autonomous adaptation, specifying if adaptation is anticipatory or reactive.
KTM B: Economic and Financing		(grey as KTM B is high-level / abstract, so unlikely to be clear cost / benefits as too general / context specific)					
KTM C: Physical and technological & KTM D: NBS and EBA	Sector: Agriculture	C1 - Physical	i.e. describe physical options associated with water management	i.e. examples	i.e. describe direct physical costs (e.g. labour and material costs) associated with water management	i.e. describe transition physical costs (e.g. monitoring, maintenance and management costs) associated with water management	i.e. describe other general costs, including non-market and human health costs, associated with water management
		C2 - Technological					
		D1 - Green options					
		D2 – Blue options					
	Sector: Biodiversity	C1 - Physical					
		C2 - Technological					
		D1 - Green options					
		D2 – Blue options					
		C1 - Physical					

	Sector: Built environment	C2 - Technological					
		D1 - Green options					
		D2 – Blue options					
	Sector: Coastal management	C1 - Physical					
		C2 - Technological					
		D1 - Green options					
		D2 – Blue options					
	Sector: Energy	C1 - Physical					
		C2 - Technological					
		D1 - Green options					
		D2 – Blue options					
	Sector: Forestry	C1 - Physical					
		C2 - Technological					
		D1 - Green options					
		D2 – Blue options					
	Sector: Human health	C1 - Physical					
		C2 - Technological					
		D1 - Green options					
		D2 – Blue options					
	Sector: Industry / Business	C1 - Physical					
		C2 - Technological					
		D1 - Green options					
		D2 – Blue options					
	Sector: Marine and fisheries	C1 - Physical					
		C2 - Technological					
		D1 - Green options					
		D2 – Blue options					
	Sector: Tourism	C1 - Physical					
		C2 - Technological					

		D1 - Green options					
		D2 – Blue options					
	Sector: Transport	C1 - Physical					
		C2 - Technological					
		D1 - Green options					
		D2 – Blue options					
	Sector: Water management	C1 - Physical					
		C2 - Technological					
		D1 - Green options					
		D2 – Blue options					
KTM E: Knowledge and behavioural change		(grey as KTM E is high-level / abstract, so unlikely to be clear cost / benefits as too general / context specific)					

Summary

This methodological note outlines the different types of adaptations actions and approaches to adaptation, along with the different categories and types of costs of adaptation. The identified adaptation cost types are being applied homogeneously by the different EU Member States, funds and adaptation actions. Likewise, the applicability of the identified approaches to adaptation is uniform among MS and at the EU level. A deeper understanding of these two issues, as well as the comparability between MS, is provided and discussed in Task 2 based on the responses received following the questionnaire dissemination.

4.3. Adaptation ancillary impacts

Introduction

Climate adaptation actions aim to "reduce risk and vulnerability to climate change" (IPCC 2014). However, these actions also have additional effects, so-called ancillary impacts. These secondary impacts can be positive (co-benefits) or negative (negative externalities). For example, a region may build a dam in order to adapt to water shortages under climate change, which can create co-benefits in the form of new recreational boating and fishing opportunities, as well as negative externalities for biodiversity due to reduced river flows. This section focuses on these positive and negative ancillary impacts of climate adaptation, and aims to understand what they are, how they differ depending on the types of climate adaptation action, and what this means for climate adaptation finance. As ancillary impacts differ depending on the specific adaptation action implemented, we assess the literature and summarise the likely ancillary impacts (economic, social, and environmental) for each adaptation action category; this is also summarised in Table 1.

What are ancillary impacts?

Although the general attention given to adaptation policies has increased over the last decade, the number of studies focusing on adaptation remains small compared to studies on mitigation. Sainz de Murieta (2020) carried out an extensive review of studies considering the ancillary impacts of climate policies. Using a systematic review approach, they developed a database of 558 studies, of which only 84 (15%) addressed adaptation policies, while the remainder were focused on mitigation. The review identifies a noted increase in studies on ancillary impacts of climate policy after 2015, though this holds only for mitigation – the number of studies focused on ancillary impacts has remained low between 2011-2018. The studies included are at the global scale, no review specific to Europe was found.

We define ancillary impacts of climate adaptation as the co-benefits or negative externalities of adaptation actions, i.e. the secondary impacts that arise due to the adaptation action but are not its primary aim. Ancillary impacts can be challenging to identify because it can be difficult to separate these secondary impacts from the broad primary impacts of adaptation. Reif & Osberghaus (2020) define the primary impacts of adaptation actions as any reduction in "current or expected impacts of climate change". We propose a narrower definition: the primary impacts of the climate adaptation action depend on the objectives of the adaptation action - any unintentional impacts are ancillary, even if these ancillary impacts help other areas/sectors adapt to climate change. We propose this approach because many adaptation action decisions have more specific and narrow goals than aiming generally for "reducing risk and vulnerability to climate change". Often, they are developed within a specific sector or by decision-makers with specific areas of responsibility. These decision-makers and sectors predominantly consider the impacts on the decision-maker's sector considered (with broader impacts "ancillary" to decisions and to cost benefit analyses) (Chambwera et al 2014). For example, if a transport authority takes the climate adaptation action of introducing green drainage to reduce urban street flooding risk, they would consider any other benefits/costs beyond reduced urban street flooding risk as ancillary, e.g. improved green access for citizens, reduced heat island effect, climate mitigation impact etc. When identifying the ancillary impacts, the decision-maker's objective is important, as the same action can have different primary/ancillary benefits, depending on the

decision-makers objective: e.g. if a city planner implements larger green spaces to reduce urban heat island effects, then the accompanying reduced urban flood risk would be ancillary. This definitional issue is important as it affects the climate adaptation costs and benefits reported as adaptation finance.

In addition to definitional challenges, the literature identifies common aspects of ancillary impacts of climate adaptation, some of which make them challenging to quantify or monetise and therefore include in climate adaptation finance reporting. Drawing on Sainz de Murieta (2020), we identify the following characteristics that can make it challenging to incorporate ancillary impacts into climate adaptation finance reporting:

- Ancillary impacts generally **accrue locally**, in the same area and scope as primary impacts, and are affected by local context. This means that while at a general level the literature can identify the expected direction of ancillary impacts (i.e. whether a specific adaptation action is likely to create co-benefits or negative externalities for society, environment, or the economy), it is difficult to generalise about the expected size of ancillary impacts, as they are locally contingent.
- Ancillary impacts are often at least partially in the form of **non-market goods**, e.g. biodiversity impacts or health impacts. It is hard to quantify or monetise these impacts, making it more difficult to include these ancillary impacts in adaptation finance reporting.
- Ancillary impacts are likely to arise on **different time-scales** to the primary impacts of climate adaptation actions. For example, reduced risk or vulnerability to climate change (the primary benefit) arises over long time scales, whereas many ancillary impacts arise in the short-term (e.g. recreation opportunities, employment impacts). The more immediate impact of some ancillary impacts could make them relatively easy to calculate, although the temporal disconnect with primary impacts may reduce this affect. Sometimes, however, the opposite can be true, where the ancillary impacts arise over the longer term (e.g. health impacts, biodiversity impacts).
- Ancillary impacts are **diverse**. As described later in this chapter, ancillary effects impact many different sectors, stakeholders, and include economic, societal, and environmental effects. This diversity also complicates cost and benefit assessment and their consistent inclusion in adaptation finance reporting.

The importance of considering ancillary impacts

Despite these challenges, it is important to include ancillary impacts in adaptation action decisions and by extension in adaptation finance reporting. From the literature, we identify the following reasons:

- **Understanding true benefits and costs of adaptation:** The most important reason for considering ancillary impacts is that adaptation actions have diverse impacts and to adequately understand the actual impact on society (i.e. the net benefit of the adaptation actions), these co-benefits and negative externalities must be considered, as they can be significant (Chambwera et al 2014).
- **Understanding the relative efficiency of different adaptation actions and prioritisation:** As co-benefits and negative externalities can be significant, decision-makers need to understand the ancillary impacts to understand the overall impact of different adaptation actions and to choose between them. This is also important at a more general adaptation finance level: decision-makers need to know the full net-benefit of adaptation expenditure so that they can decide how much to invest in adaptation, relative to other policy priorities.
- **Improve the benefit-cost ratio of climate adaptation:** Sainz de Murieta (2020) argues that adaptation action co-benefits generally outweigh negative externalities, meaning that including ancillary impacts in calculations strengthens a case for increasing adaptation action.
- **Building coalitions and increasing incentives for action:** The co-benefits of adaptation actions are often diverse, affecting multiple stakeholders in a local area; accordingly, focussing on ancillary impacts can help build coalitions to adapt by strengthening local incentives for action (Pittel & Rübbelke 2008).
- **Integrative approach most appropriate:** More philosophically, regardless of the policy question, considering ancillary impacts in an integrative manner is necessary to address the

multiple environmental crises (e.g. climate change and biodiversity loss) and social and economic challenges (e.g. COVID, economic recession, etc.) we currently face. Such integrative approaches are central to recent EU policy proposals such as the European Green Deal or COVID recovery, which recognises that these challenges cannot be solved in isolation but rather can be most effectively and efficiently approached together (European Commission, 2019).

Types of ancillary impacts

As stated, the primary aim of climate adaptation actions is to "reduce risk and vulnerability to climate change" (IPCC 2014). In order to appropriately assess the ancillary impacts of adaptation actions, it is helpful to categorise the ancillary impacts according to the areas in which they occur. Drawing on the work of Sainz de Murieta (2020), as well as Altvater et al. (2011) and Weiland et al. (2014), we identify three types of ancillary impacts of adaptation actions: economic, social, and environmental.

- **Economic:** Adaptation actions can offer significant economic benefits through avoided damages and losses as a result of climate change. These are, however, the direct impacts of adaptation. In terms of secondary economic benefits, there is a potential for the creation of jobs to implement adaptation actions (Altvater et al., 2011). Furthermore, adaptation can positively affect innovation and competitiveness (Weiland et al., 2014). For example, adaptation policies may create opportunities to develop new products or open new markets (Sainz de Murieta, 2020). Altvater et al. (2011) point to the development of more resilient energy grid layouts as a means of helping promote the diffusion of European technologies.
- **Social:** Climate adaptation can help build social capital by: providing training, strengthening relationships, developing networks, and building adaptive capacity (Sainz de Murieta, 2020). It is worth noting that quantifying such benefits is particularly difficult. Another important social ancillary benefit of adaptation actions is related to public health impacts: improved mental health (closely linked to the development of social capital) and physical health are both important secondary impacts of adaptation. Further health benefits can be achieved through adaptation measures that promote healthy lifestyles, such as bike lanes or walking paths, and increased green spaces (Sainz de Murieta, 2020). Finally, adaptation actions can have quality of life impacts as well. The improvement of green spaces may increase the attractiveness of some neighbourhoods (Sainz de Murieta, 2020), but the construction of new energy infrastructure (i.e. pylons, overhead lines), could negatively impact the quality of life for nearby residents (Altvater et al., 2011). Finally, Weiland et al. (2014) also note that adaptation actions can have effects on reducing social inequalities and vulnerabilities. European policies and practices, however, do not always adequately target the most vulnerable populations (EEA, 2018).
- **Environmental:** Certain adaptation actions – particularly ecosystem-based adaptation and green infrastructure measures – have important synergies with other environmental issues, notably mitigation efforts and biodiversity conservation (Sainz de Murieta, 2020; Weiland et al., 2014). Ecosystem-based adaptation (e.g. mangrove and salt marsh development/restoration, increased forest cover) can provide secondary benefits addressing other environmental pressures such as habitat conservation, reduced erosion, and improved water quality (Sainz de Murieta, 2020). Further, some measures can present synergies with climate mitigation efforts. Certain changes in land use may lead to a reduction of GHG emissions (Weiland et al., 2014) or to improved carbon sequestration (Sainz de Murieta, 2020). Even grey infrastructure – e.g. roads, dams, power lines – can be adapted to make better use of environmental features and promote ecosystem functions, in an approach known as "greening the grey" (EEA, 2016b).

Understanding ancillary impacts of different types of adaptation actions

As the above discussion illustrates, ancillary impacts differ depending on the type of adaptation action. In order to identify specific ancillary impacts of climate adaptation actions, we have developed an approach to categorise these benefits by adaptation type. In the following section, we summarise the ancillary impacts for each adaptation action category, applying the adaptation action categorisation approach described below.

Adaptation action categorisation

- There are many different types of adaptation action categorisations that could be used (e.g. IPCC 2014, EEA Key Type Measures, sectoral, etc.). The categorisation must be granular enough to be able to identify the primary aim of the adaptation action (and therefore the secondary ancillary impacts). Therefore, we propose using a combination of KTM and sectoral approaches as discussed in the previous chapter. For the relatively abstract, intangible and high-level KTMs A, B, and E, we will discuss potential ancillary impacts at a general level, based on existing literature.
- For KTMs C and D, we break the KTMs down further using a sectoral approach. This is necessary as KTMs C and D and the relevant sub-KTMs will be too high-level to identify ancillary impacts (which as described above often arise as secondary impacts of sectoral actions/relatively narrow adaptation actions).

For each adaptation action category, we present the results of a literature review on the ancillary impacts of different specific adaptation actions. Firstly, adaptation actions are split according to the five Key Type Measures developed by the EEA (2020). Within these, the focus of our literature review was KTM C: Physical and Technological and KTM D: Nature-based solutions. These were then further subdivided by sector. Finally, within each sector, we identified the economic, social, and environmental ancillary impacts that could arise from specific adaptation actions. We completed the literature review using a snowball approach: identifying initial summary academic papers and then using these to identify primary references. We recorded key conclusions for each sector by KTM type (and where it was possible) by type of ancillary impacts in a working excel document. Once we had completed our literature review, we used expert judgement to make an overall conclusion by ancillary benefit type. Due to the limited time available, the literature review was not exhaustive. Accordingly, this work represents a qualitative, high-level assessment and summary of ancillary impacts, and does not encompass all possible ancillary impacts. The results are summarised in Table 1. Accordingly, this work represents a qualitative, high-level assessment and summary of ancillary impacts, and does not encompass all possible ancillary impacts. The results are summarised in Table 1.

Conclusions by adaptation action category: KTMs and Sectors

Table 1 Ancillary impacts by adaptation action category (Green: generally positive; yellow: mixed; red: generally negative; grey: insufficient evidence; blue: not applicable)

			Ancillary impacts		
KTM/Sector			Economic	Social	Environmental
KTM A: Governance and Institutional					
KTM B: Economic and Financing					
KTM C: Physical and technological & KTM D: NBS	Sector: Agriculture	C1: Physical			
		C2: Tech			
		D1/D2: Green			
	Sector: Biodiversity	C1: Physical			
		C2: Tech			
		D1/D2: Green			
	Sector: Built environment	C1: Physical			
		C2: Tech			
		D1/D2: Green			
	Sector: Coastal management	C1: Physical			
		C2: Tech			
		D1/D2: Green			
	Sector: Energy	C1: Physical			
		C2: Tech			
		D1/D2: Green			
	Sector: Forestry	C1: Physical			
		C2: Tech			
		D1/D2: Green			
	Sector: Human health	C1: Physical			
		C2: Tech			
		D1/D2: Green			
	Sector: Industry/business	C1: Physical			
		C2: Tech			
		D1/D2: Green			
	Sector: Marine/fisheries	C1: Physical			
		C2: Tech			
		D1/D2: Green			
	Sector: Tourism	C1: Physical			

	C2: Tech			
	D1/D2: Green			
Sector: Transport	C1: Physical			
	C2: Tech			
	D1/D2: Green			
Sector: Water management	C1: Physical			
	C2: Tech			
	D1/D2: Green			
KTM E: Knowledge and behavioural change				

KTM A: Governance and Institutional

The Key Type Measure *Governance and Institutional* category includes three sub-types of actions: A1: Policy; A2: Management/Planning; A3: Coordination, cooperation and networking. Given the very wide range of specific actions that this key type measure covers, it is very difficult to identify general rules of thumb for associated ancillary impacts. Rather, we expect that the specific ancillary impacts will differ vastly depending on the specific primary objective of the governance and institutional adaptation action, and especially in the quality and scope of the action. Given the importance of local and central government to set the framing conditions and as a central actor in promoting the shape and direction of adaptation actions (IPCC, 2014), there is the potential for these governance and institutional adaptation actions to have very large primary and ancillary impacts, and it will be important to investigate whether these ancillary impacts are likely to be positive or negative, and under what conditions.

KTM B: Economic and Financing

The Key Type Measure *Economic and Financing* category includes two sub-types of actions: B1: Financing and incentive instruments; B2: Insurance and transfer instruments. Given the very wide range of specific actions that this key type measure covers, it is very difficult to identify general rules of thumb for associated ancillary impacts. Rather, we expect that the specific ancillary impacts will differ vastly depending on the specific primary objective and shape of the economic and financing adaptation action. Given the large impact that financial incentives have on economies and human actions, we would expect that these types of adaptation actions could have significant positive and negative ancillary impacts on the economy, society, and the environment. Like KTM A, it will be important to investigate whether these ancillary impacts are likely to be positive or negative, and under what conditions in more detail.

KTM C: Physical and Technological and KTM D: Nature-based solutions: by sector

Agriculture

Mitigation and adaptation actions in agriculture can often partially overlap. There was a relatively high availability of studies on ancillary impacts of adaptation actions in the agricultural sector: we found six relevant studies in our brief literature review. Physical adaptation actions had mixed ancillary impacts: adaptation action such as new irrigation infrastructure can improve farmer and community income and food production but can also increase energy demand and associated GHG emissions (Lobell, Baldos, and Hertel, 2013; EEA, 2019). Technological approaches such as precision farming and new crops had largely positive ancillary impacts, including positive economic impacts on productivity and environmental impacts in terms of reduced fertiliser input and higher carbon efficiency per output (Chambwera et al 2014; FAO, 2020; EEA, 2019; ICF, 2011). Green agricultural adaptation measures have positive ancillary impacts in terms of increased productivity (and

accompanying economic impacts) and numerous environmental benefits, including biodiversity and climate mitigation (Chambwera et al 2014; FAO, 2020; EEA, 2019). In terms of the types of ancillary benefits, the literature suggests that agricultural adaptation actions have positive economic ancillary impacts, such as increased productivity and local economic impacts. However, they have mixed social and environmental ancillary impacts, principally due to the increase in energy or water use associated with the adaptation measure of increased irrigation (Ibid).

Biodiversity

Due to the interconnected, reinforcing nature of biodiversity protection and climate adaptation, it is difficult to separate the primary and ancillary impacts of measures to adapt biodiversity to climate change, i.e. to tease out cause and effect. This may have been one reason for the relatively low number of references that we identified (three) on ancillary impacts of biodiversity. We found no evidence regarding the ancillary impacts of physical adaptation actions. There was also limited evidence on technological adaptation actions, with the only reference referring to the negative impact that relocating species can have on their new ecosystems (Secretariat of the Convention on Biological Diversity, 2009). Green adaptation actions such as ecosystem-based adaptation (i.e. green approaches to adapt biodiversity to climate change) positively impact local economies through tourism and agriculture sectors, increases or improves recreation opportunities and other human and societal health pathways, and has numerous environmental co-benefits (Secretariat of the Convention on Biological Diversity, 2009; Austin, 2016; (ten Brink et al , 2016). Overall, the evidence suggests that most biodiversity adaptation actions would deliver multiple co-benefits in the form of ecosystem-services, which support local economic outcomes, social, and environmental outcomes (Ibid.).

Built environment

There is a relative abundance of information regarding ancillary impacts of adaptation of the built environment. We encountered seven studies which addressed the issue. With regards to physical adaptation measures, economic and social benefits can be gained through the maintenance and improvement of buildings, for example. Adaptation actions like increasing buildings' energy efficiency through insulation can lead to cost savings and increased property values, while also contributing to health improvements from improved air quality and thermal comfort (Floater et al., 2016; Chambwera et al., 2014). Retrofits of existing buildings, as well as promoting active and passive cooling strategies for new buildings, can increase labour productivity, as well as reduce health impacts from heat (Floater et al., 2016). Consideration of potential flood and storm risks in planning and design of buildings can also have economic and social benefits (Floater et al., 2016; Chambwera et al., 2014). In terms of environmental ancillary effects, Cheng & Berry (2013) note that the use of air conditioning to reduce morbidity and mortality is identified as an adaptation measure in many heat adaptation plans, which can have negative environmental impacts due to the associated energy consumption and greenhouse gas emissions. Rashidi (2019) argues that appropriate adaptation planning in urban energy systems will be attractive to investors, leading to higher capital inflow to cities, thus boosting their creditworthiness.

Within the built environment sector, *green/blue* measures are also widespread, and are shown to have a range of economic, social, and environmental ancillary impacts. Alves (2018) has extensively detailed these. For example: increasing vegetation can lead to real estate value appreciation, while reducing runoff can also decrease wastewater treatment costs. Increased urban green space and be connected to increased labour productivity (Floater et al., 2016). The social ancillary impacts of green/blue adaptation are also numerous (Alves, 2018): an increase in green areas, trees, and water spots can have positive effects on heat stress reduction, air quality, recreation, health (see also Cheng & Berry, 2013; van den Berg et al., 2015), food security, and energy saving. These same adaptation measures naturally have positive environmental effects too, improving water quality, groundwater recharge, and biodiversity (Alves, 2018). Finally, measures reducing heat stress (e.g. green spaces, reducing sealed surfaces) can also reduce greenhouse gas emissions if designed appropriately (Cheng & Berry, 2013).

Coastal management

There are a number of studies which mention ancillary effects of coastal management measures. All activities improving coastal flood protection (incl. physical, technological, green and blue) have co-benefit to reduce the number of householders, businesses forced from homes, places of work (Floater et al., 2016). However, the most diverse co-benefits could be found for green and blue measures such as wetland restoration, reef systems, coastal vegetation incl. seagrass meadows, dune vegetation and coastal riparian vegetation. These measures can have positive ancillary impacts in terms of economic benefits for fisheries and aquaculture. Restored wetlands can be used as park area for tourism and recreation. Environmental effects include carbon sequestration, nutrient retention, sediment retention, biodiversity habitat and flood attenuation (Tanner et al. 2016, Conger, 2018). In general, adaptation for coastal management can deliver positive economic, social and environmental co-benefits; mainly related to green and blue coastal management activities.

Energy

The line between mitigation and adaptation actions in the energy sector can be somewhat blurry. As such, we only identified three studies making explicit reference to adaptation measures, with a focus on *physical* measures. In terms of economic ancillary impacts, Floater et al. (2016) point to the decentralisation of energy networks and the adoption of smart grids, which can lead to job creation and technological innovation. Altvater et al. (2011), however, note that job creation and increased investment activity should not be seen as completely adaptation-induced. The development and construction of improved pylons and overhead lines can help diffuse European technologies, but conversely this construction can negatively impact agriculture and forestry as well as property values (Altvater et al., 2011). In terms of social ancillary impacts, reducing the need to use coal-fired power plants can improve air quality and in turn improve human health (Chambwera et al., 2014). Decentralisation and smart grids can also reduce fuel poverty and reduce negative health impacts through reduced pollution (Floater et al., 2016). The construction of overhead powerlines can also have negative social impacts: they can decrease the beauty of the natural landscape and diminish its recreation and touristic value (Altvater et al, 2011). Finally, there are environmental impacts associated with energy adaptation measures. Power lines can negatively affect biodiversity through noise and soil impacts, however suitable design could provide habitats for some endangered species (Altvater et al., 2011). Decentralisation and smart grids can also lead to improved air pollution through load shifting and demand management (Floater et al., 2016).

Forestry

We found five references related to the ancillary impacts of adaptation actions in the forestry sector. We found no references to ancillary impacts of *physical or technological* forestry adaptation actions, which may be indicative that there are few of these adaptation actions. Green adaptation actions had almost uniformly positive ancillary impacts. In terms of economic ancillary impacts, sustainable forest management was found to have general positive economic effects, while protection of forest areas could increase tourism income (Nabuurs, 2007; FAO, 2020). In terms of social ancillary impacts, sustainable forest management can improve food security and health (FAO, 2020). Urban forests provide recreation and shade (with accompanying health benefits), although they can increase allergens and support pests and insects (Cheng & Berry, 2013; Harlan & Ruddel, 2011). Green forestry adaptation actions such as sustainable forestry management also generate numerous environmental ancillary impacts, including climate mitigation, biodiversity conservation, water retention, and air quality (IPCC, 2019; Harlan & Ruddel, 2011; FAO 2020). Generally, the literature suggested that forestry adaptation measures generate diverse benefits but these are generally due to adaptation, rather than ancillary impacts (e.g. the benefits are due to successful adaptation - reduced forest fires, reduced deforestation etc.).

Human health

The information on ancillary impacts of health-related adaptation measures is limited. We identified 2 studies. Physical adaptation actions such as increased cycling and walking networks (to facilitate active lifestyles) can lead as well to reduced congestion, reduced mortality and injuries from road-related accidents; improved access and quality of life. And improved infrastructure for cycling and walking can also lead to improved air quality. Negative effects such as increased energy demand

have been mentioned for active cooling systems for hospitals and other care facilities. Child mortality could be reduced as a co-benefit of technological adaptation interventions related to vector-borne diseases and diarrhea. (Floater et al., 2016; ICF, 2011). Overall, it can be said that more often human health impacts can be seen as positive co-benefits of adaptation actions in other policy fields, such as built environment, forestry or biodiversity. The ancillary impacts of human health targeted adaptation activities are mainly related to currently existing illnesses (without climate change, also mentioned as no-regret measures in the literature).

Industry/business

Adaptation in industry/business seems to be predominantly addressed within the other sectors explored. We identified two papers which made reference to specific business-oriented adaptation measures and their ancillary impacts. Floater et al. (2016) note that cleantech business clusters and incentives can increase innovation, firm productivity, and SME growth. Additionally, an increase in ICT in adaptation systems and reduce damage costs, while reducing disruption to energy, water, and communication systems. There are also social ancillary impacts from ICT through reduced mortality and health impacts.

Within a study prepared for the German Federal Environment Agency (UBA) a number of industry-related adaptation measures were evaluated in the context of a broader assessment (Lehr at al. 2020). The analysis shows no ancillary effects (positive and negative) for some measures as they have a clear focus on the business activities, e.g. improved plant safety and strategic selection of location of production sites. Other measures, like reduced use of cooling water to increase the resiliency of industrial processes can have positive ancillary effects such as improved regulation of water balance. Improved risk management in industry to reduce environmental impacts of point sources can have positive ancillary effects such as increased water quality in non-emergency situations. However, due to change of technology and necessary investments in new infrastructure, the measures also show some negative externalities e.g. increased GHG emissions or resource use. Another group of measures tied to improved contingency planning in logistics show mainly negative externalities, as new storage capacity or redundant supply infrastructure need to be built.

Marine/fisheries

The number of studies on ancillary impacts of adaptation measures in fisheries and marine sector are limited; we found one reference. Positive co-benefits can be seen for green measures such as restoration of marine ecosystems, including the increase of economic opportunities for local fishers and positive effects on biodiversity (FAO, 2020). In general, it can be suggested that fisheries and marine area-targeted adaptation activities have mainly positive ancillary impacts.

Tourism

Some studies (4) were found on the ancillary impacts of adaptation actions for the tourism sector. Physical actions such as adapted recreation infrastructure e.g. improved walking and cycling networks in tourism regions increase human health and quality of life for tourists and local citizens (OECD, 2020). Negative ancillary effects have been mentioned for active cooling systems for summer tourism facilities due to the increased energy demand resulting in increased GHG emissions (Levine et al. , 2007; Amirkhani et al. 2020). Positive effects are mentioned for technological measures such as eco-friendly and sustainable tourism offers, change of tourism concepts from resource-intensive winter tourism to summer tourism – leading to increased economic benefits of eco/low-impact tourism sector, increased resource and energy efficiency, reduction in urban waste, maintenance and increase in urban biodiversity (Floater et al., 2016). Furthermore, a lot of studies discuss negative side-effects of artificial snow, e.g. increased water and energy demand. (e.g. Viguie et al., 2020, Vanham et al., 2009) In general, both positive and negative ancillary effects have been mentioned for adaptation measures in the tourism sector. Positive economic effects can be mentioned. Social and environmental effects are positive for adaptation actions like eco-friendly and sustainable tourism concepts, more negative for measures such as artificial snow and cooling of tourism infrastructure.

Transport

Ancillary impacts of transport adaptation were addressed in three studies, focused primarily on *physical* adaptation measures. In terms of economic ancillary effects, Floater et al. (2016) note that flood and heat resistant transport infrastructure can reduce damage costs and reduce transport disruption, leading to productivity gains. However, major employment effects are not expected if infrastructure upgrading is integrated into a regular reinvestment cycle (Altvater et al., 2011). With regards to social ancillary effects, Mayrhofer & Gupta (2016) identifies health co-benefits from expanded public transport (fewer injuries, and improved mental health through reduced noise and congestion). Adaptation measures that reduce congestion and travel cause reduced emissions of greenhouse gases, leading to a positive ancillary environmental impact (Altvater et al., 2011).

Water

We identified eight studies covering the co-benefits of adaptation approaches in water management. Frequently, these ancillary effects arise from the strong links between water use and energy consumption (the so-called "water-energy nexus"), particularly in agriculture (Cremades et al., 2016). When it comes to water management, the line between *physical* and *technological* adaptation measures can often be blurred. In terms of economic ancillary effects, desalination plants used to increase urban water supplies require increased energy use, leading to higher costs. From an environmental perspective, this also leads to higher greenhouse gas emissions (FAO, 2020; Pittock et al., 2013). Cremades et al. (2016) point out that water saving technologies used in agriculture can often require increased pumping and pressurizing, leading to higher energy consumption.

Furthermore, integrated water resource management (including measures to improve water efficiency, reduce demand, and improve water allocation) have a range of economic, social, and environmental benefits, including: cost (and energy) savings for households and industry, reduced economic impacts of water variability, increased water security in drought-prone cities, improved resource equity, aquifer protection, and reduced droughts (Floater et al., 2016; Sharifi, 2020; Dovie, 2018; EEA, 2012). Sharifi (2020) notes that environmental benefits can be obtained through rainwater and graywater recycling, due to reduced energy use and application for agricultural irrigation. Additionally, groundwater and soil moisture recharge can restore ecosystem functions and improve water security. Finally, measures for flood protection – especially green measures like floodplain restoration – can present important positive ancillary effects such as improved hydrological regimes and enhanced habitats (EEA. 2016b).

KTM E: Knowledge and behavioural change

This category of adaptation actions includes E1: Information and awareness raising; E2: Capacity building and empowering; E3: Adopted Practice and Behavioural change. Like KTMs A and B, these actions differ widely in terms of their specific shape and objective. Accordingly, it is very difficult to generalise the ancillary impacts of these types of actions, especially in relation to E3 (i.e. it depends on what type of behavioural change is encouraged). However, in our assessment of the literature, numerous sources indicated that the additional information, knowledge, and community capacity is likely to have largely positive ancillary benefits on the economy, society, and indirect (see e.g. IPCC, 2014; Floater et al, 2016; Harlan & Ruddel, 2011). It can be difficult to separate the primary and ancillary impacts of these sorts of actions, which tend to increase community or environmental resilience and decrease vulnerability both as a primary benefit and tangentially through improved knowledge, better development and implementation of public policy, and stronger communities.

Summary

This chapter has reviewed the literature to define ancillary impacts of adaptation actions and identified how these differ across different types of adaptation actions. The literature concludes that ancillary impacts can be significant and therefore it is important to consider them in decision making (and in adaptation finance) to support good decision making and strengthen arguments for implementing adaptation actions. However, due to challenges separating ancillary from primary impacts, and the diverse and often non-market nature of ancillary impacts, it is challenging to adequately consider ancillary impacts.

We find that to identify ancillary impacts, it is important to understand the primary objectives of adaptation actions. We use a sectoral approach to approximate this. While we find that for some types of adaptation actions (I.e. physical, technological, green/blue) and some sectors it is possible to generalise about the likely direction of ancillary impacts (i.e. co-benefit or negative externalities), this is not always simple. There are also many situations where the ancillary impacts may be positive for some areas (e.g. environmental co-benefits) but negative in other areas (e.g. negative societal or economic externalities). There are also a number of data gaps where further research on ancillary impacts of adaptation actions is needed, especially those related to governance and institutional and economic and financing adaptation actions (KTM A and B), and in transport and marine/fisheries sectors.

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4.4. Economic evidence on efficiency of adaptation action vs inaction

Introduction

From an economic perspective, a sufficient level of adaptation is when all individual adaptation measures are implemented where the societal, i.e. the economic, social and environmental, benefits, are at least as high as the societal costs. To say it another way, in an ideal efficient market, all socially desirable (adaptation) investments would take place (Pauw et al., 2021a).

Assessing the benefits and costs of adaptation is the basis for decision-making concerning adaptation. The decision to implement an adaptation action or the choice between different alternative options is typically based on the benefits and costs of the options.

As the adaptation challenge increases with climate change, it will be important to design adaptation policies and support efficient measures in the context of their positive impact on society as a whole. To do this, the discussion must consider the real costs and benefits of the whole economy to adapt.

The aim of this section is to identify the methodological developments in estimating the costs of inaction and adaptation to climate change.

What is the cost of inaction?

The cost of inaction can be defined as the "total cost due to climate change in the absence of adaptation and mitigation measures" (EEA, 2007; Nicklin et al., 2019). Essentially, it is the "worsening damages that will result from allowing climate change to continue unabated" (Ackerman and Stanton, 2006).

To understand the cost of inaction, it is necessary to assess the amount of damage that may occur in the absence of adaptation. This includes a consideration of the economic, social and environmental ancillary impacts (see Chapter 4.3), and the direct and indirect costs (see Chapter 4.2). Overall, the cost of inaction should be estimated in order for decision-makers to determine whether to adapt proactively or reactively, in order to save costs and maximise benefits.

The debate focuses on the perceived costs of alternative adaptation solutions, but does not tend to include the potential significant costs of inaction. This is because they are either unknown or diffuse and thus more easily shared across society. The costs of adaptation action, however, are localised and the estimates are anchored on features of known technologies and their impacts including, among others, reduced profits (Ruth, 2010).

The Technical Report *Climate Change: The Cost of Inaction vs. the Cost of Adaptation* provided the methodological issues and uncertainties of cost estimation and reviewed existing information on economic costs of climate change at the European level. Although now more than a decade old, it was useful in identifying key issues in determining the cost of inaction, including: diverse definitions

of the 'cost of inaction' and 'adaptation'; an incomplete and uncertain understanding of the costs of inaction; different assumptions and choices in the methodology for cost assessment; and limits on quantification and valuation. The following sections build on this Report, exploring whether any methodological developments that have taken place and if a methodological framework has been identified within the academic literature.

The importance of considering the cost of inaction

Policymakers need to estimate and consider the cost of inaction in order to decide the optimal time to invest in adaptation measures. It may be costlier to wait than to act now (Nicklin et al., 2019). Economic models estimated damages will be in the trillions (Kemfert, 2005), and in most developing countries, greater costs will be experienced with no benefits (Ackerman and Stanton, 2006). This will put increased risk on decision-makers and economies, which may not have the capacity to respond.

If the estimated cost of inaction omits indirect and intangible damages, it provides only an estimate of direct damage. This may also result in an underestimation of the benefits of the adaptation action. Some studies have found that investments [in flood-risk reduction] are only net-beneficial if the intangible benefits (such as loss of life) are included (Brouwer and Van Ek, 2004; Shreve and Kelman, 2014; Nicklin et al., 2019). Failing to take into account damages other than direct damages may also result in the prioritisation of adaptation action in the most economically valuable, i.e. the richest, areas, and would disadvantage those areas where particularly vulnerable or marginalised communities need help. For example, a study on pluvial flood damage used a combination of 3Di flood modelling and the WSS flood damage estimation tool to estimate direct flood damage in two urban areas, one in the UK and one in the Netherlands. Due to a lack of data, identical average asset values and damage functions were applied to both cities, resulting in underestimates. The authors of the study proposed a number of ways to improve such research, including the use of locally-tailored asset values, land use maps, and damage functions to account for differences between building types as well as study areas (Nicklin et al., 2019). However, it should be noted that such methods can cause problematic results when comparing between adaptation actions, for example, in the same river basin district, where risk reduction in one place may increase the risk elsewhere (maladaptation) or increase the cost of the adaptation measure.

The estimates of damages from climate change also need to take into account extensive and intensive margin adaptation into account, and for all climate-sensitive sectors (Auffhammer, 2018). Mendelsohn et al. (1994) were the first to estimate a damage function econometrically, using a cross-sectional Ricardian framework that is still one of the most widely used approach in climate estimations today. The Ricardian method aims to study the long-term impact of climate change on agriculture while accounting for adaptation, taking into account the ability of each farmer to adapt. The study finds that adaptation will reduce the damages from climate change. This raises the question about who bears the costs of adaptation and who benefits from the intervention, which may affect the overall efficiency of adaptation. However, the Ricardian method if criticised for assuming costless adaptation, although there are costs attached to adaptation action. If the costs are high enough, it may be optimal for the farmer to delay or avoid adaptation, or shift from one type of adaptation to another.

Estimating the cost of inaction vs. the cost of adaptation

Global adaptation cost estimates range from around USD 140 to 300 billion a year by 2020, and up to USD 280-500 billion by 2050 (Pauw et al., 2021). Based on this literature review, there are no comprehensive estimations of the costs of adaptation in Europe. The European Investment Bank found that adaptation investment needs are around USD22-105 billion per year by 2030 (EIB, 2012)13. The COACCH project produced sector estimates of the economic costs of climate change, capturing the costs and benefits to society (i.e. market and non-market impacts). Taking selected examples for sea-level rise, the costs are estimated at EUR 135-185 billion with no discounting, rising

[13] Springmann, M., (2012), The costs of climate-change adaptation in Europe: a review, German Institute for Economic Research (DIW), EIB Working Paper 2012/05

rapidly to EUR 450 -650 billion by 2080 (COACCH, 2019). River flooding costs are estimated at EUR 33 billion by 2050 to EUR 75 billion by 2080. The estimates include the combined effects of climate and socio-economic change. For transport, the baseline analysis identified EUR 200 million of direct costs, with the highest risks identified in Germany, France and Italy (COACCH, 2019).

The benefits of adaptation investments often outweigh the costs. For example, a USD 1.8 trillion investment in early warning systems, climate-resilient infrastructure, improved dryland agriculture, global mangrove protection, and resilient water resources could generate USD 7.1 trillions of benefits, mostly concerning avoided costs, and including non-monetary social and environmental benefits (Global Commission on Adaptation, 2019). The wide range is symptomatic of the poor state of knowledge, particularly regarding estimating and assessing the non-monetary benefits of adaptation.

Studies highlight that the cost of inaction in many countries, and particularly in different sectors, is increasing. As countries become more vulnerable to climate impacts and extreme weather events, the costs of inaction or failing to manage or adapt to them are increasing (Nicklin et al., 2019). Overcoming market imperfections such as information asymmetry are required to increase awareness of climate change and motivate the required investments. Governments should use support instruments for adaptation in the case of externalities, including overcoming the information asymmetry and imperfect capital market imperfections (Mendelsohn, 2000).

Many studies estimate a measure of incremental damages, or the 'social cost of carbon'. Essentially, if carbon emissions can be reduced at a cost per tonne less than or equal to the social cost of carbon', the welfare of society is increased; the reduction of damages is higher than the cost of reducing emissions (Ackerman and Stanton, 2006; DEFRA, 2006; Auffhammer, 2018). DEFRA analysed 28 studies and found that only a few explored non-market impacts (see Chapter 3).

A variety of methods have been used to conduct climate impact assessments, which includes adaptation for coastal flooding and sea-level rise (COACCH, 2019). COACCH used computable general equilibrium (CGE) models to assess the macro-economic effects of climate change, or global and continental economic estimates provided by "hard-linked" integrated assessment models (IAMs). Another study investigated the role of market-driven adaptation, which CGE models explicitly capture through an endogenous price setting mechanism (Bosello and Parrado, 2014).

In order to understand the complexity of economic assessments of climate impacts, research has begun to focus on integrated assessment models. Global economic integrated assessment models combine the scientific and economic aspects of climate change into a single framework, which can be used to quantify the economic impacts of climate change and, to an extent, the costs and benefits (ECONADAPT, 2015). Essentially, integrated assessment models can be used to translate temperature increases into GDP losses (see Nordhaus, 1991; Nordhaus and Yang, 1996; Nordhaus and Boyer, 2000; Popp, 2004; Manne and Richels, 2004; Edenhofer et al. 2005; Gerlagh, 2007), or translate climate change pressures into changes in quantity/quality of factors of production and/or in agents' preferences driving demand and supply in the behaviour of models (see Darwin and Tol, 2001; Deke et al., 2001; Bosello et al., 2007, 2008, 2012; Eboli et al., 2010; Ciscar et al, 2011).

As public financial resources are limited, decision-makers need to ensure that adaptation investments are beneficial. As public resources are limited, the most beneficial adaptation actions should be selected. In using underestimates or incomplete estimates, more proposals are likely to be endorsed rather than rejected, although they may not be best for the society (Ackerman and Stanton, 2006).

The cost of inaction vs the cost of adaptation

If the world continues on its current trajectory and does not limit greenhouse gas emissions, annual economic damages could reach USD 20 trillion by 2100 (Kemfert, 2005). The immediate adoption of climate protection policies could help to half these damages, avoiding USD 12 trillion in annual damages by spending USD 3 trillion in adaptation per year (Kemfert, 2005). Similar estimates were found using a Policy Analysis of the Greenhouse Effect (PAGE). Further mitigation delay costs a best estimate of an additional 0.5(5) trillion dollars per year (Sanderson and O'Neill, 2020).

More recently, the economics of climate change studies are dominated by three independent integrated assessment models: Dynamic Integrated model of Climate and Economy (DICE); Policy Analysis of the Greenhouse Effect (PAGE); and the Climate Framework for Uncertainty, Negotiation, and Distribution (FUND). Their main use is to derive estimates of the social costs of carbon (Faulwasser et al., 2018). The DICE model consists of clearly defined climate, carbon and socioeconomic sub-models; however, integrating uncertainty is ongoing. Since DICE focuses on the social cost of carbon, it is used primarily to estimate the total costs of mitigation, including finding optimal mitigation pathways and abatement costs (Sanderson and O'Neill, 2020). However, it is not currently applied to estimating adaptation costs.

In 1993, the PAGE model was used to assess the merits of policies to both prevent global warming and to adapt to global warming that does occur (Hope et al., 1993). They found that there is a clear argument for having a strong adaptive policy. PAGE 2002 was used to value the impacts and calculate the social cost of CO2 in the Stern Review (Stern, 2007). However, PAGE09 is an updated version of the model, which takes into account scientific and economic information from the 4th Assessment Report of the IPCC (IPCC, 2007). It uses simple equations to simulate the results from more complex specialised scientific and economic models while accounting for the profound uncertainty of climate change (Hope, 2011). PAGE2002 measures the costs of adaptation by uncertain adaptive costs parameters for the focus region, with the corresponding cost factors in non-focus regions assumed to be proportional. The adaptive costs are scale dependent as they are expressed in USD million per unit of adaptation bought, making it difficult to specify regional factors. In PAGE09, adaptation policy is specified by seven inputs for each impact sector, simplified from 480 inputs in PAGE2002. The user specifies the start date, plateau (increase in tolerable temperature) and number of years for the action to have full effect. Beyond these parameters, impact adaptation is ineffective. In PAGE09 the adaptive costs are specified as a percentage of GDP per unit of adaptation bought, making it scale independent (Hope, 2011). Overall, the PAGE09 model represents climate impacts, abatement costs and adaptation costs that result from two abatement and adaptation policies specified by the user, one of which may be a business as usual policy (Hope, 2011). However, the results from using the PAGE09 model to address remaining open questions including the costs and benefits of adaptation are not yet published. Most non-complex integrated models mislead users by attempting to find optimal trade-offs between mitigation and adaptation, based on incomplete information on impacts and the adaptation process, and avoiding the inherent climate uncertainties. However, the PAGE09 model "overcomes most, although not all, of these difficulties through its rigorous uncertainty analysis" (Warren et al, 2012). Typically such models, also discussed below, do not account for local scale issues, the organisational and institutional context of adaptation, adaptation limits and its context-specific nature, and adaptation deficits. PAGE09 overcomes many of these issues by more accurately representing the latest climate science, including catastrophic change, and by not assuming that adaptation and mitigation are perfect substitutes and for allowing lags in adaptation timing (Warren et al, 2012). Page09 still omits adaptation limits, institutional issues and local scale issues, but it does provide useful insights.

Similarly to PAGE, the Climate Framework for Uncertainty, Negotiation, and Distribution (FUND) evaluates climate policies over ensembles of many parameter values. PAGE and FUND are based on a single-equation climate model (Andrews and Allen 2008). FUND and PAGE effectively draw values of the equilibrium climate sensitivity from right-skewed distributions similar to those collected in Bindoff et al. (2013). In FUND there is a 74% chance that the climate sensitivity lies in the IPCC's likely range (≥66% chance) of 1.5°–4.5°C; in PAGE it is a 93% chance (Calel and Stainforth, 2017).

The processes underlying FUND and PAGE are similar, although they make different assumptions both about how to represent the climate system and about the values of underlying physical parameters. Calel and Stainforth (2017) found that even with identical economies, the DICE, PAGE and FUND models produced substantially different climate change forecasts; not as significant as the choice of discount rate or damage function, but nevertheless corresponding to many trillions of dollars of damage that should not be dismissed.

More than two decades of integrated assessment model research on the cost of climate change showed that climate impacts on world GDP seem to be moderately negative (see for example

Mendelsohn, 2000), or slightly positive temperature increases below two degrees. The costs become unambiguously negative under a three degree warming scenario and increase more than proportionally in temperature (Bosello and Parrado, 2014). This affects the social cost of carbon. However, these estimates are criticised for being underestimated. According to the literature search, no estimates are provided beyond the global scale, for example at the European level.

Policy analysis of the economic impacts of climate change must measure the full costs of adaptation (Auffhammer, 2018). Adaptation costs tend to focus on the costs of reducing climate impacts, while the overall response to climate change should include the costs of mitigation, i.e. those to reduce the extent of climate change, and the costs of residual damages that cannot be mitigated nor adapted to (Fankhauser, 2009). It is also important to factor in socio-economic impacts (see Chapter 3). Determining the cost-effectiveness of adaptation actions can only be achieved through an analysis of the full costs of adaptation associated with an increase in overall societal protection.

A more in-depth literature review on cost estimates and underestimation can be found in Annex I.

Cost Estimates Categorised by Key Type Measures

Following the work undertaken in chapters 2 and 3, the literature review also took into consideration the draft KTMs provided by the EEA. The analysis explores the cost estimates of both adaptation and inaction, considering the categorisation of the KTMs. It aims to provide a summary of the academic literature on estimating costs for each KTM.

A – Governance and Institutional

Most estimates tend to consider 'hard' structural adaptation measures rather than 'soft' behavioural or regulatory adaptations, resulting in most estimates underestimating the costs of adaptation. Most forecasts concentrate on the cost of investment rather than the lifetime cost of adaptation steps (Fankhauser, 2010). Work in this area has increased the focus on how to value costs and benefits that occur far into the future, particularly by showing how conventional procedures for establishing the social discount rate become problematic in this intergenerational context and what new approaches might be needed.

B – Economic and Financing

Most studies focus on the technical (engineering) costs of delivering adaptation and overlook opportunity costs (e.g. socio-economic impact of alternative use of finance) and transaction costs (see also chapter 2). Future work should build on the findings from the mapping on the types of adaptation costs to understand how indirect or transition costs may be included. For example, the actual implementation of adaptation, including design, management and execution, as well as the need for monitoring and reporting, all lead to transaction costs, which are often not included in cost estimates. Indirect climate effects also amplify adaptation costs as additional investments are not included in cost estimates. A benefits-based approach has emerged more recently, and is commonly applied in climate change financing frameworks. It assesses climate change relevance based on analysis of the proportion of total benefits from the programme associated with adaptation and mitigation, as compared with other types of benefits (economic, social, and environmental) (Allan, S., et al., 2019).

C – Physical and technological

Technological innovation and development need to be taken into account in cost estimates, particularly in future scenario planning. Predicting these, and also predicting the future effects of climate change is challenging. Adaptation may reduce the costs caused by extreme weather events, but at higher temperatures the costs of adaptation may rise sharply.

D - Nature based solutions and ecosystem-based approaches

Changes in ecosystem service provision and the failure to act will lead to ecological, social and economic damages. This will increase adaptation costs, which will generate costs for society. Economic valuation through the Economics of Ecosystems and Biodiversity (TEEB) Project aimed to

enhance the policy relevance of ecosystems; however it did not analyse the cost types. The Cost of Policy Inaction (COPI) Project, supported by the European Commission, reported monetary estimates of policy inaction against the 2010 biodiversity goals in terms of lost ecosystem value. It found that the cumulative loss of welfare may be up to EUR 14 trillion in 2050 (Rodriguez-Labajos, 2013).

Nature-based solutions are defined as "Actions to protect, sustainably manage and restore natural and modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits" (IUCN, 2020). Such solutions are typically cheaper and more cost-effective than employing artificial technologies or taking remedial measures after natural functions have been lost (UNEP, 2021). However, the characteristics and complexities of nature-based solutions pose a number of unique challenges.

Currently, the costs of adaptation for some sectors remain largely unknown, notably for biodiversity and ecosystem services. Among coastal zone risks, for example, erosion and flooding are typically covered, but ocean acidification is not. This means reported costs of adaptation are partial, and thus underestimated. The extent to which omissions of sectors and risks underestimate costs is difficult to ascertain, but it likely to be significant. The cost estimates of adapting environmental and infrastructure systems and services can provide insight into the costs of inaction, or conversely, the benefits of maintaining and protecting societal goods and services through effective policies that avoid the most severe climate impacts (Ruth, 2010).

To improve the quality of these estimates, it may be necessary to focus on the potential to deliver species and ecosystem targets rather than monetary costs and benefits. Losses due to the absence of additional measures can be identified and targets set to ensure the sustainability of the relevant ecosystems.

Considering the damage function literature, Auffhammer (2018) has considered important sectors for understanding climate sensitivity and where the literature currently stands. It brings together KTMs C and D (see also Chapter 3). For example, for the agriculture sector, the costs of inaction will include direct costs and secondary costs associated with diminished production, as well as lost production in the case of, for example, replacement of crops. In many cases, the temperature does not directly impact agriculture as much as, for example, the impacts of temperature changes on pests and diseases that affect products and yields. Changes to food quality and safety standards institutionalised by legal and regulatory mechanisms may also indirectly affect the agriculture sector (Ruth, 2010).

E - Knowledge and behavioural change

Gifford (2011) conducted research into the psychological barriers that may lead to inaction. He considered, among others, that uncertainty about climate change may also function as a justification for inaction (Gifford, 2011). He also considers that perceived (in)equality may play role; for example, if economic sectors or countries are cited as non-cooperative, this may incentivise inaction by others. There is also a fear of being victimised by free-riders. Actors that benefit from positive externalities but do not pay for them contribute to the free-rider problem, which results in the under provision of those goods or services. Adaptation investments typically provide public goods which are subject to free riding as it is not possible to exclude nonpayers. While free-riding contributes to economic inefficiency, it may be in the interests of society to encourage actors which consume goods which generate substantial (external) co-benefits. The free-rider problem also appears when the external costs of an investment are not considered, for example the use of ecosystem services.

Public actors can implement policy instruments such as linking public and private goods for users to pay voluntarily, or taxing the free-rider for their benefit of the public good. Policymakers also need regulation to prevent environmental degradation or excessive resource use. Participatory approaches could be used by public actors, drawing on various sources of private actor knowledge and experience, which would also help in the design or improvement of policy and financial mechanisms. In some sectors, costs may be reduced through learning and innovation, and with the scale of implementation.

No taxonomy or research model has been developed for climate-related behavioural change, although there were some tentative starts (see Gifford, 2008; Kollmuss & Agyeman, 2002; Lorenzoni et al., 2007). Existing models, such as the theory of planned behaviour (see Ajzen, 1991) or value-belief-norm model (see Stern, 2000) could be adjusted for climate change. Overall, specific barriers at the behavioural level need to be considered in order to understand the reasons behind inaction on more climate-friendly choices. At the societal level, Skinner (1987) argued for taking control from governments as long as they act in conflict with the long-term welfare of the species. Abrahamse, Steg, Vlek, & Rothengatter (2007) argue that better measures for carbon cost must be created, associated with various behaviour choices.

Data availability is a highly relevant as knowledge about climate risks and impacts leads to action. One study concluded that "the significance of expanding knowledge about [pluvial flood risks] and the costs of inaction cannot be understated" (Nicklin et al., 2019). Optimal policy design requires an understanding of external cost imposed by additional emissions of greenhouse gases (Auffhammer, 2018).

Summary

This chapter reviewed literature and studies to determine how the cost of inaction and the cost of adaptation are defined in the literature. It culminates in a (brief) assessment of the cost of adaptation versus the cost of inaction considering the KTMs. This will be elaborated for the Final Report.

The social optimum is a situation where the welfare of all individuals in the economy is maximised; the point where it is not possible to improve the situation for someone without making someone else worse off.

While the literature tends to focus on mitigation, it highlights that the cost of inaction will be significant and must be considered in decision making. This will support them in deciding the optimal time to invest in adaptation measures, prioritising adaptation actions, and providing appropriate incentives to adapt. This could be done with a sector-approach, considering the KTMs. However, there is a significant knowledge gap, particularly in estimating the costs of inaction and the costs of adaptation.

Adaptation has an extremely important role in reducing economic costs across Europe. Although it has a cost, it may also significantly reduce the costs of inaction, and in many cases benefits even outweigh the costs. The costs of adaptation remain likely to be higher than estimated in current global or national estimates (ECONADAPT, 2015).

Types of costs and benefits of adaptation actions

The definition of inaction to climate change is in itself a complex concept, and is dealt with differently by different studies. The aim of this section is to review existing information to give an overview on their methodologies to understand the relative efficiency of adaptation action versus inaction.

The costs of inaction can be defined as the costs that accrue in the case of no investment in adaptation. These would also increase if less GhG emissions are mitigated. 'Inaction' is defined as the reference from which the costs and benefits of different policy or actions can be evaluated (EC Communication, 2005).

In general, the assessment of the costs of climate impacts requires an assessment of the baseline climate and socio-economic scenario, a future scenario, quantification of the impacts of the future socio-economic and climate impacts, and monetary values are assigned (EEA, 2007). This is a complex process, particularly when considered across multiple sectors. Socio-economic development, for example, changes adaptation costs (see chapter 2).

In general, a wide range of estimates of costs of inaction are found, particularly in (EEA, 2007):

- scenarios;
- valuation and direct/indirect effects;
- spatial and temporal variation;
- uncertainty and irreversibility;
- coverage.

Further methodological issues arise when assessing the costs of adaptation, including (EEA, 2007):

- defining the type of adaptation and the types of costs;
- the level and timing of adaptation;
- ancillary impacts of adaptation;
- distributional aspects of adaptation.

Results of the literature review

Global adaptation cost estimates from more recent studies range from around USD 25 billion a year to well over USD 100 billion by 2015-2030, and up to USD 280-500 billion by 2050 (Pauw et al., 2021). In addition, the benefits of adaptation investments often outweigh the costs. For example, a USD 1.8 trillion investment in early warning systems, climate-resilient infrastructure, improved dryland agriculture, global mangrove protection, and resilient water resources could generate USD 7.1 trillions of benefits, mostly concerning avoided costs, and including non-monetary social and environmental benefits (Global Commission on Adaptation, 2019). The wide range is symptomatic of the poor state of knowledge, particularly regarding estimating and assessing the benefits and costs of adaptation. Economic analysis and tools must be adequate to the scale of the problem and the practical applicability.

Many different kinds of challenges complicate the estimation of both adaptation costs and adaptation finance. The UNEP Adaptation Gap Report suggests that most estimates significantly underestimate costs, resulting from (Pauw et al., 2021; UNEP, 2016; Chapagain et al., 2020; Fankhauser, 2010):

- Adaptation cost estimates are influenced by the trade-off between climate impacts (depending on mitigation level in the cost estimate), the costs of adaptation, and the residual costs (after adaptation). The Adaptation Gap Report states that "it is scientifically and ethically complex to determine the optimal combination between these three elements" (Pauw et al., 2021).
- As discussed in chapter 2, the cost of adaptation in some sectors, for example biodiversity and ecosystem services, remain largely unknown. Therefore, adaptation costs are typically

underestimated, but it is difficult to know the extent of this underestimation. It also becomes more important to understand and assess the ancillary impacts.

- Also covered in chapter 2, indirect and unforeseen climate impacts can increase adaptation costs as they may lead to additional investments in adaptation that are not included in cost estimates.
- Autonomous adaptation tends to be omitted in the literature, which focuses on planned adaptation (see chapter 2).
- Some studies aggregate the positive impacts of climate change with adaptation costs, which assumes that the benefits and costs affect the same communities, sectors or countries, or that the costs and benefits can be transferred between them (see chapter 2). This cannot be applied generally but where it is true, it may be a simplification that makes implementation possible.
- As discussed in chapter 3, co-benefits or ancillary impacts are not always included in benefit estimates.
- Many countries do not incorporate the adaptation deficit into their adaptation management plans and strategies.
- Learning, knowledge and innovation may reduce adaptation costs particularly in some sectors (see chapter 2).
- Most estimates tend to consider 'hard' structural adaptation measures rather than 'soft' behavioural or regulatory adaptations.
- Some indirect adaptation costs such as implementation costs, opportunity costs and transaction costs are not included in many studies or cost estimates (see chapter 2).
- If actions are not recognised or quantified as adaptation – so called silent adaptation –cost estimations may be lower (see chapter 2).

Overall, the literature points to the absence of measureable outcomes or indicators and a difficulty in defining adaptation in practice, which hinders adaptation cost estimates and adaptation tracking (Ford et al., 2013). Additionally, economic analyses do not typically include uncertainties surrounding adaptation costs and benefits, which may lead to substantial underestimations. Appropriate data sources need to be identified, with metrics that can be sufficiently analysed and the results compared at the national or global level (Silvestrini et al., 2015).

The following section provides an overview of the literature review conducted on the efficiency of the cost of adaptation action and inaction. Without claiming to be a full literature review, it aims to introduce the methodologies used in adaptation literature and studies, and draw an analysis of the methodological developments that have taken place.

Methodologies and methodological developments

In 2007, the UNFCCC Secretariat commissioned five studies to understand the investment needs for adaptation, globally and in developing countries (UNFCCC, 2007). The estimates cover different sectors and use different methodologies. For example, coastal protection costs were based on the Dynamic Interactive Vulnerability Assessment (DIVA) model, which uses a limited set of global adaptation options. The estimate considered both adaptation costs and residual damages, a unique methodology in these set of studies. A sixth study was commissioned on ecosystem adaptation (KTM D), but the results were not sufficiently robust (Fankhauser, 2010). The Study was also criticised for underestimating the true cost of adaptation, and focusing only on adaptation costs at the exclusion of adaptation deficits and residual damages (Parry et al., 2009). The UNFCCC identified four methods for estimating global and regional adaptation costs (UNFCCC, 2007). A bottom-up approach estimates the costs of specific adaptation action. The UNFCCC argued that only partial information could be obtained from National Adaptation Programmes of Action (NAPAs) and National Communications, but that where costs have not been estimated they can be derived. Drawing on Raworth (2007), an extrapolation of the bottom-up method could be used: extrapolating estimated adaptation costs in NAPAs to al developing countries using three factors; population, income and land. A third method is to use current global expenditures in the agriculture, forestry and fisheries, natural ecosystems and infrastructure and apply a rule of thumb to estimate additional costs. This

could be done using the World Bank method of assuming development costs, and is similar to conducting a sensitivity analysis. The final proposed approach was a top-down quantitative approach using models to estimate biophysical impacts and applying uniform cost rules to estimate costs.

In 2010, the World Bank measured the climate-sensitive part of an investment and used a 'mark-up' to represent the cost of the climate proofing element. They assumed 2-10% of GDI, 10% of FDI, 40% of ODA would be sensitive to climate change (Fankhauser, 2010). This approach was also used in the Stern Review and Human Development Report, with adaptation costs added to adjust poverty reduction strategies (USD 40 billion a year) and strengthen disaster response system (USD 2 billion a year) (Fankhauser, 2010). The World Bank focused on the infrastructure sector, analysing the higher order effects of adaptation on the economy as a whole; however, adaptation was pushed to the point where there was no residual damage and marginal adaptation costs equal marginal adaptation benefits (Fankhauser, 2010). The literature review has not found whether the evaluation of the numbers has been used since 2010. It cannot be corroborated whether they provided an appropriate estimation.

Economic Approaches

The economic approach to adaptation involves extensive risk screening to identify the main areas of vulnerability. A 2013 Study proposed the use of the expected value/expected utility maximisation, if climate outcomes can be quantified and their probabilities are known. *Non-probabilistic approaches* like *maximin* focus on worst possible outcomes; Info-gap decision theory emphasises the robustness of a decision; while *multi-criteria analysis* is typically used by analysts to understand whether impact can be monetised (Fankhauser and Soare, 2013). The Study provides examples of costs and benefits from Swiss Re (2009) and ASC (2011); however, there are few examples given on adaptation practices.

Mendelsohn et al. (1994) use the Ricardian method, which aims to study the long-term impact of climate change on agriculture while accounting for adaptation, and taking into account the ability of each farmer to adapt. The study finds that adaptation will reduce the damages from climate change. This raises the question about who bears the costs of adaptation and who benefits from the intervention, which may affect the overall efficiency of adaptation. Mendelsohn (2000) argues that adaptation is only efficient if the cost is less than the resulting benefits; and that private adaptation only benefits one beneficiary (the decision-maker), while joint adaptation has many beneficiaries. He argues that adaptation must maximise the net benefits to the individual, and if there are substantial externalities, it is inefficient. He furthers his argumentation in 2006, defining the cost of adaptation as, "any costs that must be borne to make this change happen", and efficient adaptation as "net benefits of adapting being maximised by the set of adaptations" (Mendelsohn, 2006). Private adaptation may result from poor decision-making if there is uncertainty about the future benefits, which lead to hesitation about adaptation choices. In the short term (adaptation) capital is largely fixed, while in the longer term, all capital must be replaced, for example changes over time in residential buildings, factories and transportation can be made relatively more cost-efficiently than one immediate retrofit (Mendelsohn, 2000). Governments should use support instruments for adaptation in the case of externalities, including overcoming the information asymmetry and capital market imperfections (Mendelsohn, 2000). In comparison to private adaptation, joint adaptation provides positive externalities to many beneficiaries in the form of public goods. Therefore, government intervention should be used to maximise the adaptation action. Dynamic adaptation involves adaptation actions with large capital stocks. Capital intensive sectors such as the coastal sector and timber may need to forecast climate change, and require dynamic analyses of adaptation as they are vulnerable to rapid changes, while sectors such as agriculture can adapt more flexibly.

The discussion on the cost of inaction must consider the real costs and benefits of the whole economy to adapt. Mendelsohn (2006) analyses the agriculture, water and biodiversity sectors, focusing on the role of markets and governments to foster efficient adaptation. The role of markets is to adjust the supply and demand of products and global prices will also change accordingly, in an example of market adaptation. Water allocations are also deemed inefficient, as supply-demand driven water pricing would not work in many economies. If water prices are fixed at a lower than market price,

investing in efficient water infrastructure less attractive. In accepting this market imperfection, a policymaker would need to subsidise such investments.

Cost-Benefit Analyses

Cost-benefit analyses (CBA) have become a core tool of public policy (OECD, 2019); the systematic process of calculating the costs and benefits of policy options and projects to understand how society would benefit and how particular goals can be achieved. Climate economics has recently been used to appraise policy actions to mitigate or adapt to climate change. The focus has increased on how to value costs and benefits that occur in the future, as well as lead to further thinking on how to deal with uncertainty in CBA (OECD, 2018).

Chambwera et al. (2014) state that "economic analysis of adaptation is moving away from a unique emphasis on efficiency, market solutions, and benefit/cost analysis to include consideration of non-monetary and non-market measures, risks, inequities, behavioural biases, barriers and limits, and consideration of ancillary benefits and costs". Considering the move away from CBA, the literature discusses impact assessments, focusing on technical adaptation and future climate impacts, and the 'policy first' approach, which is more useful for practical (early) adaptation (ECONADAPT, 2015). Here, the analysis focuses on adaptation as the policy objective. Global economic integrated assessment models combine the scientific and economic aspects of climate change into a single framework, which can be used to quantify the economic impacts of climate change and, to an extent, the costs and benefits (ECONADAPT, 2015). The literature also focuses on the iterative framing, considering early low-regret options (climate resilience) or decision making under uncertainty (future planning). Many of the low-regret options include opportunity, transaction or policy costs that are not included in adaptation cost estimates (Watkiss et al., 2014; ECONADAPT, 2015).

Yohe et al. (1996) studied the impacts of when and where to build a sea wall along the cost of the United States. Mendelsohn (2006) uses the example of a low sea wall costing $500.000 to protect properties from rising sea levels in 2030, and a high sea wall estimated to cost $2 million to protect additional properties from flooding by 2080. Initial studies did not consider the timing of adaptation and chose the response with the smallest cumulative cost, predicting society should build the sea wall costing $2 million. Choosing the dynamic response, and integrating a 5% real interest rate, the present value of building the sea wall just before 2030 and a high sea wall just before 2080 was just $148.000, considerably lower than the initial reported $2 million cost (Mendelsohn, 2006).

In 2020, a study was conducted on global-scale benefit–cost analysis of coastal flood adaptation (Tiggeloven et al., 2020). The authors calculated the expected annual damage of coastal flooding for scenarios with and without adaptation, with the difference representing the adaptation benefits. The damage was calculated for each year of the lifetime of the dike for a certain return period, and increases linearly. In the no adaptation scenario the expected annual damage increases by a factor of 150 between 2010 and 2080. The cost of flood protection was estimated using a quantification of the costs involved with the multiple adaptation objectives by summing up the maintenance and improvement costs over time for raising dikes to stop floods. A benefit-cost analysis was conducted for four adaptation objectives: Protection constant (current protection levels are kept constant also in the future); Absolute-risk constant (calculating future protection standards when the absolute value for the expected annual damage is kept the same as the current one); Relative-risk constant (calculating future protection standards when the expected annual damage as a percentage of GDP is kept the same; and optimise (calculating future protection standards by maximising the NPV). When no adaptation takes place, future protection standards are calculated by assuming that dikes are maintained at the current height with no additional heightening. The benefit-cost analysis was performed by calculating the benefits and costs for adaptation until 2100 for sub-national regions. To assess the benefits and costs of adaptation objectives, information on current protection standards is important and these standards are estimated by FLOPROS modelling approach. The study found that the protection constant adaptation objective benefits outweigh the costs for the majority of the regions. However, the model scheme does not include dynamic inundation modelling at the cost of increased computing time. The resolution of the model should be improved to better understand local-scale signals and patterns as scale of assessment and resolution of input data have a significant

implication on flood risk model results. Data on flood protection along the global coastlines were not available (Tiggeloven et al., 2020).

Most adaptation policies will not be based solely on a CBA, but an analysis, even incomplete, provides important and useful information to decision makers (UNFCCC, 2009). However, CBAs are limited, and it may not be optimal to choose adaptation actions where the benefits outweigh the costs. A cost-effectiveness approach allows options to be selected that have the lowest cost for achieving a specific goal or target. Alternatively, a risk-based approach ensures policies achieve an acceptable level of risk. Alternatively, a multi-criteria methodology may be adopted. However, in all cases and all methodologies, the distributional effects need to be taken into account and the most vulnerable communities and groups must benefit (UNFCCC, 2009). One Study cited national policy and legal frameworks as the main drivers for adaptation planning.

Considering those vulnerable communities, early frameworks for adaptation decision-making typically adopted a vulnerability-based approach, providing climate observations and scenarios modelling as a starting point for adaptation options (Palutikof et al., 2019). More recent work considers risk-based approaches that focus on a specific climate-related hazard, and integrate risk assessment, systems thinking and an assimilation of data including scientific and non-scientific (Morioka et al., 2020). This draws on recommendations on, for example, the NAP process to be country-driven, drawing on the best available science as well as traditional and indigenous knowledge (UNFCCC, 2011). This use of tools, processes, practices and interactions resulted in a holistic understanding of the complex environment of climate adaptation, including on national decision making through strategies and priorities collaborative structures involving multiple stakeholders, and domestic and international coursed on climate and non-climate information (Morioka et al., 2020). Although more stakeholders could have been consulted, this inquiry approach provided allowed researchers to identify where things were working well, and where there was information gaps. One limitation was that it did not measure the effectiveness of adaptation practices, or the efficiency of adaptation approaches or decisions made.

Monitoring Evaluation Approaches

Overall monitoring evaluation approaches are useful for identifying practical approaches to addressing the methodological challenges as well as accountability and learning needs. *Developmental evaluation* focuses on systems and problems that are complex, characterised by uncertainty and dynamic change and is a "mindset of inquiry" rather than set of methods or tools. The role is to support data-based decision-making process. For adaptation, this methodology should be combined with formative and summative evaluations (Dinshaw et al., 2014). *Longitudinal evaluation* addresses the evolution of programmes over time, while *impact evaluation* assesses the direct and indirect contribution of an intervention and answers the question of whether specific interventions has direct relationship to specific outcome. *Institutionalised learning* is the third approach of learning function proposed in the paper, taken by USAID in Uganda with the Collaboration, Learning and Adapting (CLA) Plan. They created a unit that initiates dialogue, consultations, develops response plans and tests innovative approaches (Dinshaw et al., 2014).

Assessing attribution, i.e. whether an intervention has a direct relationship to a specific outcome, impact evaluations are usually used. For example, Prowse and Snielsveit (2010) assessed the use of the impact evaluation method for adaptation interventions, and found that techniques to assess the effectiveness of climate change interventions is limited (Prowse and Snielsveit, 2010). Quantitative methods are sometimes criticised in the literature for being too narrow, excluding the complex development context that influences outcomes, and do not conclude whether an intervention can be replicated (Ravalion 2008; Picciotto, 2013; Patton, 2011; Woolcock, 2009). This can be counterbalanced through a combination of qualitative and quantitative methods. In general, data triangulation, i.e. using a combination of qualitative and quantitative indicators (mixed-method approach), is visible in almost all adaptation projects (Silvestrini et al., 2015). Since attribution becomes more challenging over a longer time period, assessing contributions to a general direction of change may be more feasible than establishing a direct causal attribution (Dinshaw et al., 2014). For establishing baselines and targets, projection techniques and trend extrapolation methods can

be used to estimate baselines, in the absence of relevant climate data. In one study, the International Fund for Agricultural Development (IFAD) Independent Evaluation Office, for example narrowed the search to impact evaluations. Since baseline data was absent, the study attempted to reconstruct the baseline through recall methods, and used a quasi-experimental design that does not strictly require baseline data (Silvestrini et al., 2015). Taking the above into account, Dinshaw et al. (2014) propose a number of methods that can be used to monitor and evaluate adaptation initiatives at project and programme level.

Objectives- or Benefits-based Approaches

There are diverging approaches to assessing climate change relevance, a measure of the percentage or programme or budget line related to climate change (adaptation or mitigation), and two approaches emerged (Allan et al., 2019). The objectives-based approach originates from the Climate Change Public Expenditure and Institutional Review (CPEIR) and used in OECD ODA climate change markets. The assessment focuses on the extent to which climate change is a part of the explicit or implicit objectives of the programme, with bands defined such as those below:

- 75–100%, where climate change is a primary objective of the spending programme;
- 25–75%, where it is one of a mix of objectives; and
- 25% or less, where climate change is a secondary or significant implicit objective.

The Climate Change Impact Appraisal (CCIA) benefits-based approach has emerged more recently, and is commonly applied in climate change financing frameworks (Allan et al., 2019). Climate change relevance is assessed on the proportion of total benefits from the programme associated with adaptation and mitigation, compared to other types of benefits (economic, social, and environmental). The analysis compares the benefits delivered in the case of no climate change (i.e. development benefits do not change and adaptation/mitigation has no value) with the benefits in the case of climate change (i.e. the benefits increase (or decrease for maladaptation) and reductions in GhG emissions have a value). Climate budgeting can be applied at the sub-national level from a sectoral perspective, with CCIA used to facilitate mainstreaming. CCIA can also be integrated into public investment management processes (a bottom-up approach). However, CCIA seeks to quantify the adaptation and mitigation benefits of an investment. The challenges in quantifying the negative economic consequences of climate change and the positive economic returns to adaptation investments made it difficult to make the case for adaptation finance (Allan et al., 2019). The approach also allows all key departments involved to identify which public investments are most vulnerable to climate change, as well as specific opportunities to invest to make them more resilient. In one case study (in India), this information was then used to inform the State Budget to show the climate relevance and sensitivity of the schemes of all departments , and helped to strengthen decisions around budget allocations from a climate change perspective (Allan et al., 2019). Such an approach is also difficult to standardise, thus hindering cross-country analysis, and tend not to be used for international reporting purposes. However, at the national level it is a useful approach to identify trends on adaptation spending and whether budget processes prioritise programmes that deliver greater adaptation benefits.

Social Science Methods

Formal social science methods including *socio-economic and census surveys* can provide reference data for estimating baselines. These are also used in beneficiary monitoring by being involved as a public perception surveys technique, and used as secondary administrative data (national surveys) in the approach to develop baselines. *Focus groups* are used to elicit changes in farmers' attitudes after a land-use programme, for example, was implemented. *Interviews*, together with other techniques, can be used to measure contribution of programmes to outcomes. For econometrics and statistics, evaluations using modelling and statistical analysis can be very useful for adaptation efforts that include environmental interventions and physical processes as flooding or drought. *Statistical analyses* may be useful for adaptation efforts that include environmental interventions. *Stochastic baseline* models can help to establish baselines since they are based on the premise of uncertain and

complex contexts. *Deterministic baselines* are a useful tool for projecting baselines but can be fairly complicated to construct. In these models variables are determined by the parameters in the model. Experiment-related methods include experimental and quasi-experimental design. *Experimental design* compares the treatment group against a control group, but cannot be used with adaptation initiatives as the design is too complicated or complex. *Quasi-experimental design* addresses the validation challenges of attribution and the counterfactual when evaluating the impact of intervention by comparing intervention participants and some form of non-intervention control. This can be used for adaptation interventions. Participatory methods such as *most significant change analysis (MSC)* or *recall techniques* asks participants and beneficiaries to provide their experiences of the intervention. *Beneficiary monitoring* involves techniques such as public perception surveys, citizen scorecards and beneficiary satisfaction indicators in a log frame format. To track the provision of climate resilient services, beneficiary satisfaction and potential proxies for vulnerability over time, the approach needs to be used in the local level in climate adaptation approaches. *Limiting factor analysis* is mostly used for the evaluation of biodiversity projects. Techniques to develop a common understanding of the key factors that must be assessed for the project to be viable over the long term. Iterative methods may also be used for adaptation interventions. For example, *sequential targeting,* for achieving outcomes, establishes realistic targets that contributes on intended impacts as short term objectives. *Results based monitoring*- has strong measures for learning through information exchange, reporting, learning sessions and knowledge products. *Theories of change* include assumptions made at project inception, and mid-term objectives feed into long-term goals. If established at the local level, this can help the community to better understand and analyse the effects of the intervention on their livelihoods. When developing this approach for adaptation initiatives, the first step should be to conduct a context analysis focused on climate vulnerability and risks. The *stepwise approach* is used to monitor and evaluate health systems strengthening initiatives (HSS). When applied to adaptation initiatives, ongoing monitoring on the intervention implemented over long period of time that has challenges with financial commitment is very important. Based on the set of scenarios that influence the evolution of the intervention, *scenario building* can support adaptation, through providing a good understanding of projected climate risks to identify targets that factor in different scenarios*. Rolling baselines* allow baselines to be collected during the different stages of the programme instead of collecting them at one point in time.

Questionnaires were used in a 2020 study that aimed to provide a comparative analysis of progress towards adaptation strategies in 9 coastal areas in North West Europe (Rutherford et al., 2020). 17 European partners were selected and the respondents were closely involved in the adaptation work; from academic and administrative management bodies. Additional information was collected through *face-to-face interviews, email and telephone correspondence* to ensure having a complete information for each target area. The study found that both "hard" and "soft" adaptation methods need to be considered; from engineering and infrastructure, to social, economic, political and institutional, and that adaptation strategies to be flexible enough to take social infrastructure investments and new knowledge as it is generated, rather than inflexible large-scale hardware. Limitations included that questionnaires do not cover longitudinal view of progression, but rather a brief snapshot. Also, due to the differences in policy and governmental structures across the different countries, some indicators did not apply to all respondents and corrections were needed to ensure a valid comparative analysis throughout. Although all countries goals are to adapt, each country had different targets and timeframes.

A Sectoral Approach

In 2009, Parry et al. evaluated different methodologies for different sectors. For example, to estimate the actual and potential costs of adaptation in the water sector, it is possible to construct experimental design which enables the estimation of the costs of adaptation and residual impacts at the scheme or management-unit level. Estimating global costs through experimental design is challenging, and the authors recommend extrapolating costs from a small case study sample. However, case studies can be misleading, resulting in underestimated costs, and it is not possible to take a realistic top-down approach (see also UNFCCC 2007 above). Taking a top-down approach, costs would be estimated by applying generalised cost functions. Although this does not provide

precisely accurate results, it provides the magnitude of adaptation and residual damage in a consistent way (Parry et al., 2009). The study finds that the costs of adapting infrastructure are underestimated as they do not cover all extreme-weather disasters. The costs for full-range water storage and distribution is generally underestimated as the use of average climate change scenario is used rather than one that specifically describes the range of possible impacts.

A variety of methods have been used to conduct climate impact assessments, which includes adaptation for coastal flooding and sea-level rise (COACCH, 2019). The economic costs and adaptation costs of coastal flooding impacts were among the most comprehensively covered. COACCH used the global integrated assessment model DIVA (see above) and presented results in the form of expected annual damage costs (undiscounted). To assess the potential river flooding impacts in Europe, the study used the GLOFRIS model and presented the results in the form of expected annual damage costs (undiscounted). COACCH assessed the number of people flooded to evaluate the levels of flooding. Estimates of the impacts related to changes in temperature and heatwaves were performed using *econometric analysis* and combining *spatial information* on sectoral labour productivity with high resolution subnational meteorological data. An econometric analysis was undertaken to assess the effects of changing wind patterns on wind energy production and changes in hydropower production (see above). COACCH used OSdaMage, a continental scale flood risk model developed on European road infrastructure. To assess the costs of climate change on agriculture, COACCH used three crop models (EPIC, GEPIC and LPJmL 5) and two bioeconomic models (MAgPIE 4 and GLOBIOM-EU) covering the land use and marine production sectors. MAgPIE models were used to estimate the impact of climate change on EU-28 production (area and yield). The economic climate impacts on forestry and fisheries were investigated using the biophysical forest model G4M, GLOBIOM, MAgPIE, the Wildfire Climate Impacts and Adaptation Model (FLAM), along with the IIASA's global forestry model G4M. The study used GLOBIO, which is a scenario-based gridded global model for biodiversity estimating the Mean Species Abundance on the basis of a meta-analysis of a range of studies, and GLOBIOM model, this last to identify and quantify the impacts on land use, fertiliser and greenhouse gases from adaptation in agriculture and forestry management, and potential impacts on biodiversity. COACCH used computable general equilibrium (CGE) models to assess the macro-economic effects of climate change, or global and continental economic estimates provided by "hard-linked" integrated assessment models (IAMs). To assess the Flood insurance affordability in Europe, COACCH used an adapted version of the "Dynamic Integrated Flood and Insurance" (DIFI) model. To assess Food Production Shocks, COACCH used GLOBIOM-X, which is a nonstationary model for market stabilization policy design based on the bio-economic land use model GLOBIOM.

A Project Approach

At the project level, Silvestrini et a., (2015) analysed different options for analysing adaptation. The *Partial Least Squares* analysis is a multivariate statistical approach for the estimation of causal relationships. It is a variance-based, non-linear iterative method based on a linear regression model. It allows the estimation of concrete values for latent (i.e. non-observable/measurable) constructs with the help of manifest (i.e. observable/measurable) indicators. Causality must be established to understand why particular incidents occurred during and after a project or programme. Time series deigns may be particularly useful for adaptation projects as they cover longer periods than those set by a project. In determining the impact of a project, a structural equation modelling (SEM) can be applied to measure large-scale policy-based programmes that aim to affect an entire sector, country or region. SEM allows the measurement of a statistical relationship between several influencing factors (e.g. public investments, project funding, disaster resilience of a population). Each factor can be estimated independently. However, both SEM and time-series designs only estimate the contribution made by an intervention to observed changes.

In 2009, the UNFCCC undertook a review of the methodological issues for estimating the costs and benefits of adaptation options and found that there are benefits in adopting multiple methods and approaches, including non-monetary ones (UNFCCC, 2009). However, EconAdapt found that as the evidence base is extended, it becomes more challenging to directly compare studies and sectors and

aggregate estimates, because of the diversity of methods, assumptions, treatment of socio-economic change, discount rates, etc. (ECONADAPT, 2015). National estimates, for example, typically indicate higher adaptation costs than global estimates. This may be because they include a greater coverage of risks, and a wider range of climate projections, leading to higher estimates. However, these may omit low-cost market-based adaptation, such as international trade (ECONADAPT, 2015).

The main finding in the literature is that a baseline must be established to determine the impact of adaptation, as it provides a reference point against which change can be measured (Dinshaw et al., 2014). For adaptation, this must also take into account future effects, i.e. a baseline of how the climate will change (Silvestrini et al., 2015). This also leads to a significant challenge in the efficiency of adaptation: climate change is uncertain and likely to unfold differently than planned, leading to a 'shifting baseline' (Silvestrini et al., 2015).

Many different methods are used to assess adaptation costs and ancillary impacts, making it difficult to draw comparisons at the global, or European, scale (Climate Change Association and Committee 21, 2019).

5. RECOMMENDATIONS FOR METHODOLOGICAL IMPROVEMENTS

5.1. Draft a Briefing

It is important to assess benefits and costs of adaptation as the basis for decision-making and prioritising adaptation actions and incentives and support efficient measures in the context of their positive impact on society as a whole. However, most European countries are only starting to address the issue of clearly defining the concepts and limits of adaptation finance and tracking adaptation costs and ancillary impacts.

There are a number of challenges in quantifying and assessing adaptation costs and benefits. The types of adaptation costs are diverse and heterogeneous and can be characterised and categorised in many different ways. The same challenge exists for ancillary impacts; they are typically sector-specific, accrue locally, generate public goods, arise on different time-scales, and are diverse. Typically, then, the costs of adaptation are underestimated, and there are a limited number of studies discussing the efficiency of the cost of inaction, or proposing methodologies for cost estimates. Another challenge relates to the fact that the costs of adaptation usually overlap and it can be difficult to make a clear distinction.

In 2021, EEA plans to publish a briefing addressing the cost, efficiency, and effectiveness of adaptation measures. There have been developments in this area over the last years at the European and national level, but availability of information on the cost of inaction and cost of adaptation is still very fragmented and incomplete.

This briefing should build on the foundation of this exploratory Phase, including the preliminary interviews, questionnaire responses, and literature review on methodological frameworks to understand and assess the cost of adaptation action and inaction.

Cost Estimate Approaches

Using the work from Chapter 4, different methods and approaches should be further analysed for their applicability for estimating adaptation costs.

Quantitative methods are criticised in the literature for being too narrow, excluding the complex development context that influences outcomes and an interventions' replicability. This can be counterbalanced through a combination of qualitative and quantitative methods.

For example, the Climate Change Impact Appraisal (CCIA) benefits-based approach has recently emerged in the literature. It allows the integration of a sectoral perspective into climate budgeting

also using a multi-stakeholder consultation process to strengthen decisions around budget allocations from a climate change perspective. Although the approach is difficult to standardise, at the national level it is a useful approach to identify trends on adaptation spending and whether budget processes prioritise programmes that deliver greater adaptation benefits.

A second method that may be of interest to consider further is the Policy Analysis of the Greenhouse Effect (PAGE) approach, which has been recently updated to more accurately represent the latest climate science). Although Page09 still omits adaptation limits, institutional issues and local scale issues, it does provide useful insights (see Chapter 4.4).

A third method that may be considered are risk-based approaches focusing on a specific climate-related hazard draws on recommendations on, for example, the NAP process to be country-driven, drawing on the best available science as well as traditional and indigenous knowledge. The use of tools, processes, practices and interactions provides a holistic understanding of the complex environment of adaptation. It allows the identification of where things are working well, and where there are information gaps.

Phase 2 could also explore ways to categorise adaptation expenditure, including expanding on the KTM framework and sectoral approach introduced in Phase 1.

In addition, phase 2 could include the review of additional examples for ancillary benefits, in line with the work undertaken in line with the KTMs. For instance, examples will be reviewed from the KTM A: Governance and Institutional and KTM B: Economic and Financing, as well as human health and business/industry (KTM C) categories, which may also include a review of the preliminary March 2021 report on adaptation actions. This will focus on the potential for governance and institutional adaptation actions to have very large primary and ancillary impacts, and whether these ancillary impacts are likely to be positive or negative, and under what conditions.

The Briefing

The Briefing should analyse the current status of adaptation finance in Europe, including a summary of key results taken from Phase 1.

The briefing could provide benchmarks, taken from the questionnaire responses and additional literature review, to provide examples, distributed both geographically as well as countries who were frontrunners in developing a NAP and those who have recently developed one, or are in the process of updating theirs. This could build on the questionnaire responses.

The briefing could be concluded with recommendations on the activities the EEA should prioritise in Europe, including in recommending a methodological framework, if possible, to estimate the cost of adaptation action and inaction. Many countries focus on specific adaptation actions or projects, rather than having a methodological framework in place to collect data on overall (national) adaptation finance spending. Such a framework should concentrate on a European policy perspective covering the full costs of climate adaptation, including the economic costs of climate impacts and advice on additionality. In this context, the EEA should also consider approaches on how to use the EU Taxonomy in its processes and schemes.

EconAdapt (2015) found that as the evidence base is extended, it becomes more challenging to directly compare studies and sectors and aggregate estimates, because of the diversity of methods, assumptions, treatment of socio-economic change, discount rates, etc. However, such a methodological framework should be developed in a way that it allows EEA Member States to express climate impacts in quantitative terms, through the provision of common definitions and a common metric to assess across countries, regions, and sectors. This would allow further measurement and monitoring of adaptation finance data. It would also provide an economic perspective in European adaptation policy, to ensure cost effective and proportionate adaptation, and to consider the wider economic costs and benefits of adaptation. However, it should be noted that the development of such a framework might be outside of the scope of this project.

The briefing should not only highlight the work conducted in Phase 1 on the methodologies available and the methodological developments in recent years, but also focus on the research agenda for future research. For example, economic analyses must be transparent about input data, assumptions, methodologies and sensitivity of the results to support decision making and enable meaningful comparisons. National estimates, for example, typically indicate higher adaptation costs

than global estimates. New topics such as the total investment costs necessary for adaptation could also be the focus of future research, for example considering climate impacts for each country and how we might attempt to address the knowledge gap on adaptation finance in this way.

Any methodological framework that is developed should be scalable and replicable, and should show, for example, how adaptation finance data availability has changed, and hopefully increased, over time. Therefore, we also recommend working towards a regular monitoring of adaptation finance.

5.2. Regular Monitoring

This second part of Phase 2 could examine lessons learned in this exploratory Phase 1, culminating in recommendations to the EEA on how to improve their data collection in the future and contribute to a regular, more systematised monitoring of adaptation finance data in Europe.

This may include:

- **An annual questionnaire.**

As several countries prioritise certain sectors or projects, an annual questionnaire would allow the EEA to understand the level of data both available and how this has increased (or decreased) over time. It also allows an understanding of the gaps in adaptation finance data.

- **A dialogue platform.**

The questionnaire responses demonstrated that different countries are at different stages of developing and implementing adaptation finance reporting. This suggests that it would be beneficial to provide a platform for countries to exchange information, share experiences, learn lessons from benchmark countries or initiatives, or have access to a summary of approaches applied in a briefing. A number of countries mentioned planned further improvements of their adaptation finance data collection and monitoring. Such a platform could build on, or parallel with, Climate-ADAPT.

Such processes could be used to provide lessons learned for other countries. However, it also provides an opportunity for the EEA to standardise a monitoring process now in order to feed into national level data tracking and collection improvement processes.

- **A regular briefing** on green or adaptation budgeting to be sent to all EEA Member States to improve their knowledge base and make climate budgeting permanent in the long-run.

Such briefings could include, for example, definitions of adaptation finance such as additionality, the cost of adaptation or inaction, economic analyses, etc. The questionnaire responses demonstrated that data availability, definitions and methods, governance structure, and additionality are major challenges for all EEA Member States.