IMPETUS

Turning climate commitments into action

Deliverable Report

Guidelines for decision-makers for business opportunities, financing mechanisms and policy and market instruments (v2)

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[1] PU = Public
CO = Confidential, only for members of the consortium (including the Commission Services)
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Disclaimer

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Abbreviations

Abbreviation / Acronyms	Description
AUEB	Athens University of Economics and Business
BANC	Business Angels Network of Catalonia
BFM	Benefit Transfer Method
BIC	Bayesian Information Criterion
CA	Climate Adaptation
CAPEX	Capital Expenditure
CBA	Cost-Benefit Analysis
CFS	Certificate of Financial Statement
CM	Climate Mitigation
CNMV	National Securities Market Commission
DACC	Department of Climate Action, Food and Rural Agenda
DE	Germany
DoA	Description of the Action
DS	Demo site
EAB	External Advisory Board
EBAN	European Business Angels Network
EC	European Commission
EEA	European Ecosystem Assessment
EIB	European Investment Bank
ES	Ecosystem Services
ESDV	Ecosystem Services Valuation Database
EU	European Union
EUT	Eurecat
EVRI	Environmental Valuation Reference Inventory
EYDAP	Athens Water Supply and Sewage Company
FP	Framework Programme
GA	Grant Agreement
GDP	Gross Domestic Product
GR	Greece
HDI	Human Development Index
ICF	Catalan Finance Institute
ICO	Official Credit Institute
IDAE	Institute for Energy Diversification and Saving
IT	Italy
LOB	Lobelia
LV	Latvia
MAES	Mapping and Assessment of Ecosystems and their Services
MBR	Membrane Bioreactor Unit
MITECO	Ministry for the Ecological Transition and Demographic Challenge
MRM	Meta-analysis Models
NL	Netherlands
NLP	Natural Language Processing
NO	Norway
NPV	Net Present Value
NTUA	National Technical University of Athens
OPEX	Operating Expenditure

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PC	Project Consortium
PSB	Project Steering Board
PMT	Project Management Team
RKB	Resilience Knowledge Boosters
R&D	Research and Development
SCBA	Social Cost-Benefit Analysis
SH	Stakeholders
SM	Sewer Mining
SME	Small and Medium Enterprise
TEC	Total Economic Value
TF-IDF	Term Frequency – Inverse Document Frequency
UOC	Open University of Catalonia
UPC	Polytechnic University of Catalonia
VC	Venture Capital
WP	Work Package
WPL	Work Package Leader
WTA	Willingness To Accept
WTP	Willingness To Pay

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Executive Summary

This deliverable D6.4 - *Guidelines for decision-makers for business opportunities, financing mechanisms and policy and market instruments v2,* is the outcome of T6.1 and the activities undertaken during the months M18 to M36. It is aimed at offering a first set of guidelines to policymakers and decision-makers in public agencies and administration on the identification of business opportunities and financial mechanisms related to the Climate Adaptation (CA) solutions. Such guidelines also include information about the identification of social costs and benefits coming from the solutions, as well as the relevant policies to consider for implementation. To draft these guidelines, workshops were carried out with DS2 and DS3 partners and, additionally, a social cost benefit analysis and a policy analysis (comprising a policy mapping exercise) have been executed, based partly on initial work developed under WP1 (D1.3). These activities and the corresponding results obtained have led to the formulation of preliminary policy recommendations with the overarching aim to facilitate the implementation of CA solutions. This deliverable also lists further actions and steps, which will be considered for D6.5 and D6.10, together with the final conclusions of T6.1.

1 Introduction and background

Climate change effects observed worldwide over the past few years have accelerated the urge of designing and implementing measures aimed at adapting to this new context of extreme events. Historically, the focus was set on mitigation, meaning that such measures were solely addressed at reducing the future impacts of climate change on society and on the environment, mainly through reducing the emission of greenhouse gases into the atmosphere. However, more recently, adaptation has gained importance and institutions are taking on actions directed at adjusting to and anticipating the new circumstances caused by climate change. In that sense, policymakers and decision-makers in public agencies and administration have an important role in promoting CA solutions by laying out the policy framework, as well as by providing financing mechanisms and information to the relevant stakeholders.

An appropriate example is the EU's Climate-ADAPT strategy[1] for the period 2022 to 2024. It consists of a Climate Adaptation Platform that supports the development and implementation of EU adaptation policies, in line with Europe's main target of becoming climate resilient by 2050. The stakeholders involved in this platform are mainly policymakers from EU member states, that are actively setting policies and providing financing for adaptation. The following figure shows the principal target audience of Climate-Adapt:

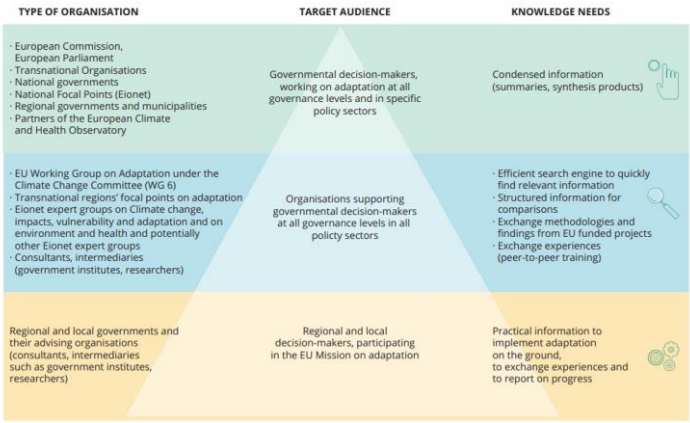

Figure 1. Climate-ADAPT target audience and needs. Source: Climate-ADAPT strategy 2022-2024

[1] Climate-ADAPT 2022-2024 strategy (europa.eu)

Despite this progress, there are still some challenges that slow down the implementation of CA solutions and therefore need to be addressed.[2] For instance, regarding the financial framework, there is a general lack of resources which leads to having much higher adaptation needs in relation to the actual financing available, together with a lack of knowledge and awareness of CA finance. Consequently, both the public and the private sector find it more difficult to found and channel the adequate financing. Additionally, there are challenges arising from coordinating the actions taken by different actors which can include international organizations, public multi-level governance and the private sector. Therefore, to adequately promote CA solutions, it is essential to provide guidelines addressed at policy advisors and decision-makers that inform about such challenges, and that incentive holistic strategies involving different types of agents to tackle them.

1.1 Objectives of task and deliverable

The present deliverable D6.4 is undertaken under the task T6.1 Provision of briefings and guidelines for decision-makers in public agencies and administration. As part of the WP6, this task aims to ensure the generation of long-term impact of the IMPETUS outcomes.

This deliverable primarily aims to provide a preliminary set of recommendations for policy and decision-makers to inform policy development and decision-making, as outlined in section 4.1. These recommendations are derived through a structured, evidence-based methodology involving several key steps: policy mapping and analysis, stakeholder workshops, and analytical techniques such as the Social Cost Benefit Analysis (SCBA). This comprehensive approach ensures that the recommendations are grounded in thorough research and stakeholder engagement. A methodological description of these steps is outlined in section 2.

Overall, WP6 aims at ensuring the long-term impact of the IMPETUS results by facilitating relevant information and recommendations to policy and decision-makers in order to influence policy design and decisions. According to the DoA, WP6 carries out the following actions:

(i) Provide briefings and guidelines to decision-makers in public agencies and administration, offering assessments of social benefits and costs connected with CA solutions, and identifying policies (including market-oriented instruments) suitable for innovative climate change adaptation measures.
(ii) Provide briefings and guidelines to decision-makers in industry and finance, signalling business opportunities connected with CA solutions, identifying financing mechanisms, market potentials and synergies with public policy.
(iii) Actively support the exploitation of innovative initiatives evolving from the resilience knowledge boosters of IMPETUS.

T6.1 specifically addresses the first action (i) the elaboration of briefings and guidelines to decision-makers in the public sector, providing relevant data derived from the Social Cost Benefit Analyses (SCBA) carried out, to identify interesting policies to support the implementation of CA solutions. Within the task, 2 subtasks are expected:

- Subtask T6.1.1, led by AUEB, implies the elaboration of social cost-benefit analyses of climate change adaptation solutions developed in the Demo Sites (DS). AUEB will select criteria to identify the gains and losses associated with these innovations and identify means to overcome current and future barriers and reluctances towards adaptation measures. By thoroughly evaluating the social and economic impacts of these measures, this subtask aims to provide a robust analytical foundation for policy recommendations.

[2] What is climate change adaptation and why is it crucial? | Climate Promise (undp.org)

- Subtask T6.1.2, led by EUT, will be based on the social cost-benefit analyses and selected criteria from subtask T6.1.1. It will also comprise a policy mapping exercise and a policy analysis of the various climate mitigation (CM) and climate adaptation (CA) interventions in the DSs to provide actionable guidelines for decision-makers in the public agencies and administration. The briefings and guidelines generated will enable them to effectively build on the CA innovative solutions provided by IMPETUS, facilitating the integration of these solutions into public policy.

Overall, T6.1 serves as a baseline to develop the exploitation of results (T6.3) and the involvement of the private sector for financing opportunities related to the IMPETUS solutions (T6.2). This initial task focuses specifically on the public sector to study the available public financing, analyse current policy gaps, and boost the impact of the IMPETUS solutions.

The present deliverable D6.4 compiles the following sections:

- Methodological Approach: The scope of T6.1 within the rest of WP6 tasks has been explained in this section, as well as the methodology followed to collect the information included in this deliverable.
- Empirical analysis: Based on the application of the methodology, relevant results of the activities undertaken have been included in this section.
- Conclusions: Finally, after a reflection exercise, general implications and guidelines for decision-makers have been elaborated.
- Next steps: The stages to follow after this deliverable have been detailed in this section.

2 Methodological approach

WP6 tasks have progressed in parallel and have considered two different levels of analysis:

1. EU, national and regional analysis, considering only the countries and regions involved in the project DS.
2. CA Solutions, prioritising the ones in the DS according to a criterion that are exposed in Section 5 of the deliverable *D6.6 Market perspectives report. Scenarios of the future and assessment of anticipated business opportunities.*

Based on the first level of analysis, within T6.1 we have undertaken a European, national and regional policy mapping of CA and Climate Mitigation (CM) interventions in the 7 DS countries. Section 2.1 details the methodological approach followed for this exercise.

Additionally, through internal workshops with DS leads, an analysis of policy barriers and opportunities has been carried out – initially, for this deliverable, we have considered the 2 frontrunners (DS2 and DS3), for which we have a larger availability of data. The remaining DS will be added in a future version of this deliverable. The methodological approach for these workshops is detailed in section 2.2.

Regarding the second level of analysis, further analysis has been done under T6.1 based on the list of CA Solutions per DS and the prioritisation of some of these according to their innovation and exploitability potential (Section 5 of the deliverable D6.6 - *Market perspectives report. Scenarios of the future and assessment of anticipated business opportunities*).

After performing the prioritisation exercise of the solutions identified for DS2 and DS3, a SCBA of the solutions and a concrete identification of policy barriers and opportunities has been done (Section 2.3). During the internal workshops with the DS, the key decision makers in the public and private sector were mapped and prioritised at a stakeholder matrix.

Figure 2 shows a summary of all the tasks and subtasks carried out under WP6. Work under T6.1 explained in this section is highlighted in green. This figure visually summarizes the interlinkages between the tasks that will lead to relevant implications and conclusions for the WP6.

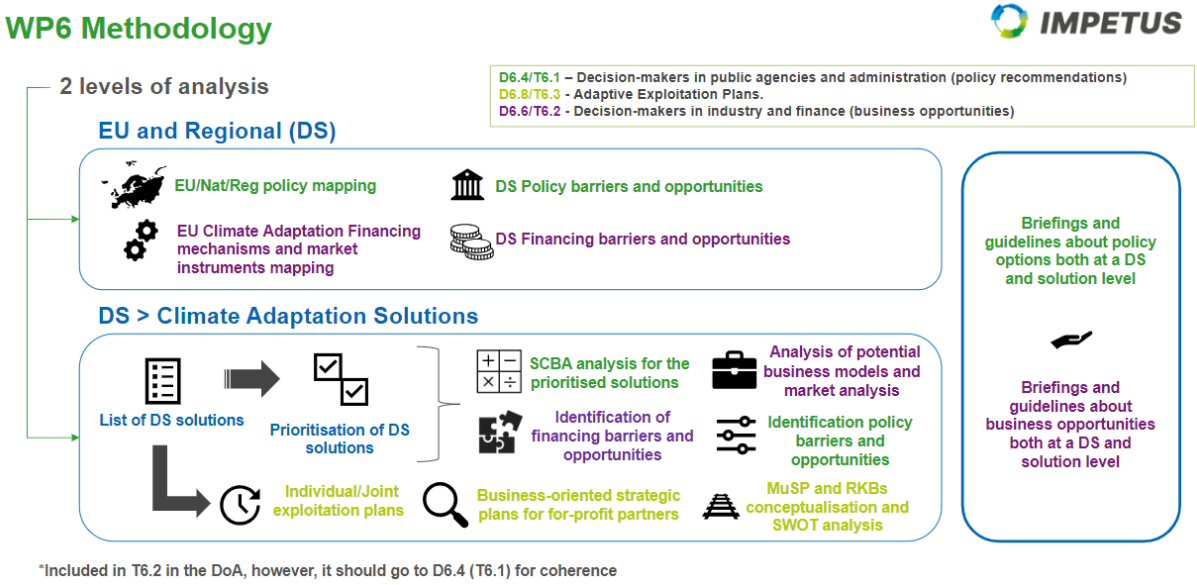

Figure 2. WP6 Methodology

The different outcomes are divided in 3 different deliverables: D6.4 - *Guidelines for decision-makers for business opportunities, financing mechanisms and policy and market instruments v2* (T6.1), D6.6 - *Market perspectives report. Scenarios of the future and assessment of anticipated business opportunities* (T6.2) and D6.8 - *Adaptive Exploitation Plans v2* (T6.3). T6.1 focuses on decision-makers in the public agencies and administrations as key stakeholders, that can enable the IMPETUS solutions to reach the market and that require quantitative arguments (SCBA) and a qualitative analysis (policy gaps) to overcome its barriers and leverage the existing opportunities.

2.1 Policy mapping and analysis

To get a detailed understanding of the current policy framework underpinning both climate mitigation (CM) and CA interventions in each of the DS, we have developed a policy mapping exercise at European, national and regional level. The results of this mapping exercise are summarized in section 3.2.

To select the policies, we have taken D1.3 as a starting point, which had already identified the most relevant policies (European, national and regional), for each DS. Next, through an in-depth search of the policies mentioned in the previous deliverable, a policy mapping table has been completed (see Annex I: Policy mapping exercise).

This exercise has resulted in a sample of 102 relevant policies across the 7 DS plus the EU (full results are detailed in section 3.2). The mapping exercise has consisted in listing these 102 policies and categorizing them by the following criteria in a policy mapping table, as shown in Annex I: Policy mapping exercise:

- DS Country
- Territorial Scope
- Title of the policy

- Brief description of the policy
- Policy by ultimate goal
- Policy by type of intervention
- To what sector the policy applies
- Responsible authority
- Whether the policy stems directly from the implementation of an EU Directive
- Implementation start date

Table 1 shows the options for each category:

DS Country	Territorial Scope	Policy by ultimate goal	Policy by type of intervention	Sector	Responsible authority	Implementation of EU Directive?
EU **DE (Germany)** **ES (Spain)** **GR (Greece)** **NL (Netherlands)** **NO (Norway)** **LV (Latvia)** **IT (Italy)**	European National Regional Local Other	CM CA CM & adaptation	Direct investment in assets and physical infrastructure Economic and fiscal instruments Informational, non-mandatory instruments Multiple interventions / Framework policy Other R&D funding and programmes; promotion of innovative technologies Regulatory instruments	Energy supply and consumption Transport and mobility Waste and Water management Agriculture and Rural Development Industry Multiple sectors Other	European authority National authority Regional authority Local authority Public-private partnership Private sector Other	Y N

Table 1: Options for each category considered as part of the policy mapping exercise

In terms of categorizing policies by goal, the following criteria has been used[3]:

- **CM policies** aim to reduce or prevent the emission of greenhouse gases to limit the extent of global warming. These policies focus on actions that lower the carbon footprint, such as transitioning to renewable energy sources, improving energy efficiency, and promoting sustainable land use practices. While the primary goal of mitigation is to address the root causes of climate change, these policies often encompass a range of activities aimed at creating a sustainable, low-carbon economy.

- **CA policies** focus on adjusting to the effects of climate change that are already occurring or are anticipated to occur. These policies aim to enhance resilience and reduce vulnerability to climate impacts, such as strengthening infrastructure to withstand extreme weather events, protecting ecosystems, and developing strategies for managing water resources. The goal is to

[3] These definitions are based on widely accepted definitions and frameworks from various reputable sources, including: Intergovernmental Panel on Climate Change (IPCC); United Nations Framework Convention on Climate Change (UNFCCC); the European Commission Climate Actions; and the World Resources Institute (WRI).

minimize the adverse effects of climate change and help communities and systems cope with its impacts.

Table 2 lists some examples of each type of policy by goal:

Mitigation policies (examples)	Adaptation policies (examples)
Renewable Energy Targets	Infrastructure, Business and Industry Resilience
Carbon Pricing	Natural Resource Management
Energy Efficiency Standards	Urban Planning and Design
Low-Carbon Transportation	Agricultural Adaptation
Phase-Out of Fossil Fuel Subsidies	Insurance and Risk Reduction
Building Codes and Standards	Public Health Initiatives
Industrial Emissions Regulations	Ecosystem-based Adaptation
Research and Development Funding	Climate Education and Awareness

Table 2.Policy categorisation by ultimate goal

Regarding policies by type of instrument, the following categorization has been suggested (Table 3):

Regulatory	Economic and fiscal instrument	Direct investment in physical infrastructure	R&D funding and programmes; promotion of innovative technologies	Informational; non-mandatory instruments
Regulatory instruments use laws and regulations to achieve specific environmental outcomes: emissions standards; mining regulations; phase-out plans, etc.	Financial incentives or disincentives to influence behavior and investment decisions: carbon pricing; subsidies and grants; tax incentives.	Investment in the development and enhancement of physical infrastructure: Building and Upgrading Transit Networks; accessibility improvements; intermodal connectivity.	Fostering research, development, and deployment of innovative technologies that support cleaner energy transitions	Public Awareness Campaigns; Labelling and Certification Programs; Carbon Footprint Calculators; Corporate Sustainability Reports; Educational Programs and Workshops; Green Business Awards; Climate Information Websites and Apps; Public Engagement Initiatives

Table 3. Policy categorisation by type of instrument

The information needed to fill the policy mapping table and categorize the policies by these criteria has been found through researching mainly in the official governments' websites or, in the cases where the EU intervened, in official websites from the EU.

2.1.1. Some limitations and considerations for future work

This policy mapping exercise presents some limitations, which will be considered and addressed, as much as possible, in future iterations of this exercise, as explained in section 4.2.

First, it is important to stress that the 102 policies analyzed do not constitute a scientific, randomized sample, but an initial selection of policies which brings us an initial understanding of the policy framework in each DS country. Although we aim to draw some conclusions from this analysis, together with evidence from the workshops and the SCBA exercise, it is important to bear in mind the limitations of the sample, namely:

- **Number of policies per DS**: The number of policies selected per DS is not homogeneous, so any comparisons between DS will need to account for this difference. To adjust for this, when comparing the weight or preponderance of the relevant variables and categories across the DS, a weighted mean has been carried out.
- **Type of selected policies**: While the criteria for policy selection in D1.3 was intended to be homogenous, we see some policies being more relevant than others depending on the DS. This may be because DS countries prioritize different types of policies, but given the sample is not randomized we cannot completely rule out certain selection bias.
- **Responsible authorities**: The same selection bias could apply to the number of policies selected implemented by a given authority.

These limitations will be addressed as much as possible in future work by validating the table with DS leaders; building a joint, robust methodology of policy selection and categorisation, and expanding the sample accordingly, making it as scientifically-based as possible. With these improvements we expect to obtain sample of policies more directly comparable throughout the DSs, minimising selection bias.

Secondly, the categorisation of policies will be refined, amongst others, by adding more qualitative information on other key issues of policy analysis besides the type of instrument, particularly in relation to effects and implementation, so to answer the following questions such as *What effects (intended and unintended) does the policy have on the targeted climate adaptation challenges? How does it impact key stakeholders? Do they accept it?* Similarly, we will also aim to factor in the policy analysis elements from the SCBA to make it more consistent, including the climate risk/hazards categorisation presented in section 2.3.3.

Overall, we expect these improvements to allow us to strengthen and expand the policy analysis, which in turn will make the final recommendations more robust.

2.2. DS Workshops on Policy and Financing Barriers and Opportunities

Two workshops were organized in June 2024 with the aim of obtaining the relevant information for each DS regarding the policy and financing dynamics, as well as the different barriers and opportunities in each case. The participants included different IMPETUS partners located in the DS where these workshops took place. Up to the current moment, these workshops have only been done in Catalonia and Greece, DS2 and DS3, as the frontrunner sites, but it is intended to apply the same methodology for all the DS.

As for the structuring, the exercise was split into two parts: a first general characterization of the DS in accordance with the expertise of the partners, and then a more specific study on the CA solutions intended for each DS. The duration of the workshop was 2 hours, and the format was online.

AGENDA

10:00-10:15	**Introduction to the workshop: WP6 needs and outcomes from DS** (Laura Armayones, EUT, WP6 leader)
10:15-11:00	**Dynamic 1**: Generic DS characterisation (Laura Armayones, EUT; Kostas Dellis, AUEB)
11:00-11:10	Break
11:10-12:00	**Dynamic 2**: Climate Finance Adaptation Solutions characterisation per DS (groups per hazard) Group 1: Laura Armayones, EUT; Kostas Dellis, AUEB Group 2: Maria Zaragoza, EUT; Georgios Economou, AUEB

Table 4: Agenda of the policy and financing workshop

To start with, for the general characterization, the participants were asked a set of questions regarding the identification of key players for financing the opportunities on CA, and regarding the challenges arising from the implementation of the solutions. Additionally, this exercise included questions concerning the different types of financial instruments used for CA as well as the financing barriers and opportunities particular to each DS. The participants were also asked to specify their financial and policy needs for the exploitation of the solutions in the DS. Lastly, there was a question about the relevance of different barriers depending on the source of financing, which can be private, public or blended. Once the question was posed and partners provided their answers, a discussion among the partners was moderated to express their respective points of view.

This part of the workshop was done through Mentimeter, which is an interactive tool that allows the respondents to give their responses live and engage more in the exercise. The following figure depicts a question and its corresponding solutions, asked during the workshop via Mentimeter, as an example of the structure and format of the platform.

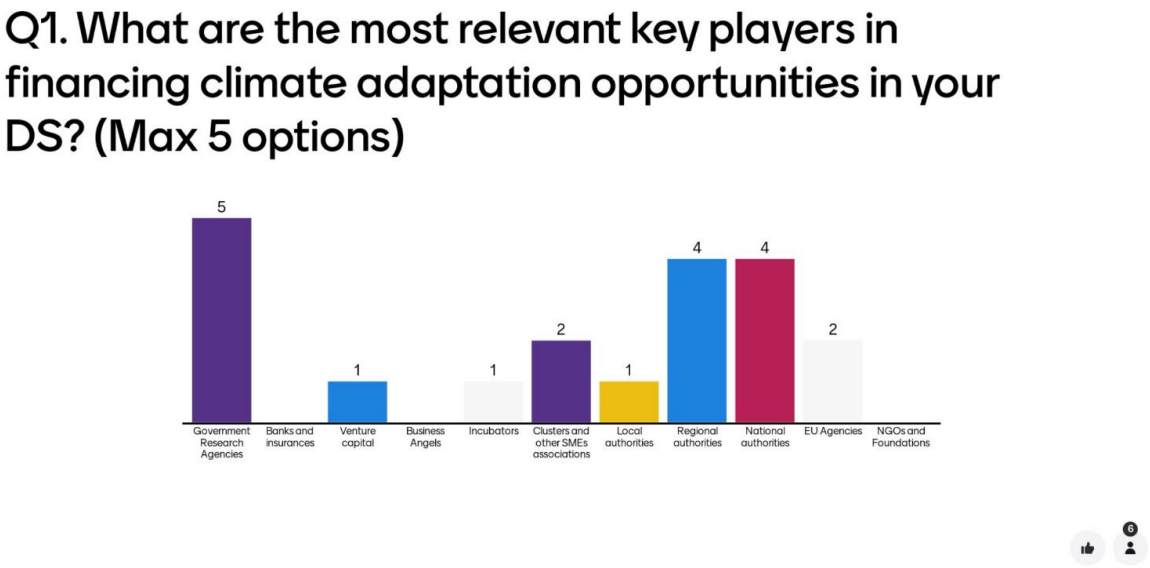

Figure 3. Mentimeter for DS3 workshop

Moving on to the second section of the workshop, it consisted of an interactive exercise where the partners were asked specific questions related to the CA solutions proposed for their DS. Here, the topics discussed were regarding the key stakeholders, business models and the financing and policy barriers and opportunities specific to each solution. This last section was carried out through another interactive digital platform named *Miro*, which used post-it notes for the partners to write in their solutions. As an example, the following image displays one of the questions asked in the Miro, regarding what climate risk is addressed in a specific adaptation solution and its overall relevance. In order to correctly carry out the exercise, the partners were asked to drag the sticky notes that contained different types of climate risks to the level of relevance they considered. This same methodology was used for the other remaining questions contained in this section of the workshop.

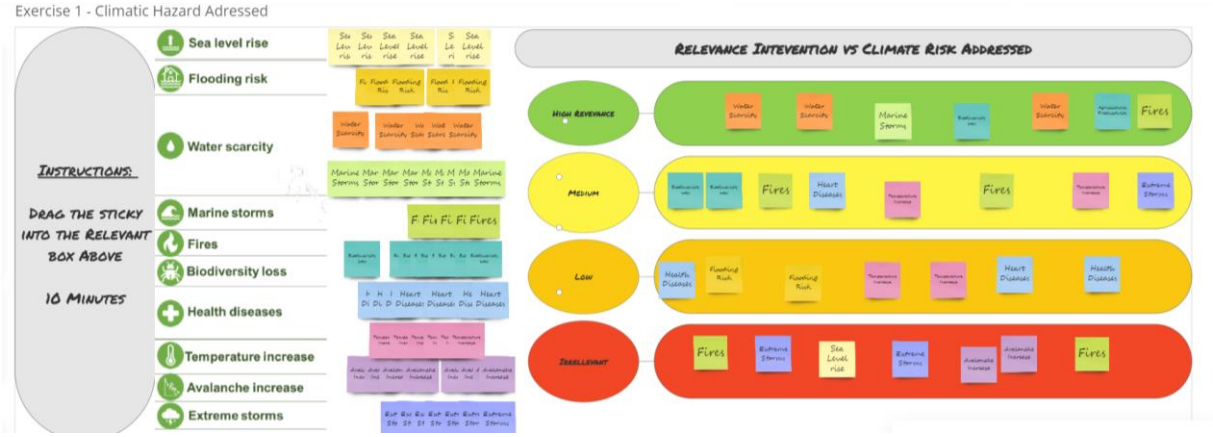

Figure 4. Miro Workshop

The use of these platforms posed several advantages in terms of the well-functioning and practicality of the workshop. Both Mentimeter and Miro allowed for the partners to give their responses online, so that the exercise does not necessarily require physical attendance. Additionally, given that these platforms are interactive, it allowed for personalized responses to the questions made, leading to more information and a better overall understanding of the policy and financing barriers and opportunities in each DS.

The results obtained from the two workshops in DS2 and DS3 have been included in this deliverable (Section 3) and, also, in *D6.6 Market perspectives report. Scenarios of the future and assessment of anticipated business opportunities*. Given the nature of this deliverable, which mainly focuses on the general framework for policy and financing in each DS and on the challenges and opportunities that arise in these matters, the results from the first part of the workshop have been analyzed here, including the results obtained from the Mentimeter. On the other hand, deliverable D6.6 contains the results from the second part, the Miro. This is so because D6.6 focuses more on the business opportunities that come with the different solutions, and on how to introduce them into the market. In line with this, the results from the Miro exercise are more specific to each solution.

2.3. IMPETUS Social Cost Benefit Analysis (SCBA)

Social Cost-Benefit Analysis (SCBA), also known as Cost-Benefit Analysis (CBA), is a structured methodology used to assess the potential effects of a project, policy, or program on society. This process involves measuring and comparing the associated costs and benefits to determine whether the decision is economically sound or socially beneficial. SCBA is widely utilized in economics and public policy to help decision-makers evaluate the efficiency and appeal of different projects and policies.

The process typically begins with identifying various options or alternatives. For instance, if a government is considering constructing a new highway, one alternative could be to proceed with the

highway construction, while another could be to invest in public transportation instead. The next step involves estimating the costs and benefits associated with each option. Costs might include construction expenses, maintenance, and other related expenditures, while benefits could range from economic advantages like increased productivity or reduced travel time, to social and environmental improvements such as lower pollution levels or enhanced public health.

The Valuation, or assigning monetary values to Costs and Benefits, is essential for making them comparable. This can be particularly challenging for environmental and social goods, as it may require estimating intangible benefits or predicting future outcomes. Methods such as willingness-to-pay surveys, market prices, or other econometric models and techniques are often employed to value non-market goods and services.

Discounting future costs and benefits is typically applied to reflect the time value of money. This means that future costs and benefits are valued less in today's terms, and hence a discount rate is applied to convert them into present values. The net present value (NPV) is calculated by subtracting the present value of costs from the present value of benefits for each alternative. A positive NPV indicates that benefits exceed costs, suggesting the project is economically viable, and this metric can be used to prioritize projects based on their expected Total Economic Value, which includes the intangible aspects of environmental costs and benefits.

Climate change mitigation and adaptation projects often require consideration of a long-term horizon for benefits to materialize, necessitating the use of more advanced techniques and time-decreasing discount rates.

Sensitivity analysis is often incorporated into SCBA to account for uncertainties in cost and benefit estimates. Decision-makers may evaluate different scenarios and their effects on the overall assessment. Based on the analysis results, decision-makers can select the alternative with the highest NPV or make informed choices about project implementation.

Social cost-benefit analysis aids policymakers in making more informed decisions by considering the broader social, environmental, and economic impacts of their actions. However, it has limitations, such as the difficulty in accurately valuing certain intangible factors and the potential for subjective judgments during the process. Nevertheless, it remains a valuable tool for evaluating the efficiency and desirability of projects and policies, .as well as a tool to shortlist between projects to optimize the selection process of the portfolio of solutions to be included in a resilience action plan.

Intangible (non-market) benefits (or Costs) refer to those non-physical advantages provided by ecosystems that are often difficult to measure or assign a monetary value to. In economic theory terms these are often related to market failures, e.g. externalities, public or social goods—such as clean air, biodiversity, cultural significance, and aesthetic beauty—which benefit (harm in case of costs) society without being directly bought or sold in markets.

Incorporating Ecosystem Services (ES) valuation into a SCBA is essential for recognizing and quantifying these intangible benefits. Traditional economic analyses tend to focus on direct, tangible outcomes (e.g., timber from forests or agricultural production), often overlooking or underestimating the broader range of services ecosystems provide that contribute to human well-being, environmental health, and economic stability. By including the value of these ecosystem services in decision-making, we can make more informed and sustainable choices, balancing economic development with environmental conservation.

The integration of the ES monetization, e.g. integrating non-market values, enhances the economic valuation of interventions in a multi-faceted way. Traditional CBAs may prioritize the short-term

economic gains, while SCBA helps decision makers consider the long-term environmental and social costs, leading to more comprehensive, balanced and sustainable decisions.

ES valuation helps reveal hidden costs of ecosystem degradation and uncovers the long-term benefits of conservation efforts, leading to more accurate and balanced assessments of economic and environmental trade-offs.

Additionally, ES valuation aligns economic policies with broader sustainability goals, such as the United Nations Sustainable Development Goals (SDGs). It internalizes environmental externalities by placing a value on ecosystem services, ensuring that the costs of environmental damage and the benefits of ecosystem preservation are reflected in decision-making processes. This approach supports risk management, strengthens incentives for conservation, and promotes nature-based, cost-effective solutions that benefit both society and the environment in the long term.

Ecosystem services valuation can support the design of economic instruments like subsidies to promote water conservation and optimal management by recognizing the full value of ecosystem services related to water resources. These subsidies would act as incentives for preserving the ecosystems that provide critical water-related services, correcting the market failure where water conservation is underinvested due to the lack of pricing for these ecological benefits. As a result, economic instruments would help align private water usage with the broader public goal of sustainable water management and conservation.

2.3.1. Monetary Valuation of Ecosystem Services

2.3.1.1. Natural Capital

Natural capital can be viewed as a stock in nature that generates a stream of benefits for people and the economy. The goods and services provided by natural capital, such as food, water, shelter, and climate regulation, are known as ecosystem services, and they form the foundation of healthy lives and economic activities.

However, growing pressures from climate change and biodiversity loss are leading to significant degradation in these services, posing substantial challenges and risks for both humans and businesses. This relationship between human, produced, and natural capital is illustrated in Figure 5. The figure emphasizes that natural capital, often overlooked in economic analyses, acts as a catalyst for production and human capital by supporting, regulating, and preserving ecosystem services.

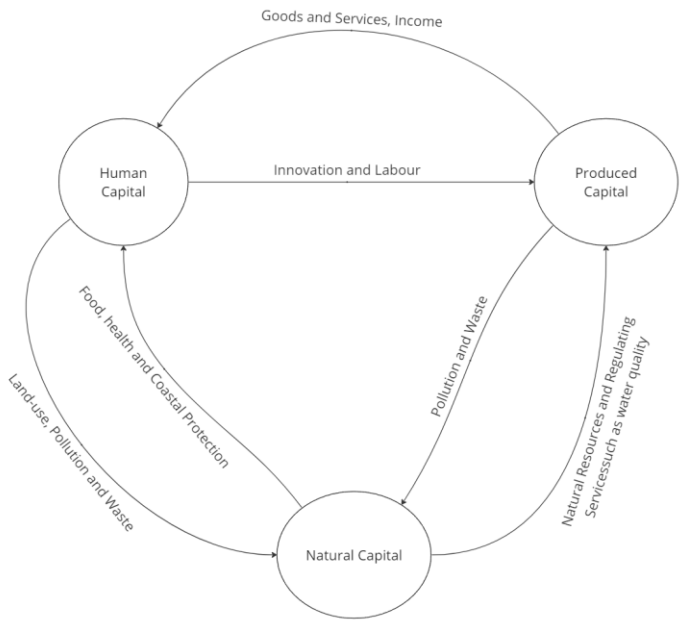

Figure 5. The Relationship between different types of Capital. Source Authors Elaboration from Dasgupta (2021)

People gain economic value from natural resources and the environment, even though this value may not be reflected in market prices. Total Economic Value (TEV) consists of both use and non-use value. The use value of a resource can be a market value, such as minerals, wood, water, and other goods, or a non-market value, like outdoor recreation, landscape amenity, and other similar benefits. Non-use values include the significance people place on specific habitats or species. Despite the clear importance of ecosystem service values, policymakers often overlook the value of environmental goods and services and their economic and social benefits due to market failures. Since many ecosystem services are not traded in markets, they lack a price. TEV represents the total well-being benefit from a policy, encompassing both people's willingness to pay (WTP) and their willingness to accept the policy (WTA).

Therefore, valuing ecosystem services is crucial as it helps individuals (and more importantly, policymakers) make informed decisions. By valuing ecosystem services, policy decisions can consider the costs and benefits of the natural environment and their impact on human well-being, while guiding policymakers toward alternative policies.

So far, metrics like Gross Domestic Product (GDP) or even the UN Human Development Index (HDI) measure only economic progress and, in the case of HDI, human well-being, but fail to capture benefits such as pollination, regulation, and nature's ability to mitigate disasters. This inability to account for the total economic value of ecosystems, combined with the vicious cycle of overproduction and overexploitation, has significantly contributed to the degradation of ecosystem services, threatening the possibility of future growth and prosperity. As a result, incorporating the economic value of ecosystem services into mainstream public and private decision-making is essential to reverse ecosystem degradation.

2.3.1.2. Ecosystem services

The productivity of natural capital is driven by its quality and quantity, which are both tied to its biodiversity. Thus, keeping the stock of this capital stable ensures the provision of ecosystem service flows, which are essential for both current and future human prosperity (TEEB, 2010).

Ecosystem services (ES) are final products or outcomes that have direct and indirect impacts on human well-being, and these factors can complement an economic strategy. According to Daily (1997), ES are "The conditions and processes through which natural ecosystems, and the species that compose them, sustain and fulfil human life," while Costanza et al. (1997; 2014; 2017) describe them as "Benefits human populations derive, directly or indirectly, from ecosystem functions."

The primary reason for valuing ecosystem services is that it helps people make informed decisions. It ensures that policy decisions consider the costs and benefits of the natural environment and their effects on human well-being, while also offering policymakers new insights. The term "ecosystem services" indeed highlights the connection between natural capital and the economy, reflecting the utility people gain from utilizing ecosystems.

The Millennium Ecosystem Assessment (MA, 2005) identified four categories of ecosystem services, which are illustrated in Figure 6 along with their respective sub-categories:

- Provisioning services: products obtained from ecosystems, such as water, food, and fiber.
- Regulating services: benefits provided by the regulation of ecosystem processes, including climate regulation, water regulation, and pollination.
- Cultural services: non-material benefits derived from ecosystems, such as recreation, aesthetic enjoyment, spiritual and religious experiences, and cultural heritage.
- Supporting services: services essential *to produce* all other ecosystem services, such as nutrient cycling, soil formation, and primary production.

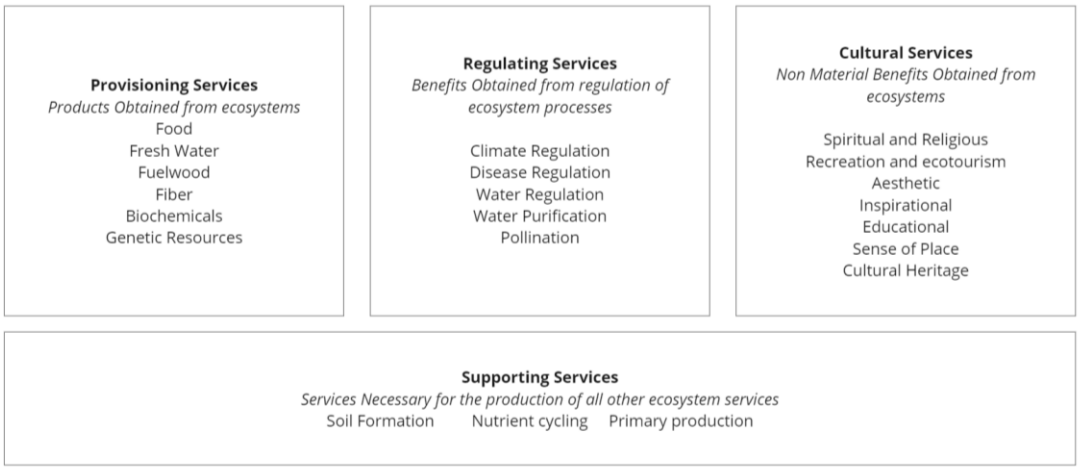

Figure 6. Classification of Ecosystem Services. Source Millenium Ecosystem Assessment (MA,2005)

To date, only a small portion of the products provided by nature are reflected in existing metrics used to measure economic progress (GDP) and human well-being (Human Development Index), as pointed out by Dasgupta (2021). Additionally, other benefits like pollination, regulation, and nature's capacity to mitigate disasters have not been adequately captured. This inability to fully account for the economic value of ecosystems and biodiversity, coupled with the rapid pace of economic activity, has greatly contributed to their degradation.

2.3.1.3. Valuation of ecosystem services

Valuing ecosystem services is the final step in an often-extensive study of how a policy change will impact them. The valuation method chosen depends on the type of ecosystem service and the quality and quantity of available data. Ecosystem services are crucial because they generate value for humans. Total Economic Value (TEV) includes all the ways in which ecosystem services provide both tangible and intangible benefits, enhancing well-being. Figure 7 outlines the broader value categories, considering both the use and non-use values that individuals and society gain or lose due to small changes in ecosystem services. Since many ecosystem services are not traded in markets, they lack a price, making it necessary to use non-market valuation methods to determine their worth. Use value stems from the direct exploitation of ecosystem services for human well-being and includes:

(i) direct use value, where humans intentionally use the ecosystem, such as for nutrition, irrigation, timber, etc.

(ii) indirect use value, where benefits are received by humans without directly using environmental resources, as in water regulation

(iii) option value, which reflects the value of preserving environmental resources for the possibility of future direct or indirect use. Lastly, non-use value is based on the idea that simply recognizing the existence of ecosystem services holds value for human beings.

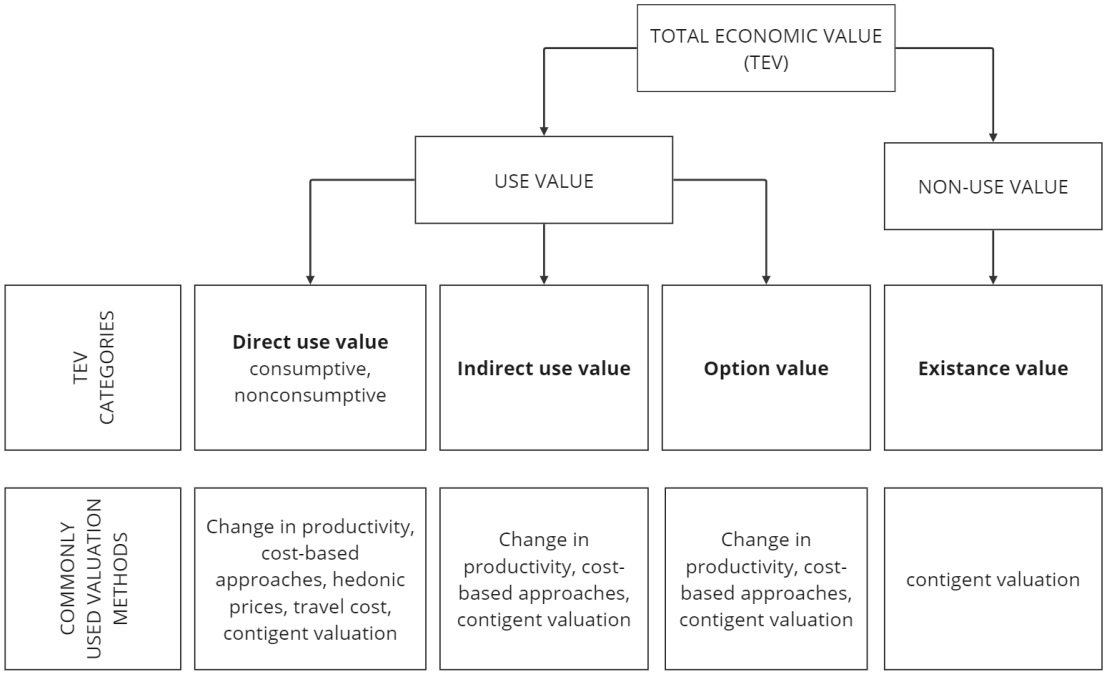

Figure 7. The Total Economic Value Framework. Own Elaboration of Millenium Assessment (MA, 2005)

Non-market valuation methods are techniques used to estimate the economic value of goods and services that are not traded in markets, such as ecosystem services. These methods are crucial for capturing the value of environmental benefits that lack a market price. Figure 8 lists the most used models and econometric techniques. Key approaches include contingent valuation, where individuals are directly asked their willingness to pay for specific environmental services; hedonic pricing, which infers value from related market goods, like property prices affected by environmental quality; travel cost method, which estimates the value of recreational sites based on the cost of travel to them; and benefit transfer, which applies existing valuation estimates from similar studies to new context.

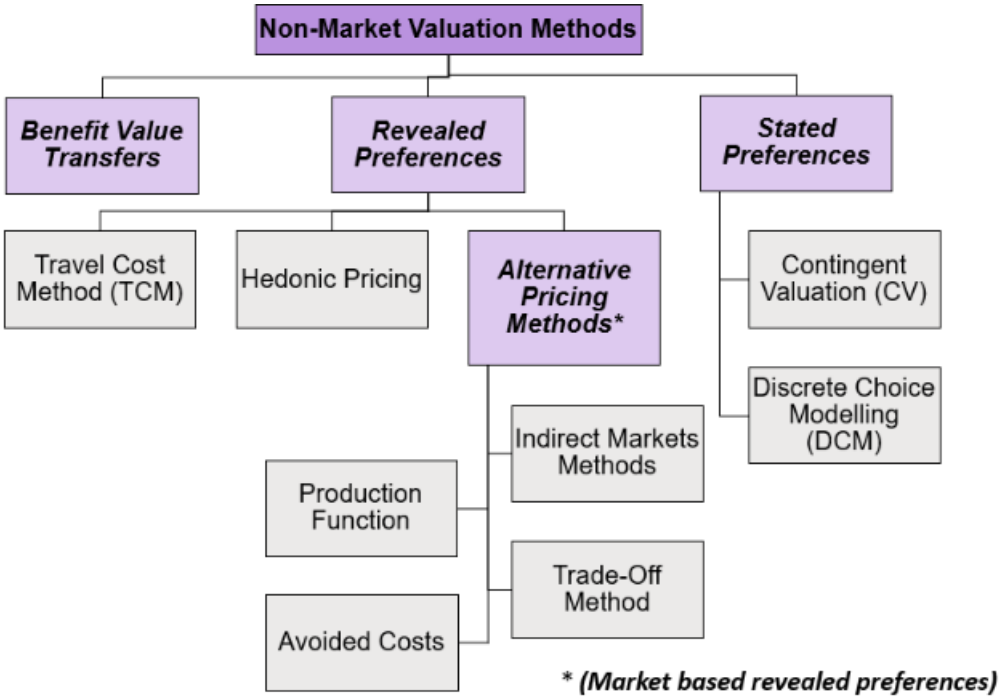

Figure 8. Econometric Techniques used in the valuation of ES. Source: University of Queensland

Among all the available techniques, the Benefit Transfer method, which is based on econometric meta-regression analysis, is used for the valuations performed in IMPETUS. It is supported by a comprehensive database that has been processed to provide data for these regressions.

This database primarily draws from publicly available sources such as the Environmental Valuation Reference Inventory (EVRI) and the Ecosystem Services Valuation Database (ESDV)[4]. It includes primary literature on ecosystem services valuation from 2012 to 2022. Studies are selected based on the type of ecosystem, the specific ecosystem services valued, and the geographical location of the study[5].

For the classification of Ecosystem services, we follow the MA classification as presented in previous sections, while the classification of ecosystem follows the Mapping and Assessment of Ecosystems and their Services (MAES) Typology, as outlined in the European Ecosystem Assessment (EEA Technical Report, no 6/2015)[6]. That is ecosystems are categorized into three main groups:

- Terrestrial ecosystems, including urban areas, cropland, grassland, forest, heathland, shrubland, sparse vegetated land, and inland wetlands.
- Marine ecosystems, encompassing marine inlets, transitional waters, coastal areas, shelf, and open oceans.
- Freshwater ecosystems, such as rivers and lakes.

Additionally, following the IMPETUS methodology of classifying Demo Sites based on bio-geographical regions, the study areas are defined according to the Habitats Directive (92/43/EEC)[7] and the

[4] Accessed at https://evri.ca/en and https://www.esvd.info/
[5] A list of all papers and the database used in the analysis can be found here: https://tinyurl.com/3rx72svr
[6] https://www.eea.europa.eu/publications/european-ecosystem-assessment/
[7] https://eur-lex.europa.eu/eli/dir/1992/43/oj

EMERALD Network established under the Bern Convention[8]. This classification includes nine EU biogeographical regions—Alpine, Atlantic, Black Sea, Boreal, Continental, Macaronesia, Mediterranean, Pannonian, and Steppic—and five EU marine regions—Marine Atlantic, Marine Baltic, Marine Black Sea, Marine Macaronesia, and Marine Mediterranean. Figure 9 illustrates the MAES Ecosystem Typology categories, the classes of ecosystem services, and the specified biogeographical and marine regions.

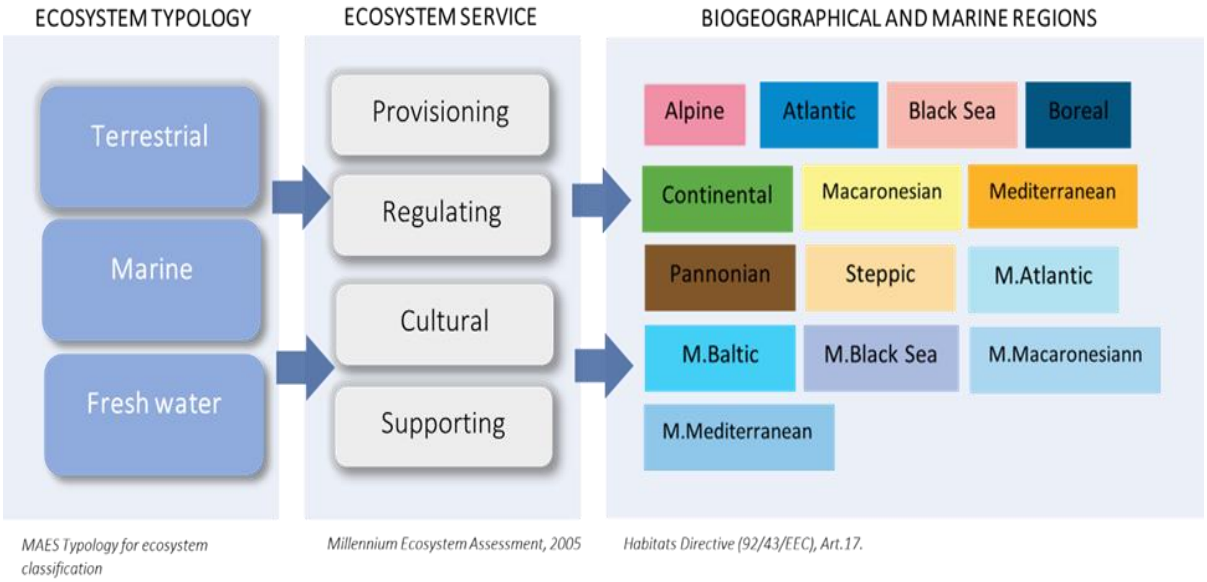

Figure 9. Mapping of Ecosystems Typology to Services across Biogeographical regions. Source: MAES, 2015

2.3.1.4. Benefit Transfer Method

To summarize and integrate the empirical results from various studies, we employ a meta-regression analysis using the provided summary statistics. We use the "weak structural utility theoretic approach" (Bergstrom and Taylor, 2006). Benefit transfer Method (BFM) uses results from prior research studies at one or more study sites to predict value estimates at other policy sites for which value estimates are unavailable. BFM is a universal component of large scale SCBA (Johnson et al., 2015).

The goal is to statistically account for the variations observed in the studies by examining identifiable characteristics such as the valuation method, geographic location, specific factors of the studies, survey mode, and other relevant determinants and demographic factors. The meta-analysis models (MRM) refer to several linear and non-linear Least Squares models of the form:

$$Y_i = f(X_i) + \varepsilon_i \qquad \text{(eq 1)}$$

where index i corresponds to each observation gathered from the studies under consideration, Y denoted the dependent variable in our case, Willingness to Pay (WTP), and X is a matrix containing the rest of explanatory variables and ε is the error term with the usual properties.
The dependent variable in a benefit transfer MRM is WTP from revealed or stated preference valuation studies, addressing the same good at many different sites. Specifically, Willingness to Pay represents the average annual amount (in euros) that individuals are willing to pay for ecosystem services. To

[8] https://www.nature.scot/professional-advice/protected-areas-and-species/protected-areas/international-designations/emerald-network#:~:text=The%20Emerald%20Network-,The%20Emerald%20Network%20was%20established%20in%201989%20under%20the%20Bern,EU's%20obligations%20under%20the%20Convention.

account for the variations observed, we examined a range of explanatory variables, notably a categorical variable representing the type of ecosystem according to the MAES classification: Forest, Cropland, Heathland and Shrub, Sparsely Vegetated Land, Inland Wetlands, Rivers and Lakes, Urban, Grassland, and Marine ecosystems. The estimations also included a categorical variable for the valuation method, which could include Contingent Valuation, Choice Experiment, Actual Market Price, Count Data Model, Hedonic Price Method, Hedonic Property, Meta-Analysis, Replacement Costs, and Travel Cost Method. Additionally, indicator variables were included to account for different types of ecosystem services—Cultural, Provisioning, Regulating, and Supporting—based on MA Reporting categories. Socioeconomic variables, such as age, income, gender, and educational levels of the sample population, were also considered. The final dataset comprises 212 papers from the Environmental Valuation Reference Inventory (EVRI), with 165 papers used for the estimation. Appendix II provides the detailed definitions, and the descriptive statistics of all variables included in the estimations.

2.3.2. Social Discount Rates

The declining discount rate concept in social cost-benefit analysis involves applying a lower discount rate when assessing the benefits and costs of projects or policies with long-term impacts, particularly those related to climate change adaptation that affect future generations. This method recognizes that some projects or policies have effects extending far into the future and that using a constant, high discount rate may not properly reflect the preferences and well-being of future generations or the long-term implications of climate change adaptation.

Traditional cost-benefit analysis typically employs a constant discount rate to convert future benefits and costs into present values, reflecting the rate of time preference, which shows how much society values future benefits and costs compared to those in the present. A high constant discount rate significantly reduces the importance of future benefits and costs in the analysis.

In contrast, a declining discount rate uses a decreasing rate for future periods, meaning that benefits and costs further in the future are weighted less than those in the near term. This approach acknowledges that society might place greater importance on the well-being of future generations and the conservation of natural resources and ecosystems.

The rationale for adopting a declining discount rate stems from ethical and intergenerational considerations, suggesting a more sustainable and long-term perspective in evaluating the costs and benefits of policies or projects with significant environmental, climate change, or intergenerational effects. In our analysis we use three alternative social cost of capital discount rates, the annual estimates suggested by Florio et al (2013), the annual rates proposed by Tajani et al. (2023), as well as a moderate, which is calculated as the average between the two rates. For all three scenarios we do apply a declining discount rate following the methodology in Koundouri et al (2008). Table 5 presents the social discount rates used in our analysis following the geographical dispersion of IMPETUS demo sites.

Country	Florio et al (2013)	Tajani et al. (2023)
Germany	2.84	2.14
Greece	2.39	3.88
Italy	1.13	2.14
Latvia	2.97	3.89
Netherlands	2.30	2.14
Norway	3.42	2.25
Spain	2.09	1.99

Table 5. Social Discount rates (%) used in SCBA

Period	Germany	Greece	Italy	Latvia	Netherlands	Norway	Spain
1	2,14	3,88	2,14	3,89	2,14	2,25	1,99
20	1,95	3,54	1,95	3,55	1,95	2,05	1,82
40	1,85	3,35	1,85	3,36	1,85	1,95	1,72
60	1,78	3,22	1,78	3,23	1,78	1,87	1,65
80	1,72	3,11	1,72	3,12	1,72	1,80	1,60
100	1,66	3,00	1,66	3,01	1,66	1,74	1,54
150	1,51	2,74	1,51	2,74	1,51	1,59	1,40
200	1,33	2,41	1,33	2,42	1,33	1,40	1,24
250	1,12	2,03	1,12	2,03	1,12	1,18	1,04
300	0,86	1,56	0,86	1,57	0,86	0,91	0,80
350	0,60	1,09	0,60	1,10	0,60	0,63	0,56
400	0,47	0,86	0,47	0,86	0,47	0,50	0,44

Table 6. Declining Discount Rates (%) based on Tajani et al. (2023) 2023 estimated rates and Koundouri et al. (2008) Methodology

2.3.3. Mapping Interventions/Solutions to Ecosystem Services

In cooperation with WP3 and specifically tasks 3.5.1 and 3.5.2, we performed a mapping between the relevant climate risks/hazards, climate change related solutions/interventions, as well as the underlying ecosystem services. The mapping is based on initial desk research including all papers available in the EVRI database[9], and it's described in detail in deliverable D3.5 as part of the valuation tools developed in WP3 and specifically in Task 3.5. To perform the mapping, we constrained the analysis to the climate risks covered in IMPETUS project (Table 7).

Table 7 provides the mapping between the interventions/solutions developed in WP4 and the climate risks addressed. Based on our initial desk research we further expand the mapping to all types of interventions investigated in the literature, by also linking them to the underlying provisioning, regulating, cultural and supporting ecosystem services and Key Economic Impacts. Table 7 reports the mapping of Interventions by Climate Risk/ Hazard[10].

In our analysis, we aimed to categorize and quantify the relationship between various proposed interventions and the four major ecosystem services: provisioning, regulating, supporting, and cultural services. To achieve this, we employed a method that assesses the textual similarity between the descriptions of the interventions and predefined descriptions of these ecosystem services. By comparing the content of each intervention to the ecosystem service descriptions, we could measure the degree to which each intervention aligns with each service.

The similarity calculations allowed us to distribute a set of weights, expressed as percentages, across the four ecosystem services for each intervention. These weights indicate the proportionate relevance of an intervention to each service. For instance, an intervention might be predominantly linked to provisioning services with some relevance to regulating services, while another could be more balanced across multiple services. This method provides a nuanced view of how interventions contribute to different aspects of ecosystem services, allowing for a more informed evaluation of their potential impacts and benefits within an economic and environmental context.

[9] As of January 2024, the list contains 5.486 papers. The full list of papers is available here: https://tinyurl.com/5dw9ptr9
[10] Appendix III Tables A6.3.1 and A6.3.2, present the mapping of Ecosystem Services and Socioeconomic Economic Impacts by Hazard accordingly.

Climate risk addressed	R&I Solution
Sea level rise	**[COASTAL]** Below sea-level multifunctional wetland **[ARCTIC]** Climate-proofing of the city centre and of its urban water infrastructure against sea level rise
Flooding risk	**[ATLANTIC, BOREAL]** Digital twins and advanced tools for climate adaptation
Water scarcity	**[COASTAL, MEDITERRANEAN]** Decentralized circular-economy inspired water/energy/materials reuse innovations **[MEDITERRANEAN]** Controlled environmental agriculture (CEA) solutions **[MEDITERRANEAN]** Digital twins and advanced tools for climate adaptation **[MEDITERRANEAN]** Water-energy master plan and business plan for autonomous climate proof regions **[CONTINENTAL]** Decision Theatre (DTh) for regional integrated water resource management **[CONTINENTAL, MOUNTAIN MEDITERRANEAN]** Advanced tools for regional water management
Marine storms	**[COASTAL]** Sand dunes restoration techniques and monitoring **[COASTAL]** Sediment transportation through irrigation networks
Fires	**[MEDITERRANEAN]** Forest fires and restoration
Biodiversity loss	**[MEDITERRANEAN]** Supporting reforestation and biodiversity **[COASTAL]** Changes in the spatial distribution of species
Health diseases	**[COASTAL]** Improving bathing water quality after extreme storm events. **[COASTAL]** Increasing resilience of water plants to water-borne pathogens **[ATLANTIC]** Heat awareness system
Temperature increase	**[ARCTIC]** Digital twin to co-design a Marine Spatial Planning framework **[MOUNTAIN]** Implemented bio-district to address altitudinal shifts of crops
Avalanche increase	**[ARCTIC]** Early-warning and evacuation system for geological and avalanche risk sites
Extreme storms	**[COASTAL]** Assessment of economic impacts of extreme storms in infrastructures

Table 7 IMPETUS – Climate Risks/ Hazards by R&I Solutions in Demo Sites, Source: IMPETUS Grant Agreement

The methodology employed in our analysis leverages a combination of natural language processing (NLP) techniques and statistical modelling to quantify the relationship between possible interventions and ecosystem services. Specifically, we used the Term Frequency-Inverse Document Frequency (TF-IDF) vectorization technique to convert the text descriptions of interventions and ecosystem services into numerical representations. TF-IDF is a well-established method in text analysis that highlights the importance of words within a document relative to a collection of documents. By applying TF-IDF, we effectively captured the unique characteristics of each text, enabling us to differentiate between the relevance of various interventions to ecosystem services.

Following the vectorization process, we utilized cosine similarity, a measure of similarity between two non-zero vectors, to assess the alignment between each intervention's text vector and the vectors representing the ecosystem services. Cosine similarity is particularly useful in this context as it quantifies how closely the direction of one vector (intervention) aligns with another (ecosystem service), regardless of their magnitude. The resulting similarity scores were then normalized and converted into percentage distributions across the four ecosystem services—provisioning, regulating, supporting, and cultural. These percentages (Table 8) represent the relative contribution of each intervention to the different ecosystem services, providing a nuanced understanding of their potential impact. This approach not only ensures that our analysis is grounded in robust statistical techniques but also facilitates a replicable and transparent process for evaluating interventions within the context of ecosystem service frameworks.

This analysis closely aligns with the frameworks discussed in the uploaded documents, particularly in how ecosystem services are categorized and valued. For example, the conceptualization of ecosystem services in the "Ecosystems and Human Well-being: A Framework for Assessment" (Chapter 2) document mirrors our approach, where services are divided into provisioning, regulating, cultural, and supporting categories. This alignment underscores the robustness of our method, as it is consistent with established frameworks used in environmental assessments. By grounding our analysis in these widely accepted concepts, we ensure that the resulting weight distributions are not only methodologically sound but also relevant to ongoing discussions in the field of ecosystem service valuation. This relevance strengthens the applicability of our findings within broader research and policy-making contexts, particularly within the framework of Horizon projects where these considerations are paramount.

The table as follows summarises the mapping interventions by type of ES:

Hazard	Interventions Type	Ecosystem Services			
		Provisioning (%)	**Regulating (%)**	**Supporting (%)**	**Cultural (%)**
Sea Level Rise	Coastal Restoration: Restoring mangroves, salt marshes, and other coastal ecosystems to enhance resilience and maintain ecosystem services.	0,30	0,29	0,23	0,17
	Integrated Coastal Zone Management: Implementing sustainable practices that balance development with conservation.	0,42	0,32	0,27	0,00
	Infrastructure Adaptation: Designing and retrofitting coastal infrastructure to withstand rising sea levels and increased flooding.	0,40	0,26	0,18	0,16
	Community Engagement: Involving local communities in planning and decision-making to enhance resilience and protect cultural heritage.	0,40	0,26	0,20	0,14
Flooding Risk	Wetland Restoration (Restoring wetlands can enhance their capacity to absorb floodwaters and improve water quality)	0,52	0,17	0,17	0,14
	Riparian Buffer Zones (Establishing vegetated areas along waterways can reduce erosion, filter pollutants, and provide wildlife habitat)	0,51	0,28	0,12	0,08
	Green Infrastructure (Implementing green roofs, permeable pavements, and rain gardens in urban areas can reduce runoff and mitigate flood risks)	0,51	0,20	0,14	0,14
	Floodplain Mangement (Protecting and restoring floodplains can enhance their natural flood-regulating functions)	0,40	0,22	0,21	0,16
	Community Preparedness (Educating and preparing communities for flooding can reduce risks and improve resilience)	0,38	0,28	0,17	0,17
Water Scarcity	Water Conservation (Implementing efficient water use practices in agriculture, industry, and households to reduce water demand)	0,33	0,33	0,21	0,13
	Rainwater Harvest (Restoring and protecting wetlands to enhance their natural water storage and purification functions)	0,34	0,25	0,23	0,19
	Wetland Restoration (Restoring and protecting wetlands to enhance their	0,34	0,25	0,23	0,19

	natural water storage and purification functions)				
	Desalination (Using desalination technologies to convert seawater into freshwater, although it is energy-intensive and costly)	0,41	0,28	0,18	0,12
	Sustainable Water Management (Implementing integrated water resource management practices to balance water use among agricultural, industrial, and domestic sectors)	0,34	0,32	0,26	0,08
Marine Storms (hurricanes, typhoons, and cyclones)	Ecosystem Restoration: Restoring and protecting coastal ecosystems like mangroves, coral reefs, and salt marshes to enhance their natural protective functions.	0,35	0,25	0,21	0,19
	Building Resilience: Designing and constructing resilient infrastructure that can withstand marine storms and reduce damage.	0,47	0,21	0,17	0,14
	Early Warning Systems: Implementing early warning systems to provide timely information and facilitate evacuations and preparations.	0,30	0,28	0,24	0,18
	Sustainable Coastal Management: Integrating sustainable practices into coastal development and land use planning to reduce vulnerability.	0,50	0,22	0,15	0,13
	Community Preparedness: Educating and preparing communities for marine storms to reduce risks and improve response and recovery efforts.	0,29	0,28	0,23	0,19
Fires	Fire Management: Implementing controlled burns and firebreaks to reduce the risk of uncontrolled wildfires.	0,33	0,27	0,26	0,15
	Forest Management: Practices such as thinning and removing deadwood can reduce fuel loads and fire risk.	0,43	0,37	0,13	0,07
	Early Warning Systems: Developing and maintaining systems to detect and respond to fires quickly.	0,37	0,23	0,22	0,17
	Community Preparedness: Educating and preparing communities for fire risks to improve response and recovery efforts.	0,37	0,23	0,22	0,18
	Restoration Efforts: Replanting and rehabilitating areas affected by fires to restore ecosystem services and reduce future fire risks.	0,36	0,28	0,20	0,16
Biodiversity Loss	Conservation Efforts: Protecting and restoring natural habitats to preserve	0,39	0,25	0,21	0,15

	biodiversity and ecosystem services.				
	Sustainable Practices: Implementing sustainable agricultural, forestry, and fishing practices to reduce impacts on biodiversity.	0,38	0,34	0,15	0,12
	Climate Action: Addressing climate change to reduce its impacts on biodiversity and enhance ecosystem resilience.	0,44	0,36	0,13	0,07
	Community Engagement: Involving local communities in conservation efforts to ensure sustainable and culturally appropriate solutions.	0,30	0,30	0,20	0,20
	Policy and Regulation: Strengthening policies and regulations to protect biodiversity and promote sustainable development.	0,40	0,23	0,21	0,16
Health Diseases	Conservation and Restoration: Protecting and restoring natural ecosystems to maintain their health-promoting services.	0,28	0,26	0,24	0,23
	Sustainable Practices: Implementing sustainable agriculture, forestry, and fishing practices to enhance ecosystem services and food security.	0,35	0,32	0,20	0,13
	Pollution Reduction: Reducing pollution to protect air and water quality, directly benefiting human health.	0,59	0,20	0,15	0,05
	Urban Planning: Incorporating green spaces into urban areas to improve air quality, encourage physical activity, and provide mental health benefits.	0,61	0,19	0,11	0,08
	Climate Action: Addressing climate change to reduce its impacts on ecosystems and human health, such as reducing the frequency and severity of climate-related diseases.	0,37	0,23	0,20	0,19
Temperature Increase	Climate Mitigation: Reducing greenhouse gas emissions to limit global temperature rise.	0,94	0,04	0,02	0,00
	Ecosystem Restoration: Restoring forests, wetlands, and other ecosystems to enhance their carbon sequestration and resilience to temperature increases.	0,29	0,28	0,23	0,20
	Sustainable Agriculture: Implementing practices that improve soil health, water efficiency, and crop resilience to temperature changes.	0,48	0,33	0,10	0,08
	Water Management: Developing strategies to manage water resources	0,40	0,28	0,19	0,13

	efficiently, including conservation, recycling, and infrastructure improvements.				
	Public Health Measures: Strengthening healthcare systems to address the impacts of heat-related illnesses and expanding monitoring and control of vector-borne diseases.	0,34	0,26	0,26	0,14
	Urban Planning: Designing cities to mitigate heat effects, such as increasing green spaces, improving building designs, and implementing heat action plans.	0,45	0,34	0,15	0,07
Avalance Increase	Monitoring and Early Warning Systems:Avalanche Forecasting: Implementing advanced monitoring and early warning systems to predict avalanches and alert communities and tourists in high-risk areas.	0,33	0,29	0,20	0,18
	Ecosystem Management - Vegetation Management: Maintaining and restoring vegetation in avalanche-prone areas to stabilize slopes and reduce the risk of avalanches.	0,33	0,27	0,26	0,14
	Infrastructure Design-Protective Structures: Building protective structures such as snow fences, barriers, and deflection dams to mitigate avalanche impacts on human settlements and infrastructure.	0,37	0,29	0,23	0,12
	Community Preparedness: Education and Training: Educating and training communities and tourists on avalanche risks, safety measures, and emergency response.	0,29	0,26	0,23	0,22
	Climate Change Mitigation:Reducing Greenhouse Gas Emissions: Addressing the underlying drivers of climate change to reduce its impacts on snow and ice dynamics, and consequently on avalanche frequency and intensity.	0,37	0,25	0,24	0,14
Extreme Storms	Ecosystem Restoration:Reforestation and Wetland Restoration: Restoring forests and wetlands to enhance their ability to absorb stormwater, reduce erosion, and provide other ecosystem services.	0,31	0,25	0,23	0,21
	Sustainable Land Use:Protecting Natural Buffers: Conserving and managing natural buffers such as mangroves and coastal dunes	0,40	0,34	0,14	0,12

	to protect against storm surges and erosion.				
	Climate Resilient Infrastructure: Building Resilience: Designing infrastructure to withstand extreme weather events and protect critical services such as water supply and waste management.	0,39	0,29	0,24	0,08
	Community Preparedness: Emergency Planning: Educating and preparing communities for extreme storm events through early warning systems, evacuation plans, and disaster response training.	0,36	0,28	0,18	0,18
	Policy and Regulation:Land Use Planning: Implementing policies that prevent development in high-risk areas and promote sustainable land use practices.	0,34	0,32	0,26	0,08
	Climate Action:Reducing Emissions: Mitigating climate change by reducing greenhouse gas emissions to decrease the frequency and intensity of extreme storms.	0,40	0,25	0,23	0,13

Table 8: Mapping Intervention Type By Ecosystem Services

3. Empirical analysis

The two workshops carried out in DS2 and DS3 with the respective partners, as well as further extensive research, have provided relevant insights for the exploitation of the IMPETUS solutions in each region. In the upcoming future, further workshops are expected to take place in the remaining demo-sites, using these first two as references, and their results will be presented in the final deliverable D6.5.

Accordingly, this section analyses the results obtained in such workshops, regarding relevant topics such as the key players in financial aid, as well as the identification of barriers and opportunities in terms of financing and policy. Given the results obtained, conclusions are extracted regarding the essential information for each solution analysed in terms of policy and its financing, highlighted in the following blue boxes.

This section also presents the results for the Cost benefit analysis in selected solutions for DS2 and DS3, as well as the results of the policy mapping exercise and the policy analysis for DS2 and DS3. The analysis for all DSs will be included in the final deliverable D6.5.

3.1. Monetary Valuation – All Demo Sites

To estimate the non-market values to be included in the cost benefit analysis, the first step required the estimation of the benefit transfer value discussed in section 2.3.1.4, equation 1. We conduct several stepwise specifications for variables that exhibit slight elasticity in terms of their individual statistical significance, using Newey-West heteroskedasticity and autocorrelation robust standard errors. In addition to the conventional significance levels ($\alpha = 0.01$, $\alpha = 0.05$, and $\alpha = 0.1$), we have included p-values less than 0.25 in our analysis. The Bayesian Information Criterion (BIC) was employed for model selection. We excluded the top 1% of extreme WTP observations from the analysis.

Table 9Table 9 presents the meta-regression estimates (e.g. benefit transfer functions) for a model that includes both Terrestrial and Marine & Freshwater ecosystems[11]. P-values for the Newey-West HAC standard errors are provided in brackets.

[11] For Freshwater Ecosystem, only 14 papers are included in the database, so Marine and Freshwater Ecosystems are grouped together.

	All Ecosystems	Terrestrial	Marine & Fresh Water
ALPINE	**148.94**	**105.93**	43.01
	[0.020]	[0.041]	[0.279]
ATLANTIC	**-86.23**	-21.91	**-64.32**
	[0.084]	[0.487]	[0.091]
BOREAL	-82.96	19.39	**-102.34**
	[0.286]	[0.748]	[0.040]
CONTINENTAL	-48.36	-7.07	-41.29
	[0.162]	[0.817]	[0.269]
MEDITERRANEAN.	**-91.73**	**-54.37**	-37.36
	[0.057]	[0.069]	[0.344]
MARINE_ATLANTIC	**-74.40**	**-62.46**	-11.95
	[0.106]	[0.059]	[0.779]
PROVISIONING	**59.32**	25.77	33.55
	[0.075]	[0.292]	[0.259]
REGULATING	**53.19**	12.98	**40.21**
	[0.224]	[0.541]	[0.214]
SUPPORTING	**42.70**	13.46	29.24
	[0.117]	[0.599]	[0.312]
SD_QUESTIONNAIRE	-42.09	**-50.20**	8.11
	[0.351]	[0.118]	[0.803]
AGE	**3.77**	**1.14**	**2.64**
	[0.007]	[0.127]	[0.023]
EDUCATION	**-5.20**	-0.60	-4.60
	[0.187]	[0.853]	[0.387]
CHOICE_EXPERIMENT	**-79.15**	-0.52	**-78.63**
	[0.157]	[0.983]	[0.126]
CONTINGENT_VALUATION	-60.07	10.78	**-70.84**
	[0.297]	[0.704]	[0.161]
R-squared	0.32	0.27	0.18
Adjusted R-squared	0.20	0.15	0.04
F-statistic	**87.90**	**75.71**	**1.96**
	[0.000]	[0.000]	[0.0229]
MWTP	**80.53**	**38.42**	**42.10**

Table 9 Benefit Transfer Functions – Terrestrial and Marine & Freshwater Ecosystems

Relying on the statistical significance of these variables our meta analysis model was specified as

$$WTP_i = \beta_0 + \beta_1 \text{Alpine} + \beta_2 \text{Atlantic} + \beta_3 \text{Continental} + \beta_4 \text{Boreal} + \beta_5 \text{Continental} +$$

$$+\beta_{6-} \text{Mediterranean} + \beta_7 \text{Marine Atlantic} + \beta_8 \text{Provisioning} + \beta_9 \text{Regulating}$$

$$+\beta_{10} \text{SD\_Questionnaries} + \beta_{11} \text{Age} + \beta_{12} \text{Education} + \beta_{13} \text{CE} + \beta_{14} \text{CVM} + \varepsilon_i \quad \text{(eq 2)}$$

In the overall sample, biogeographical and marine regions, particularly Alpine, Atlantic, Mediterranean, and Marine Atlantic, are significant at the usual levels of significance. Provisioning and supporting ecosystem services are also significant, and regulating services appear to have some influence. Age is significant across all statistical levels, while education shows some influence as well. Regarding valuation methods, choice experiments (CE) and contingent valuation methods (CVM) are both prominent. The estimated willingness to pay (WTP) per household for the entire sample is €80.52 annually, which corresponds to a monthly WTP of €6.71.

For terrestrial ecosystems, Alpine, Mediterranean, and Marine Atlantic regions remain significant at the usual levels of significance. Provisioning services seem to be influential, and the survey design using stated preference questionnaires is significant. Age continues to show influence. The estimated WTP per household for terrestrial ecosystems is €38.42 annually, translating to a monthly WTP of €3.20.
In the case of freshwater and marine ecosystems, the Atlantic and Boreal regions are statistically significant, while the Alpine and Continental regions show influence. Age remains significant, and both valuation methods are again prominent. The estimated WTP per household for freshwater and marine ecosystems is €42.10 annually, implying a monthly WTP of €3.51.

Based on the above results, the benefit transfer function is defined as:

$$\widehat{WTP_i} = \sum_{i=1}^{14} \widehat{b_i}\,\overline{x_i} \qquad (eq2)$$

Where $\widehat{b_i}$ refers to the estimates of Table 9 and $\overline{x_i}$ is the average value of the depended variable in the site of interest. The Marginal willingness to pay ($\widehat{WTP_i}$) is considered as the “Shadow Price” of the underlying ecosystem services, e.g. the monetary value of the environmental externalities. The first column can be used to calculate aggregate benefits in relation to both Terrestrial and Marine & Freshwater ecosystems. On the other hand, the benefit functions of columns two and three can be used when focusing only on the benefits in relation to Terrestrial ort Marine & Freshwater respectively.
To validate the out of sample accuracy of our MRM forecasts we apply an iterative leave-one-out convergent validity test. We begin with metadata of n observations, omitting the Nth observation from the metadata and estimate the MRM with the n-1 observations. We do repeat this process, each time omitting one observation. In each of the N-1 iterations, the results are used to forecast the WTP of the Nth omitted observation and an error is calculated as the difference between the estimated and the fitted value. From all N-1 errors the Mean Absolute Error is calculated to 25% which is an acceptable magnitude of error for MRM Benefit Transfers.

Just to showcase the implementation of the Benefit Transfer Function to the countries of the IMPETUS demo sites, Figure 11, Figure 12 and Figure 13 display the Annual Marginal Willingness to Pay for both ecosystems, Terrestrial and Marine & Freshwater Ecosystems respectively for the regions of the demo sites, broken down into three ecosystem services: Provisioning, Regulating, and Supporting. The classification of countries into Biogeographical Regions follows the European Environmental Agency's definitions (Figure 10). Based on Figure 10, Table 10 provides the specification of the biogeographical dummy variables for the regions of Interest, while Table 11 presents the relevant socioeconomic data and their source. All estimates are for 2023.

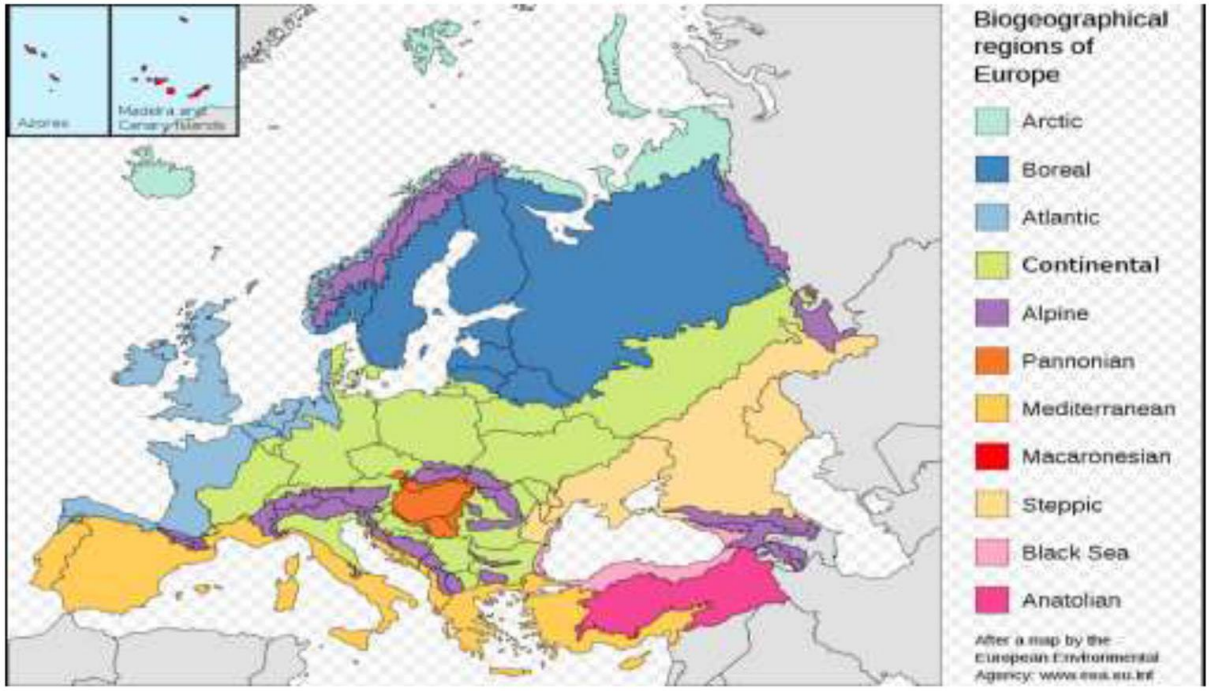

Figure 10. European Bio Geographical Regions. Source: European Environmental Agency.

	Alpine	Atlantic	Boreal	Continental	Mediterranean
Berlin-Brandenburg, DE	0,00	0,00	0,00	1,00	0,00
Region of Attica, GR	0,00	0,00	0,00	0,00	1,00
Valle dei Laghi area, IT	1,00	0,00	0,00	0,00	0,00
Zemgale Region, LV	0,00	0,00	1,00	0,00	0,00
Province of Zeeland and Rijnmond, NL	0,00	1,00	0,00	0,00	0,00
Coast of Catalonia, ES	0,00	0,00	0,00	0,00	1,00
Troms & Finmark, NO	0,15	0,00	0,85	0,00	0,00

Table 10: IMPETUS Demo Sites - Biogeographical Region Specification

	age	educ	Source
Berlin-Brandenburg, DE	44,3	0,39	Statistisches Bundesamt (Destatis), Eurostat, Statista
Region of Attica, GR	45,9	0,38	Hellenic Statistical Authority (ELSTAT), Eurostat, Statista
Valle dei Laghi area, IT	48,5	0,32	Istituto Nazionale di Statistica (ISTAT), Eurostat, Statista
Zemgale Region, LV	43,5	0,30	Central Statistical Bureau of Latvia, Eurostat, Statista
Province of Zeeland and Rijnmond, NL	43,7	0,43	Statistics Netherlands (CBS), Eurostat, Statista
Coast of Catalonia, ES	43,2	0,36	Instituto Nacional de Estadística (INE), Eurostat, Statista
Troms & Finmark, NO	43,0	0,35	Statistics Norway (SSB), Statistics

Table 11: IMPETUS Demo Sites – Socioeconomic data

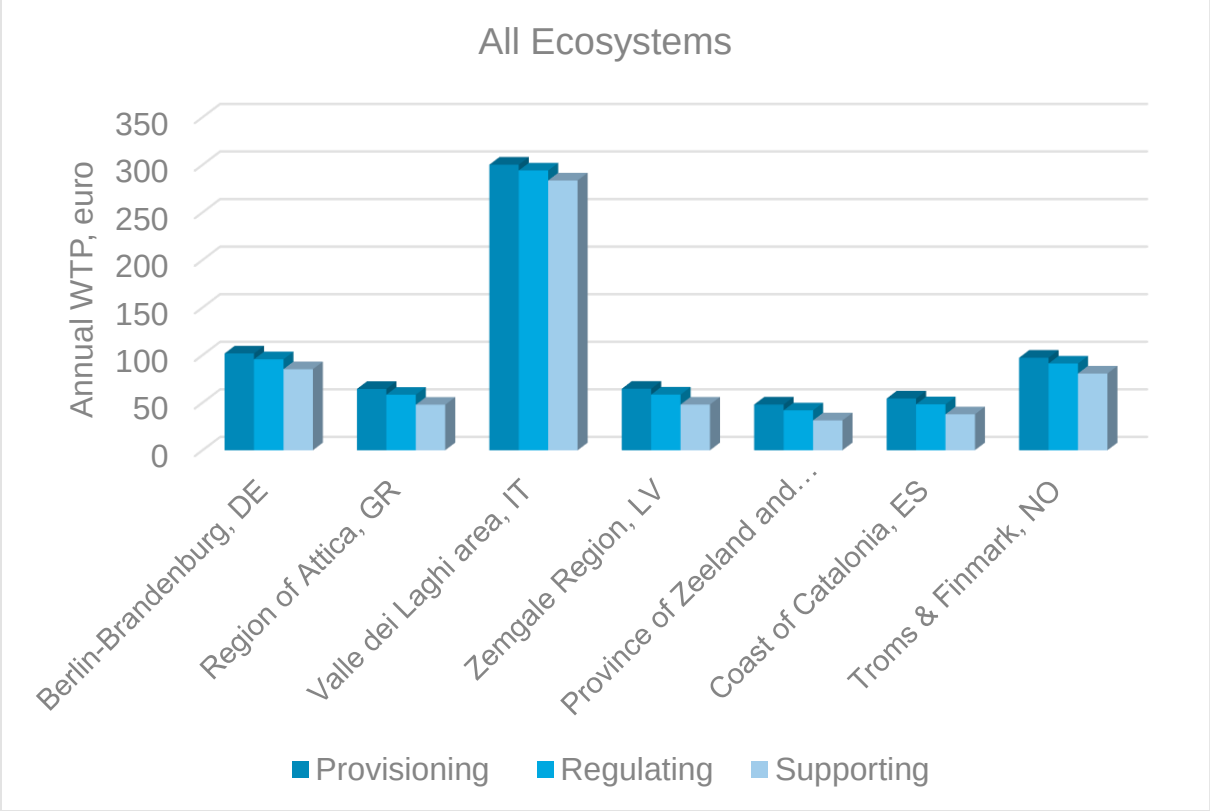

Figure 11. Annual Willingness to Pay, Per Household, All Ecosystems, By Ecosystem Service

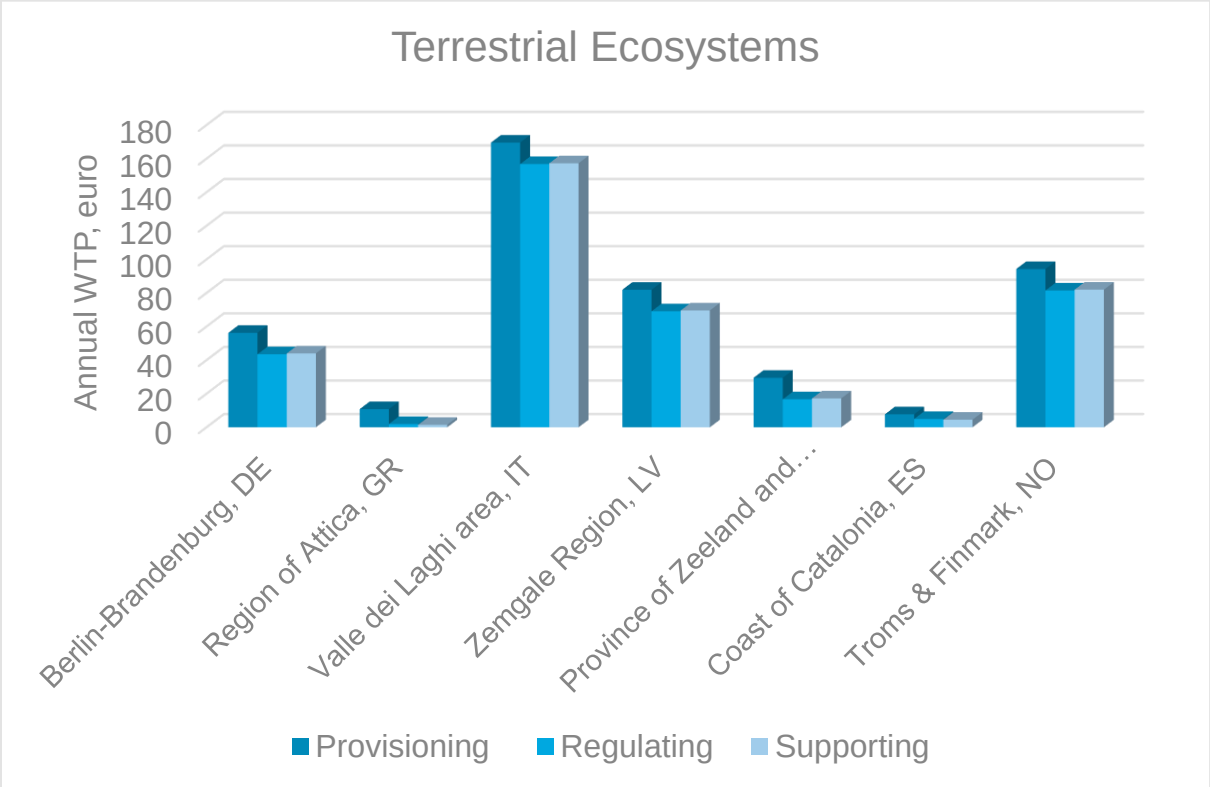

Figure 12. Annual Willingness to Pay, Per Household, Terrestrial Ecosystems, By Ecosystem Service

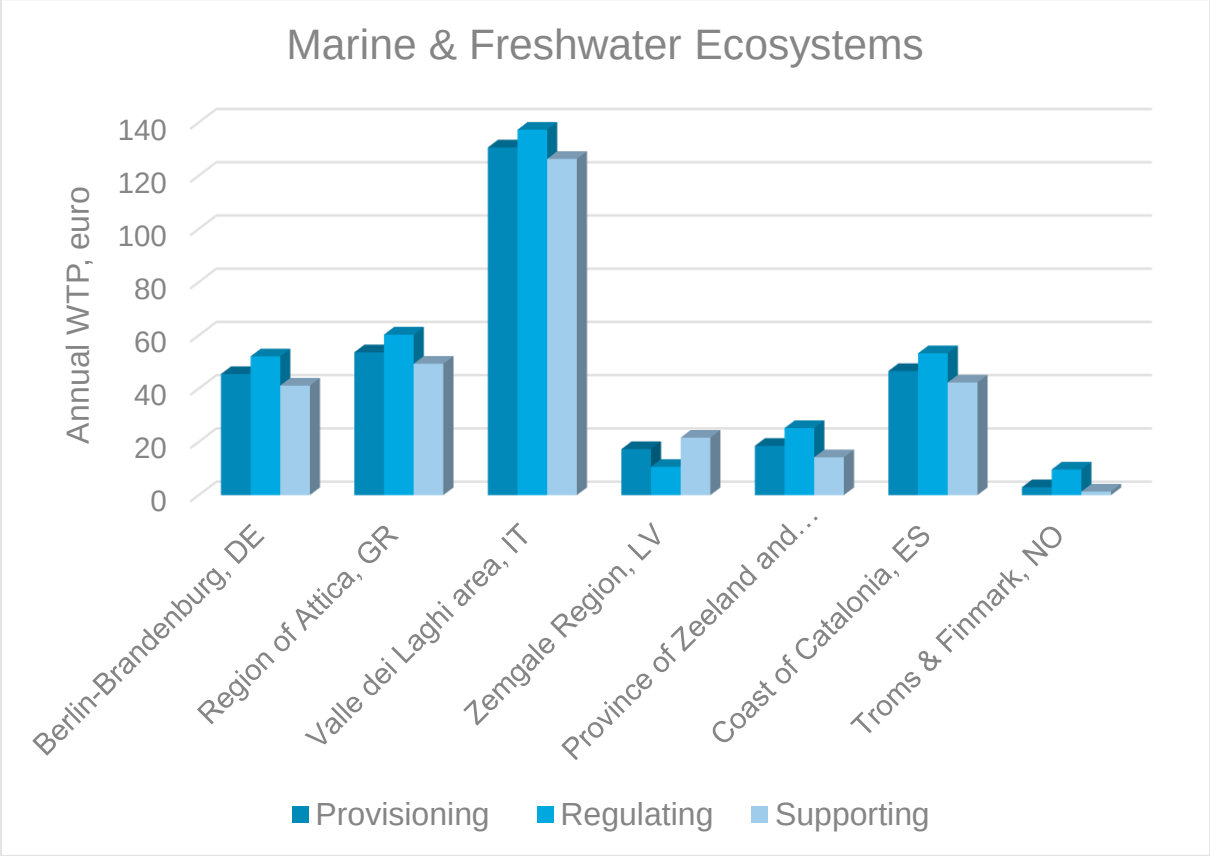

Figure 13. Annual Willingness to Pay, Per Household, Marine & Freshwater Ecosystems, By Ecosystem Service

Using the mapping of type of solutions/interventions, presented in Table 7 to ecosystem services, we can use the benefit transfer functions to shortlist different type of innovations against the expected Benefit. As an example, Table 11 presents the results for all types of interventions for DS2 and DS3.

Hazard	**Interventions Type**	**Region of Attica, GR**	**Coast of Catalonia, ES**
Sea Level Rise	Coastal Restoration: Restoring mangroves, salt marshes, and other coastal ecosystems to enhance resilience and maintain ecosystem services.	48,44	38,35
	Integrated Coastal Zone Management: Implementing sustainable practices that balance development with conservation.	58,09	48,01
	Infrastructure Adaptation: Designing and retrofitting coastal infrastructure to withstand rising sea levels and increased flooding.	50,59	40,51
	Community Engagement: Involving local communities in planning and decision-making to enhance resilience and protect cultural heritage.	51,30	41,21
Flooding Risk	Wetland Restoration (Restoring wetlands can enhance their capacity to absorb floodwaters and improve water quality)	52,39	42,30
	Riparian Buffer Zones (Establishing vegetated areas along waterways can reduce erosion, filter pollutants, and provide wildlife habitat)	55,72	45,63
	Green Infrastructure (Implementing green roofs, permeable pavements, and rain gardens in urban areas can reduce runoff and mitigate flood risks)	52,56	42,47
	Floodplain Mangement (Protecting and restoring floodplains can enhance their natural flood-regulating functions)	50,07	39,98
	Community Preparedness (Educating and preparing communities for flooding can reduce risks and improve resilience)	50,03	39,94
Water Scarcity	Water Conservation (Implementing efficient water use practices in agriculture, industry, and households to reduce water demand)	51,17	41,09
	Rainwater Harvest (Restoring and protecting wetlands to enhance their natural water storage and purification functions)	48,08	38,00

	Wetland Restoration (Restoring and protecting wetlands to enhance their natural water storage and purification functions)	48,08	38,00
	Desalination (Using desalination technologies to convert seawater into freshwater, although it is energy-intensive and costly)	52,39	42,31
	Sustainable Water Management (Implementing integrated water resource management practices to balance water use among agricultural, industrial, and domestic sectors)	53,64	43,55
Marine Storms (hurricanes, typhoons, and cyclones)	Ecosystem Restoration: Restoring and protecting coastal ecosystems like mangroves, coral reefs, and salt marshes to enhance their natural protective functions.	48,41	38,33
	Building Resilience: Designing and constructing resilient infrastructure that can withstand marine storms and reduce damage.	51,88	41,80
	Early Warning Systems: Implementing early warning systems to provide timely information and facilitate evacuations and preparations.	48,35	38,27
	Sustainable Coastal Management: Integrating sustainable practices into coastal development and land use planning to reduce vulnerability.	52,78	42,69
	Community Preparedness: Educating and preparing communities for marine storms to reduce risks and improve response and recovery efforts.	47,35	37,27
Fires	Fire Management: Implementing controlled burns and firebreaks to reduce the risk of uncontrolled wildfires.	49,77	39,69
	Forest Management: Practices such as thinning and removing deadwood can reduce fuel loads and fire risk.	55,93	45,85
	Early Warning Systems: Developing and maintaining systems to detect and respond to fires quickly.	49,25	39,16
	Community Preparedness: Educating and preparing communities for fire risks to improve response and recovery efforts.	48,81	38,72
	Restoration Efforts: Replanting and rehabilitating areas affected by fires to restore ecosystem services and reduce future fire risks.	50,02	39,94
Biodiversity Loss	Conservation Efforts: Protecting and restoring natural habitats to preserve biodiversity and ecosystem services.	50,37	40,28
	Sustainable Practices: Implementing sustainable agricultural, forestry, and fishing practices to reduce impacts on biodiversity.	52,54	42,46
	Climate Action: Addressing climate change to reduce its impacts on biodiversity and enhance ecosystem resilience.	55,86	45,77
	Community Engagement: Involving local communities in conservation efforts to ensure sustainable and culturally appropriate solutions.	47,70	37,62
	Policy and Regulation: Strengthening policies and regulations to protect biodiversity and promote sustainable development.	50,18	40,10
Health Diseases	Conservation and Restoration: Protecting and restoring natural ecosystems to maintain their health-promoting services.	45,50	35,41
	Sustainable Practices: Implementing sustainable agriculture, forestry, and fishing practices to enhance ecosystem services and food security.	51,55	41,46
	Pollution Reduction: Reducing pollution to protect air and water quality, directly benefiting human health.	57,50	47,42
	Urban Planning: Incorporating green spaces into urban areas to improve air quality, encourage physical activity, and provide mental health benefits.	56,39	46,30
	Climate Action: Addressing climate change to reduce its impacts on ecosystems and human health, such as reducing the frequency and severity of climate-related diseases.	48,31	38,23
Temperature Increase	Climate Mitigation: Reducing greenhouse gas emissions to limit global temperature rise.	63,87	53,79
	Ecosystem Restoration: Restoring forests, wetlands, and other ecosystems to enhance their carbon sequestration and resilience to temperature increases.	47,22	37,13
	Sustainable Agriculture: Implementing practices that improve soil health, water efficiency, and crop resilience to temperature changes.	55,76	45,68
	Water Management: Developing strategies to manage water resources efficiently, including conservation, recycling, and infrastructure improvements.	52,13	42,05
	Public Health Measures: Strengthening healthcare systems to address the impacts of heat-related illnesses and expanding monitoring and control of vector-borne diseases.	50,16	40,07
	Urban Planning: Designing cities to mitigate heat effects, such as increasing green spaces, improving building designs, and implementing heat action plans.	55,83	45,74
Avalance Increase	Monitoring and Early Warning Systems:Avalanche Forecasting: Implementing advanced monitoring and early warning systems to predict avalanches and alert communities and tourists in high-risk areas.	48,59	38,50
	Ecosystem Management -Vegetation Management: Maintaining and restoring vegetation in avalanche-prone areas to stabilize slopes and reduce the risk of avalanches.	50,21	40,12
	Infrastructure Design- Protective Structures: Building protective structures such as snow fences, barriers, and deflection dams to mitigate avalanche impacts on human settlements and infrastructure.	52,08	42,00
	Community Preparedness: Education and Training: Educating and training communities and tourists on avalanche risks, safety measures, and emergency response.	46,00	35,92
	Climate Change Mitigation:Reducing Greenhouse Gas Emissions: Addressing the underlying drivers of climate change to reduce its impacts on snow and ice dynamics, and consequently on avalanche frequency and intensity.	50,58	40,50
Extreme Storms	Ecosystem Restoration:Reforestation and Wetland Restoration: Restoring forests and wetlands to enhance their ability to absorb stormwater, reduce erosion, and provide other ecosystem services.	46,51	36,42
	Sustainable Land Use:Protecting Natural Buffers: Conserving and managing natural buffers such as mangroves and coastal dunes to protect against storm surges and erosion.	53,12	43,03

	Climate Resilient Infrastructure: Building Resilience: Designing infrastructure to withstand extreme weather events and protect critical services such as water supply and waste management.	54,13	44,05
	Community Preparedness: Emergency Planning: Educating and preparing communities for extreme storm events through early warning systems, evacuation plans, and disaster response training.	49,26	39,17
	Policy and Regulation:Land Use Planning: Implementing policies that prevent development in high-risk areas and promote sustainable land use practices.	53,56	43,48
	Climate Action:Reducing Emissions: Mitigating climate change by reducing greenhouse gas emissions to decrease the frequency and intensity of extreme storms.	51,55	41,46

Table 12. Non-Market Benefit (Annual WTP Per Household) By Intervention Type

The above analysis provides a criterion for decisionmakers to shortlist between different Innovations and it needs to be considered when calculating the TEV through Cost Benefit analysis, as described in the following sections.

3.2. Policy mapping results

This section details the results obtained through the policy mapping exercise, whose methodology is explained in section 2.1.

A total of **102 relevant policies** have been identified across the 7 DS plus the EU, with over half of them (52%) corresponding uniquely to the category of CM policies, 25,5% to the category of CA policies, and 22,5% being a combination of CA and CM policies (see subsection 6.1.)

This result was expected given that the category of mitigation policies covers well-established interventions such as setting renewable energy targets, whereas adaptation policies tend to be relatively more novel and less widespread. Additionally, the existence of current climate hazards in most of these regions, but particularly in Southern Europe and the Mediterranean region, explains the preponderance of mitigation policies to address these risks.

That said, we also find a substantial percentage of policies that represent **a combination of adaptation and mitigation**; these are, usually, overarching plans, strategies and framework policies which contain a wide range of interventions - it is the case of all the EU policies presented.

Per DS[12], we observe some variation in the **preponderance of adaptation policies** versus the rest of categories (Figure 14), with the Netherlands and Latvia presenting the highest percentage (50% each), followed by Spain (33,3%), Germany (30%), Norway and Italy (18,2% each) and Greece (17.9%). Italy and Norway present both the highest percentage of combined adaptation + mitigation policies (27,3%).

[12] To identify the weight of type of policy per DS, a weighted average has been calculated.

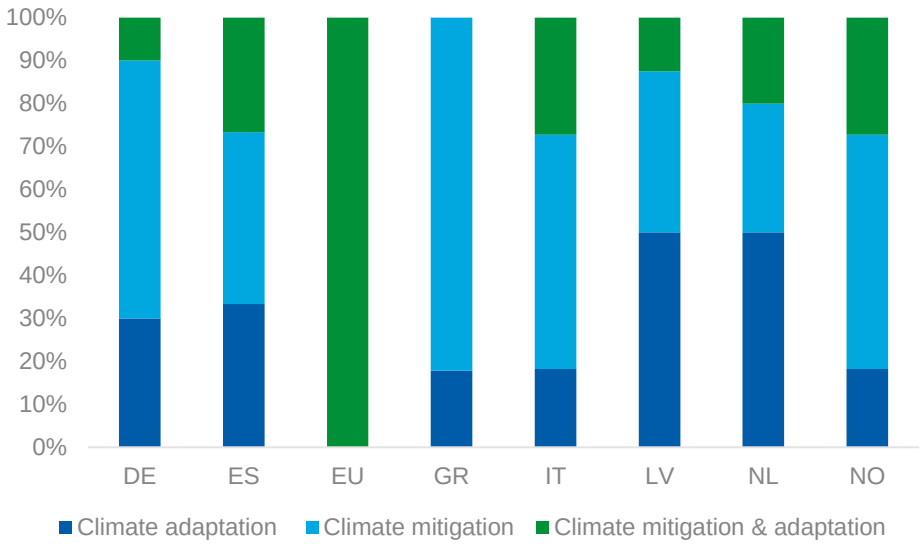

Figure 14. Preponderance of CA, CM, and CM&A policies in the 7 DS member states + the EU

In terms of the **type of instruments implemented** during the policy interventions, there is a preponderance of regulatory instruments (52,9%), mostly laws and regulations (e.g. establishing targets), followed by interventions consisting of multiple instruments (e.g. a framework policy) in 21,6% of the cases. The rest of instruments consist of R&D funding and programs, and informational, non-mandatory instruments (6,9% each); direct investment in assets and physical infrastructure (5,9%); economic and fiscal instruments (4,9%) and other instruments (1%).

Regarding **the type of instruments used per DS** (Figure 15), the weight of regulatory instruments is particularly significant in Italy (90,9%), whereas in the rest of DS we observe more variety – albeit regulatory instruments continue to dominate as the most used policy instrument in all the DS. Germany is the DS country which presents a wider range of instruments used, with regulatory instruments accounting only for the 30% of total instruments.

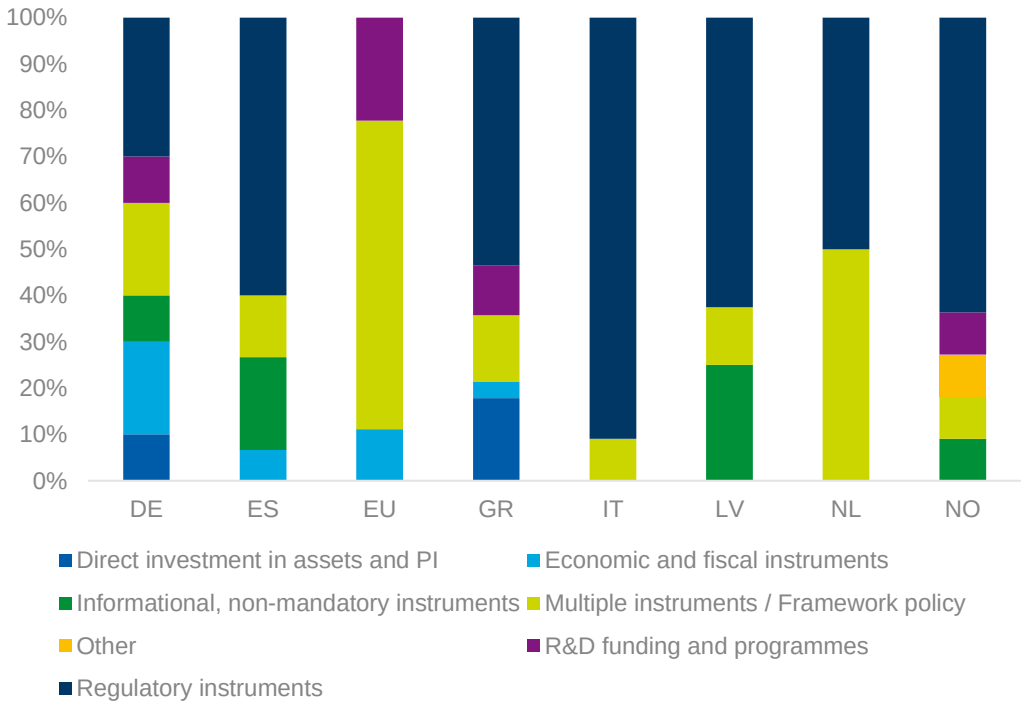

Figure 15. Weight of the various policy instruments in the 7 DS countries + the EU

In terms of the **policy authority responsible for implementing the policy**, in 66% of the cases the intervention was led by a national government or authority, followed by a regional government (22%), and a European authority (9%, this is only the case of European policies). Only in 3% of the cases, the policy was implemented by a local authority, highlighting the potential lack of subsidiarity when it comes to implementing climate policies across the selected countries.

Figure 16 below shows the picture per DS countries. Germany, Norway and Spain are the DS member states with the highest percentage of policies implemented by regional governments, testament of their decentralized, multi-level governance systems, whereas Greece presents a 100% of the policies implemented by the national government. Halfway through we find Latvia, Italy, and the Netherlands, with 33,3%, 27,3% and 20% of the policies being implemented by regional governments. That said, in both Italy and Latvia local governments play a larger role than in the rest of the selected countries, where there are no policies implemented by local authorities within the sample.

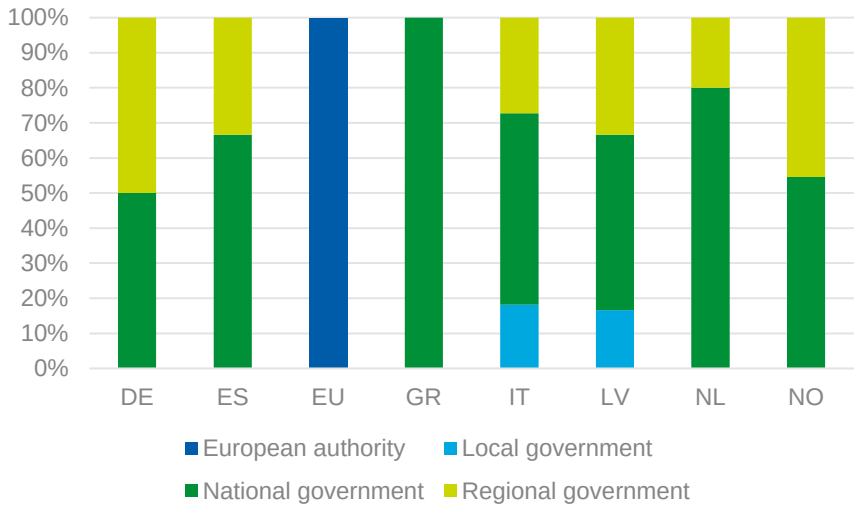

Figure 16. Main authority responsible for implementing the selected policies in the 7 DS countries + the EU

3.3. DS2 – Coastal: Coast of Catalonia, ES

3.3.1. Cost Benefit Analysis of Selected Solutions

Among the interventions selected by the DS, we choose to showcase the CBA process focusing on satellite-based coastal monitoring system, since based on Table 11, the interventions under the type of "Sustainable Coastal Management" and "Early Warning Systems", imply the highest nonmarket benefit among those addressing Coastal Erosion. The final deliverable D6.5, will apply the analysis for all interventions selected by the DS, for which cost data are available and analysis is feasible.

To verify the scope of the intervention and the most significant impacts in the case study we organized a workshop with case study participants to identify the focus of the case study as well as the most important hazards.

Hazards		Impacts
Sea level rise, Coastal Flooding and inundating low-lying areas	Storm Surges, Hurricanes and Typhoons	Damage to critical infrastructure such as ports, roads, bridges, buildings and utility systems. Infrastructure critical to emergency response, such as hospitals, evacuation routes, and emergency shelters.
Coastal Erosion	High winds and heavy rainfall	Damage/ stability of coastal infrastructure (beaches, cliffs, and coastal roads).
Wave Action and Coastal Defenses	Waves	Damage or breach coastal defenses (seawalls and breakwaters). Inland areas exposed to increased flooding and erosion.
Coastal Infrastructure Overload	Overload of ports and transportation networks	Disruptions to supply chains. Disruptions to transportation routes. Disruptions to economic activities.

Saltwater Intrusion into freshwater sources	Storm Surges, Precipitation patterns	Affects consumption. Affects irrigation and production (Degrade soil quality, Agricultural lands and Water supply systems).
Power Outages	High winds, storm surges, and coastal flooding	Damages to electrical infrastructure (powerlines and substations). Power supply to residential areas.
Loss of Coastal Habitats (Mangroves and salt marshes)	storm surges and erosion	Increased damage to Coastal Infrastructure (beaches, cliffs, and coastal roads).
Economy	Extreme Events	Decline in visitors and/ or economic activities due to the destruction of infrastructure, beaches, and/or attractions. Shipping and Industrial Transportation. Coastal resources (fisheries).
Social Disruptions and Displacement	Extreme Events	Social disruption. Strain on emergency response systems. Displacement of communities.

Table 13: Stakeholder Validation of Focus of the case study and relevant Economic Impacts

The participants identified the coastal erosion as the main hazard, followed by the Loss of Coastal Habitats, specifically in EBRO DELTA, which is one of the most important wetlands in Europe.

Table 13 describes the problem as well as the intervention, which consists of an initial consultancy study and a recurring monitoring service.

KER's market positioning	
Problem identified	Coastal erosion has become a relevant problem with tangible effects throughout the Catalan coast in the last years. There is, in general, uncertainty regarding the impact it may have, and which are the most vulnerable areas to the effects of coastal erosion in the forthcoming years.
Solution proposed	Establish a consistent time and spatial coverage of the Catalan coast by combining reliable datasets with optical satellite and synthetic-aperture radar (SAR) monitoring. Continuously monitor the effectiveness of adaptation measures on the coastline of sandy beaches. Identify and prioritize erosion hotspots to determine the most vulnerable areas to coastal erosion.

Table 13 Satellite-based coastal erosion assessment

The product offerings for satellite-based coastal erosion assessment services consist of two primary options: Consultancy Studies and Beach Monitoring Services. The Consultancy Study is a one-time service focused on conducting a historical study of a specific beach. This includes analysing past data to assess coastal changes and erosion trends. The cost of this service varies depending on the scope of the project, including the size of the area being studied, the depth of historical data analysis, and the specific requirements of the client. Pricing is not fixed, and a detailed quote is provided after an initial assessment of the project's needs. To our cost benefit analysis, we assume an initial one of cost of 25,000 euros for each Km of beach covered.

On the other hand, the Beach Monitoring Service is a recurring service designed for continuous monitoring. It includes a baseline assessment of the beach, combining historical and current data, which is critical for long-term planning. This service involves an initial setup cost (CAPEX) ranging between €3,000 and €6,000 per project, which covers the cost of setting up data collection systems and platforms. Following this, the service incurs yearly recurring costs (OPEX), typically ranging from €3,000 to €6,000 per year, depending on factors such as the length of the monitored beach, the number of reference points requiring detailed analysis, and the frequency of data provision (monthly or annual). These monitoring services allow municipalities to track beach changes in real-time, enabling them to make informed decisions on coastal management.

To assess the potential economic tangible benefits of coastal erosion and coastal flooding, we use the recent estimates of Vousdoukas et al (2020)[13]. The estimation of benefits from protection against coastal flooding and erosion in the study relies on the integrated risk assessment tool LISCoAsT (Large scale Integrated Sea-level and Coastal Assessment Tool). Two scenarios are primarily considered in the study: a sustainability scenario that assumes moderate greenhouse gas emissions (RCP4.5) and aligns with global sustainable development (SSP1), and a fossil fuel-based development scenario characterized by high emissions (RCP8.5) and significant socio-economic growth (SSP5). These scenarios help model future population growth, GDP increases, and urbanization trends, which are critical in projecting the future exposure of coastal regions to flooding and erosion risks. The benefit is expressed in economic terms, such as avoided damage to infrastructure and protected property values. Figure 17 depicts the annual expected benefits until 2100.

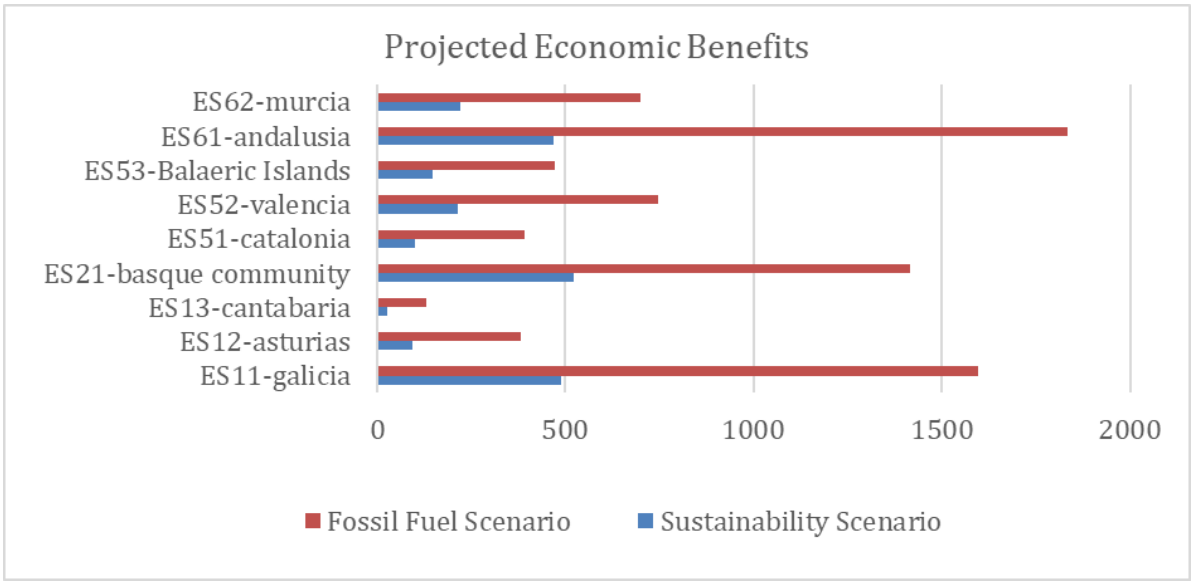

Figure 17 Projected Economic Impacts to 2010- Spanish Coastal NUTS2 Regions

The Catalan coast, located in the northeastern Mediterranean region of Spain, spans 600 km and features a variety of coastal landscapes, from cliffs to low-lying shores, including around 270 km of beaches. Currently, about 65% of these beaches are impacted by erosion (Jimenez and Valdemoro, 2019). So, the annual expected benefit for Catalonia until 2100, corresponds to 0,38 million euros per Km and 1,46 million euros per Km for the Sustainability and the Fossil Fuel scenario, respectively. Although the study presents an accurate estimation of the benefits it is mainly related to adaptation

13 The models and datasets presented are part of the integrated risk assessment tool LISCoAsT (Large scale Integrated Sea-level and Coastal Assessment Tool) developed by the Joint Research Centre of the European Commission. The dataset is available through the LISCoAsT repository of the JRC data collection: https://doi.org/10.2905/D3163B12-D931-44ED-A609-AF82860A47E0 PID: http://data.europa.eu/89h/d3163b12-d931-44ed-a609-af82860a47e0.

against Sea level rise and is expected to overestimate the expected benefits in relation to coastal monitoring in beaches.

The Catalan coast is divided into 12 coastal regions as presented in Figure 17. Garola et al (2022), outlines the economic impacts of sea-level rise on coastal tourism in Catalonia, specifically analyzing beach erosion under the RCP4.5 and RCP8.5 scenarios. It uses an input-output model linked to tourism demand and county-level impacts. Table 14 provides the estimates of Garola et al for the potential Benefits of Adaptation for the 12th Catalan districts across the Catalan Region.

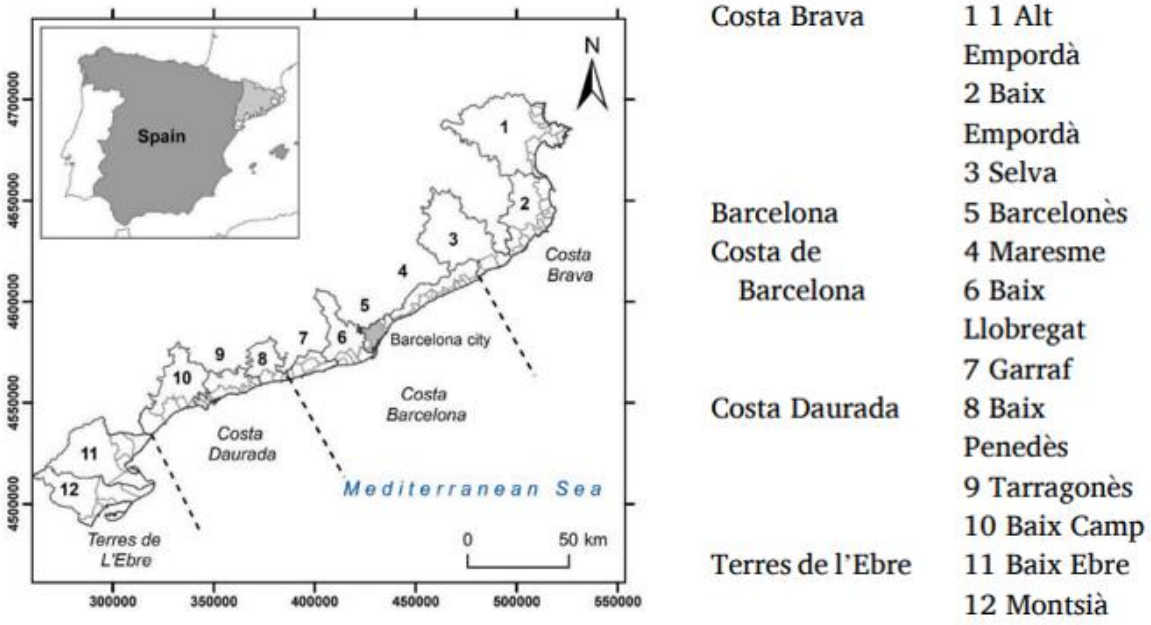

Figure 17: Catalan Coast Breakdown - Geographic coordinate system: ETRS89/UTM zone 31N

Catalan Region	RCP4.5	RCP8.5
1	18	30
2	35	45
3	100	118
4	15	20
5	0	0
6	28	30
7	19	23
8	22	32
9	40	50
10	21	28
11	6	6
12	3	3

Table 14 Catalan Regions – Benefits of Adaptation – M euro / Km

From all Regions our analysis will focus on Santa Susanna, a municipality in the comarca of the Maresme (Region 4). Santa Susanna municipality has 1320 households, a population of 3854, with an average age of 44 years and the share of people with tertiary education to be equal to 40%14.

The Total Economic Value of the proposed investment is calculated as follows:

$$TEV = NPVm + NPVnm = NPVb - NPVc + NPVnm \quad \text{(eq3)}$$

Where NPVm refers to the present value of the tangible Benefits minus the tangible Cost, while NPVnm refers to the net present value of the intangible (non-market benefits). As a discount rate we will use 5% for the net present value calculations of the market costs and benefits, while for the intangible benefits we will use the time declining rate reported in Table 11.

$$NPV = \sum_{t=0}^{76} \frac{Benefit_t - Cost_t}{(1+r_m)^t} - Cost_0 + \sum_{t=0}^{76} \frac{non-market\ Benefit_t}{(1+r_t^{nm})^t} \text{(eq4)}$$

By performing the calculations, NPVm is equal to 3,73 million euro for RCP4.5 and 5,011Million euro for RCP8.5 scenarios respectively. As explained in Table 11, the intervention also addresses the hazard of ecosystem services degradation (Loss of Coastal Habitats).

Interventions aimed at monitoring coastal erosion on beaches help protect a wide range of ecosystem services. Regulating services such as erosion control and flood regulation benefit by preserving natural barriers like dunes and wetlands, which reduce the impact of storms and prevent land loss. These areas also contribute to water purification by filtering pollutants. Provisioning services are supported as coastal ecosystems act as critical habitats for marine species, ensuring sustainable fish populations and providing resources like sand and biomass. Supporting services like habitat provision and nutrient cycling are also maintained, ensuring biodiversity and ecological stability.

In order to estimate the non-market benefits related to ecosystem services, we do apply the Benefit transfer function for Marine and Freshwater Ecosystems, that is the third column in Table 9, and the mapping between Interventions and Ecosystem services of Table 8. By applying the above and a time decreasing social discount factor, the net present value of non-market benefits is estimated at 5,1 million Euro for the beach in Santa Susanna.

3.3.2. Key stakeholders in financing CA

Despite WP1 engaging many diverse stakeholders, for this WP the financing stakeholders are key to ensuring the uptake of the project innovations. In the case of DS2, the results from the workshop and further research have led to the identification of the most relevant stakeholders.

To start with, considering the academic system, several Catalan research centers and universities have been considered essential for gathering information about CA and its financing. Some examples include universities such as the Polytechnic University of Catalonia (UPC)[15] or the Open University of Catalonia (UOC)[16]. Both have presented studies regarding adaptation to climate change in different areas, such as in ports, beaches and seafronts of cities and towns.

Moving on to the private stakeholders, many of them have been identified in the financial sector. To start with, the European Investment Bank (EIB) needs to be considered, as it has recently provided a €100

14 https://ugeo.urbistat.com/AdminStat/en/es/demografia/popolazione/santa-susanna/20223255/4; Spanish National Institute of Statistics (INE)

[15] Presentat un estudi sobre l'adaptació de ports, platges i passejos marítims de la costa catalana al canvi climàtic - UPC Universitat Politècnica de Catalunya

[16] RESIST: Testejant solucions adaptatives per a reptes climàtics | CareNet (uoc.edu)

million loan to the Catalan Finance Institute (ICF)[17] to finance CA and mitigation projects mainly carried out by small and medium-sized enterprises (SMEs), mid-caps and self-employed individuals. Such projects are destined to reduce CO2 emissions and/or to improve energy efficiency.

Also in the financial sector, other key actors in DS2 include equity investors. For example, Ship2b Foundation[18] is an organization that invests mainly in startups whose objective is to have a positive social and environmental impact, apart from maximizing their profitability. Another key stakeholder is Wthe European Private Equity and Venture Capital Association, which is now known as Invest Europe[19], and aims at representing the sectors of private equity, venture capital and infrastructure investment in Europe, and connecting them with firms to potentially invest in. In this same line of private equity, but at a more national level, SpainCap[20] can also be considered, as it represents the private equity and venture capital sector in Spain.

Business angels are also relevant in DS2, such as the Business Angels Network of Catalonia (BANC)[21], which connects enterprises seeking financing with business angels. The firms that are susceptible to receiving financing via this network can be from many different sectors, including the environment and energy sector. Similarly, EBAN[22], the European Business Angels Network, also unites investors with firms and entrepreneurs at the European level.

In the capital market, there is the National Securities Market Commission (CNMV) which supervises the national securities market in Spain and the actors that participate in it. In the aspects of CA, CNMV thrives to promote sustainable growth and to minimize and manage the financial risks that come with climate change[23].

Regarding public agencies and administration, the regional government in DS2 has set up several initiatives with the objective of subsidizing projects either for research purposes or from SMEs and businesses implementing actions for adaptation. For instance, it gives subsidies directed to universities or research centers to finance research projects related to climate change mitigation and adaptation[24]. Such projects also typically have an industrial development component in areas such as renewable energy or sustainable mobility. Additionally, the Climate Change Office[25] and the Catalan Institute of Energy[26] are also key actors in providing subsidies and financial aid for CA. Other significant initiatives implemented by the Catalan government, as a relevant stakeholder, include tax deductions for investments aimed at reducing pollution and improving the environment[27]. The Startup Capital[28] initiative by ACCIÓ is also worth mentioning, as it provides capital to technological startups that are in the initial phase of starting up their businesses. Also, Catalonia implemented a Climate Fund[29] which finances projects related to climate change adaptation and mitigation.

The Catalan Institute of Finance[30], ICF, also must be considered as it constitutes a key player in providing loans with interest bonifications for projects related to climate change mitigation and

[17] Spain: The EIB grants ICF a loan of €100 million to finance SMEs and mid-caps in Catalonia, which includes an advisory service for sustainable projects
[18] Impulsamos la Economía de Impacto | Fundación Ship2B
[19] Invest Europe - The Voice of Private Capital
[20] Spaincap
[21] Business Angels Network Catalunya | (businessangelscatalunya.com)
[22] EBAN – Europe's leading early stage investors network
[23] CNMV - Finanzas Sostenibles
[24] Ajuts per finançar projectes de recerca per la mitigació i adaptació al canvi climàtic 2023. Agència de Gestió d'Ajuts Universitaris i de Recerca (gencat.cat)
[25] Inici. Canvi climàtic (gencat.cat)
[26] Inici. Institut Català d'Energia (gencat.cat)
[27] Deduccions fiscals. Medi Ambient i Sostenibilitat (gencat.cat)
[28] Startup Capital, el acceso a la financiación. ACCIÓ - Agencia para la Competitividad de la Empresa (gencat.cat)
[29] El Govern aprova un decret per regular el Fo... - Govern.cat
[30] ICF (Institut Català de Finances) Barcelona - #ServeisPerEmprendre (gencat.cat)

adaptation. Likewise, the Official Credit Institute[31] (ICO) also gives loans for projects treating these matters. The organization Avalis[32], on the other hand, facilitates access to finance for Catalan SMEs or self-employed individuals.

At a higher level in the multi-level governance reality in DS2, the national government owns several institutions that finance CA and mitigation projects. One example is IDAE[33], the Institute for Energy Diversification and Saving, which provides financial aid for adaptation projects such as sustainable urban development or the rehabilitation of buildings. Similarly, another relevant actor is MITECO[34], the Ministry for the Ecological Transition and the Demographic Challenge. Still at the national level, the organization Enisa[35] works at providing financing to SMEs that plan to implement innovative projects.

Lastly, other stakeholders include citizens, media and culture. These can participate in crowdfunding or other projects related to adapting to the new situation arising from climate change.

3.3.3. Results of the workshop and conclusions

3.3.3.1. Key actors

The policy and financing barriers and opportunities workshop identified several **key stakeholders** involved in financing CA in the Catalan coast, with a significant emphasis on EU agencies, local authorities and regional and national authorities. This suggests a recognition that public-sector stakeholders play a crucial role in CA financing in Catalonia. If we consider the Quintuple Helix stakeholder categories, the participants in DS2 only considered the governments and their agencies and ministries as key players in financing CA, whereas the academic system, civil society, media and culture, and the industry and economic system, were not considered. During the open discussion, partners commented they agreed on only choosing public administration at an EU, national and regional level.

These results suggest that the **lack of private stakeholders** identified as facilitators of CA financing states a **current challenge** for the region. While these conclusions were reached according to the results obtained from the workshop where different partners participated, the desk research that was also carried out by WP6 suggests that there are some important private actors that play a significant role in financing CA.

When participants were asked about current relevant **financing mechanisms** in the Catalan DS, various were discussed. The participants highlighted the Climatic Fund[36] by the Government of Catalonia and other sources of support provided by the Department of Climate Action, Food and Rural Agenda (DACC[37]), and the EU project calls. These examples highlight a mix of public funding sources aimed at supporting adaptation projects. Also, the Ministry for the Ecological Transition and the Demographic Challenge (MITECO) were mentioned. These results indicate that IMPETUS partners in the DS2 region are benefiting from various sources of financing stemming from multiple governance levels, characteristic of Spain's multi-level governance system.

[31] Instituto de Crédito Oficial (ico.es)
[32] Conoce Avalis | Presentación | Avalis de Catalunya, S.G.R
[33] Inicio | Idae
[34] Ministerio para la Transición Ecológica y el Reto Demográfico (miteco.gob.es)
[35] Enisa con el emprendimiento innovador.
[36] https://canviclimatic.gencat.cat/es/ambits/Llei_canvi_climatic/el-fons-climatic/index.html
[37] https://agricultura.gencat.cat/ca/inici/index.html#googtrans(ca|en)

3.3.3.2. DS2 policy and financing challenges for exploitation

The **main challenges** recognized by the DS2 project partners to implement IMPETUS' CA solutions at a regional level after the project are significant.

In particular, partners emphasized the complexity of ensuring the **economic viability of the solutions** after the project, as also the uncertainty caused by the change of political priorities. For instance, they stated that coastal erosion is not a **high priority on the political agenda** despite its local impact, complicating the identification of responsible authorities.

Thus, as mentioned, in Spain's multi-level governance system, a notable issue is **the lack of clarity regarding financial responsibilities** between national, regional and local authorities, especially when funding local needs. These challenges highlight common issues in multi-level governance, where alignment and fast coordination across various administrative levels is crucial, particularly in the context of climate emergency.

Moreover, partners commented that **financing opportunities are unequal depending on the domain or sector of intervention**. Whereas financing is available for activities such as resilient agriculture and infrastructure, options for addressing coastal erosion are lacking. For that matter, partners highlighted the need to include CA in sectorial plans to address more concrete needs.

In line with the multi-level governance challenges identified in D1.3, funding and administrative challenges were again signaled in the workshops, as well as the lack of CA prioritization by public authorities.

3.3.3.3. Financial instruments and access and leveraging finance barriers

Regarding the **use of financial instruments** in the regions, DS2 partners rated grants as the most critical, with a score of 4.6 out of 5 on a 1-to-5 scale, where 1 signifies irrelevant and 5 signifies critical. Private equity and taxes followed, each receiving a score of 3.2. Blended finance was rated next, with a score of 2.4. Finally, crowdfunding and loans were rated lower, scoring 1.8 and 1.4 respectively. LOB highlighted their strategy of financing solutions through direct sales to leading CA companies. LOB mentioned that their solutions allow their clients to anticipate climate risks and enable proactive risk management to become more resilient. In addition, they often find that clients prefer voluntary engagement in adaptation aligned with their strategic goals rather than compliance enforced by regulations.

Following the same scale from irrelevant to critical, partners were asked to vote on the relevance of the **current barriers to access climate finance.** Partners in the Catalan region considered that adaptation needs are not sufficiently prioritized by financial decision-makers and that local actors lack the capability to identify, quantify, and attract financial resources (4.6/5). In second place, it was highlighted the insufficient understanding and estimation of available funding needs (4/5); and in third place, the poor evaluation of financial needs related to adaptation projects (3.4/4). Finally, the fact that regions and firms often do not meet the criteria set by financial institutions for obtaining funds scored 2.4/5.

After that, DS2 partners were asked to establish the relevance of pre-established barriers in relation to **leveraging financial resources**. The inaccurate budgeting and **inability to form effective public-private funding partnerships stood out** (4.6/5). In second place, partners highlighted that the mismanagement of available funds led to some inefficiencies (3.8/5). Finally, the difficulties found in creating viable investment projects and mobilizing stakeholders for funding (2.6/5), the low presence of innovative firms and systems needed to implement complex, transformational adaptation solutions (2/5) and the ineffective identification of key stakeholders and inadequate planning and monitoring of investment projects (1/5), were mentioned.

3.3.3.4. DS2 Policy and financing needs for exploitation

At the end of the workshop, an open-ended question regarding the financing and policy needs that partners have for the exploitation of solutions in the DS was put. The identified needs included, in first place, a review of current policies and regulation at EU, Spanish, and Catalan levels to align them better with the new generated knowledge. Also, the need to have clarity on policies and regulations applicable to coasts and climate change in the multi-level governance system was also highlighted. Partners widely agreed that there a is a need for policy integration in terms of key climate and social issues (e.g., health, poverty, equality, etc.).

Moreover, DACC proposed the creation of additional funding mechanisms such as specific taxes (e.g., tourist tax), specifically framed at coastal restoration and CA.

Enhancing visibility of the IMPETUS DS solutions and the partners involved among national decision-makers is crucial. Thus, besides the regional scope, coordination efforts with national authorities to ensure the uptake of solutions is critical. In that sense, partners agreed that the current collaboration challenge due to the multi-level actors in the Spanish governance model, already included in D1.3, needs to be addressed.

To face the private financing gap, partners mentioned the need for identification of investors and innovative business in the DS that can facilitate the implementation of solutions and ensure that these are also relevant for private actors. Moreover, partners supported the idea that a domino effect could happen if investors network finance some solutions initially. In that way, other more risk-averse businesses would be more willing to replicate.

As relevant implications, the DS2 workshop outcomes suggest that while there are robust financing mechanisms and stakeholders involved in CA in Catalonia, there are significant challenges and needs to be addressed. These include improving coordination between different levels of governance, enhancing financial capabilities and awareness among local actors, and ensuring long-term sustainability of adaptation solutions beyond R&D EU-funded projects. Moreover, aligning policy frameworks with evolving climate challenges, prioritising CA in public policies and sectorial plans, and securing adequate, more diversified funding mechanisms that can promote competitiveness is key. Besides public funding, blended-financing mechanisms and private financing should be on the agenda to drive a faster and broader transition, this requiring the creation of incentives from public authorities to attract private investors and create public-private funding partnerships.

3.3.4. Policy analysis for DS2

The policy mapping exercise results illustrate some of the findings derived from the workshop held with DS2 partners, particularly the reliance of stakeholders in multi-level governance to fund the CA solutions (funding in DS2 comes mainly from both national and regional governments, which are also in charge of channeling EU funds).

While national and regional governments seem to play a large role in supporting CM and CA solutions in Spain, and particularly in Catalonia, where DS2 is located, there seems to be a smaller role played by local governments and, generally, local actors. One of the conclusions from the workshop was that there is a lack of flexibility when it comes to adapting climate solutions to specific climate hazards in a given territory, plus some lack of coordination between the various levels of governance (national and regional), when it comes to anticipating these hazards, planning and executing effective climate policies, particularly CA policies.

Despite the efforts over the past few years from the Government of Catalonia to actively implement policies aimed at supporting CA strategies, as described in D6.6, partners noted CA could be further prioritized in public policies and sectorial plans. An issue here could be that the overarching policies and strategies implemented, such as the Catalan Strategy for Adaptation to Climate Change, require of a stronger coordination with local stakeholders, including local authorities, businesses and citizens, who are, at the end, those more impacted by climate hazards in a particular territory, such as coastal erosions, water scarcity or management of wastewater.

In that sense, the solutions proposed by IMPETUS in DS2 - the satellite-based coastal erosion assessment (developed by LOB), and the Water quality prediction Tool on bathing areas and under severe storms (developed by EUT) – aim to give more information and tools to both regional and local authorities so they can not only react to any given risk but, crucially, to anticipate these risks.

Taking the example of the Water quality prediction tool – local governments play a key role in managing wastewater after a storm event. A mismanagement in that sense could not just impact bathers but also damage the costal ecosystem more permanently, with implications for economic and social activities in the area (e.g. permanently bad quality bathing waters could drop tourist numbers, a source of economic growth and employment for many coastal areas in Catalonia). The solution presented therefore would not only support local authorities in their planning and management of wastewater, but also empower citizens and businesses to access this information and support their local authorities in addressing the issue quicker.

All in all, this is expected to result in an empowerment of local communities, increasing the level of subsidiarity of CA policies in DS2. Moreover, if businesses and local companies (such as hotels) see the benefits in using this tool (for example, a local coastal hotel could use the tool to inform their customers of the quality of bathing water), this could also generate incentives for private investors to support the development of this tool, diversifying the sources of financing for CA solutions in DS2.

3.4. DS3 – Mediterranean: Region of Attica, GR

3.4.1. Cost Benefit Analysis of Selected Solutions

The DS3 Mediterranean DS focusing mainly on addressing water scarcity and heatwaves (temperature increase). Among the interventions selected by the DS, we choose to showcase the CBA process focusing on Underground Sewer Mining Unit, since based on Table 11, the interventions under the type of “Sustainable Water Management”, imply the highest nonmarket benefit among those addressing water scarcity. The final deliverable D6.5, will apply the analysis for all interventions selected by the DS, for which cost data are available and analysis is feasible.

Sewer mining (SM) technology is a mobile wastewater treatment system in containers, which can extract wastewater from local sewers, treat it directly and reuse it at the point of demand in dense urban environments. The unit consists of a membrane bioreactor unit (MBR) and a UV disinfection system and produces high quality reclaimed water for irrigation of green areas, aquifer recharge and other urban uses. The SM unit is very efficient and stable in terms of treatment, it requires limited space (small footprint), reduces waste and increases availability of resources and saves energy as water is extracted, treated & reused at the same location.

Athens Water Supply and Sewage Company (EYDAP), the IMPETUS partner who has developed the SW unit, has the plan of installing 27 Units in 21 parks in Attica (largest parks next to sewerage network) as well as to EYDAP facilities, during the next 5years, with a horizon of 20 years. The total estimated

irrigation needs are 473.186 cubic meters per year, while covering a total area of 5,7 million square meters. Table 14 presents the estimates for the CAPEX and annual OPEX of the intervention.

CAPEX / unit		OPEX per year / unit	
Unit capital cost	150.000,00 € or 20,69 €/m³	Maintenance	3.500,00 € or 0,48 €/m³
Pumping station	50.000,00 € or 6,90 €/m³	Personnel cost + Analyses	4.200,00 € or 0,58€/m³
Pipes	4.000,00 € or 0,55 €/m³	Lab consumables	840,00 € or 0,12€/m³
Fence + protective shell in construction	64.000,00 € or 8,83 €/m³	Electricity cost (0.217 €/kWh)	1.960,90 € or 0,27€/m³
Solar Panel	6.047,00 € or 0,83 €/m³		
TOTAL	274.047,00 € or 37,80 €/m³	TOTAL	10.500,90 € or 1,45 €/m³

Table 14: Sewer Mining Unit - Costs

Each unit has the capacity to produce 25 cubic meters per day. EYDAP's assumptions include a total number of 290 operating days at a discount rate for market Benefits and Costs of 5% ($r_m = 5\%$) with a selling price close to 1,42 euro per cubic meter.

As a first step we will calculate the net present value of the market Benefits and Costs (NPVm) as:

$$NPV_m = \quad NPV_m = \sum_{t=0}^{19} \frac{Benefit_m - Cost_m}{(1+r_m)^t} - Cost_0 \quad \text{(eq5)}$$

The Internal Rate of Return can be calculated as the continuously compounded return from period 0 to period 19 that is:

$$IRR_m = \left(\frac{NPV_m}{NFV_m}\right)^{\left(\frac{1}{20}\right)} - 1 \; = \; 7{,}04\%, \quad \text{(eq6)}$$

where NFV is the net Future Value at period 19.

The Total Economic Value is defined as:

$$TEV_0 = NPV_m + NPV_{nm} \quad \text{(eq7)}$$

are the net discounted non-market benefits.

To verify that our implementation and mapping performed in previous sections is correct, we also scheduled a workshop with the stakeholders of DS3 to help us identify the use of the intervention and the mapping of the underlying ecosystems and ecosystem services. The results of the workshop are displayed in Table 15.

Sector	Ecosystem Service	Use	Benefits
Water Recycling and Reuse	Enhanced water availability and quality	Irrigation	Reduce demand for freshwater sources
		Industrial Processes	Contribute to water conservation
		Portable Water	Mitigate urban heat / urban heat islands
		Artificial recharge	Improve the quality of water discharged to environment
Nutrient Recovery	Nutrient cycling and soil fertility	Agriculture Purposes (fertilizers) - Capture and Recover Nutrients (such as nitrogen and phosphorus)	Sustainable farming practices
		Reduction of ferilizers use due to water rich in nutrients	Enhance soil Fertility
Energy Generation	Renewable energy production	Extraction of Energy	Renewable energy production
			Reduce carbon footprint
Reduction of Pollution and Environmental Impact	Water quality improvement	Improve Overall Quality of Water Bodies	Positive effects on aquatic ecosystems and the services they provide (e.g. habitat support)
			Reducing negative impacts on aquatic ecosystem
			Emissions Reduction
Climate Change Resilience	Adaptation to climate change	Alternative Water Sources (e,g, during periods of drought or water scarcity)	Adapt to changing climate conditions
		Stormwater Management	Reduces reliance on traditional water sources
			Manage stormwater runoff - reduce the risk of urban flooding and urban heat
Biodiversity Support	Habitat preservation and support	Wasterwater Treatment and Management	Prevent the release of harmful substances into natural water bodies
			Preserving the habitats of aquatic flora and fauna - biodiversity support
Economic Benefits	Economic development (support human well-being)	Resource Efficiency (Recovery valuable Resources from Wasterwater)	Job creation (water treatment and recycling sector)
			Cost Savings (Water Reuse)
			Resource Use Efficiency (Water)
			Resource Use Efficiency (Energy)

Table 15 Stakeholder Validation of Ecosystem Services related to Sewer Mining

The exercise required denoting with Green the ES which were highly related to the use of the intervention, with yellow and red to denote a moderate and red relationship respectively.

The connection between underground sewer mining and terrestrial or freshwater ecosystems depends on how the treated wastewater is used and managed after extraction. If the treated water from sewer mining is primarily used for irrigation in agriculture, landscaping, or green spaces, it directly affects terrestrial ecosystems. The water quality and nutrient content can influence soil health, plant growth, and local biodiversity. On the other hand, if the treated wastewater is discharged into rivers, lakes, or wetlands, it primarily impacts freshwater ecosystems. This can affect water quality, aquatic life, and the overall health of freshwater ecosystems.

Since the results of the table indicate that both water conservation and improving the overall quality of water bodies, then we will use the benefit function for the aggregate effect on both Terrestrial and Freshwater Ecosystems, with the type of intervention to be Sustainable Water Management and thus

using 53,64 as the shadow price, from Table 11. This price is the annual Willingness to pay and needs to be scaled with the underlying population affected

To more accurately estimate the number of persons inhabited in the close area of the parks, Table 16 reports the estimated population at the most granular census level for Attica Region in Greece, which is Municipal Units, with a total number of households impacted to be equal to 359.50038.

Urban Parks - Green Areas	Municipal Unit # of Households(thousands)	Municipal Unit
Lampraki hill	18	Ampelokipi
Diomidios Votanikos Kipos	18,5	Chaidari
Egaleo park	35	Egaleo
Veikou park	22	Galatsi
Finopoulou hill	15	Gizi
Glyfada Golf	25	Glyfada
Tritsi park	27	Ilion
Andrea Papandreou park	25	Keratsini
Kifisias park	18,5	Kifisia
Eleutherias park	10	Kolonaki
Akadimia Platonos	15	Kolonos
Lofos Filopappou	10	Koukaki
Alepotripa - Eikonas Hill	18	Kypseli
Pedio Areos		
Siggrou park	27	Marousi
Nea Filadelfia park	13,5	Nea filadelfia
Arditou Hill	22	Pagrati
Ethnikis Antistaseos Voula Mikrasiaton Voudouri	10,5	Voula
Vouliagmenis park Lampraki Grigoriou	5,5	Vouliagmeni
Panepistimioupoli	24	Zografou
Eirinis - Zografou park		

Table 16 Number of Households in Municipal Units around Green Park Areas (in '000). Source: ELSTAT, Census data 2021

The Net Present Value of the non-market social benefit of the intervention is calculated as:

$$\sum_{t=0}^{76} \frac{non-market\ Benefit_t}{(1+r_t^{nm})^t} \quad \text{(eq8)}$$

where r_{nm_t} is the social discount benefit, as explained and presented in Table 5 and Table 6. For a period of 20 years the rate 3,88% will apply. Also, the Annual nonmarket benefit corresponds to

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53,64x359,500= 19,3 million euro per Year. Consequently:

$NPVnm =$ 255,87m euro for the 20-year horizon.

These values, although not directly quantifiable through market transactions, contribute significantly to societal well-being and quality of life. Recognizing the high benefits that ecosystems provide, policymakers can incorporate these non-market values into decision-making processes to ensure that economic policies reflect the full range of ecosystem services. The inclusion of non-market values can also drive the design of economic instruments such as subsidies, taxes, and payment-for-ecosystem-services schemes. When the benefits of ecosystems are adequately represented in economic analyses, it becomes possible to design instruments that incentivize sustainable practices and investments in ecosystem health. For instance, in this case binding subsidies to mitigate against the high initial costs and support the uptake of such innovations to the market and they can enhance both environmental quality and economic resilience.

3.4.2. Key stakeholders in financing CA

In accordance with the information from the past deliverable D1.3 and further desk research, several key stakeholders have been identified for providing financial assistance for CA in DS3.

To start with, within the public sector, the Greek government supposes a key stakeholder for financing CA. More specifically, the Ministry of Environment and Energy (MEEN)[39] is committed to promoting CA and facilitating financing for this matter, especially through the coordination of the National Adaptation Strategy. Also responsible for this strategy, and another potential key actor, is the National Climate Change Adaptation Committee (NCCAC). On the same note, a relatively new actor is the Ministry of Climate Crisis and Civil Protection[40], created in 2021 with the goal of coordinating other ministries that deal with CA issues.

At a lower level of governance, the regional government in the region of Attica should also be considered. Particularly, the Decentralized Administration of Attica[41] is the main authority governing the region, and deals with environmental issues.

On the other hand, in the private sector, the Bank of Greece[42] plays an important role in financing CA. Specifically for this matter, it set up the Climate Change Impacts Study Committee (CCISC)[43] aimed at providing research on the economic, social and environmental impacts of climate change. Later, the Climate Change and Sustainability Center[44] was also established with the initiative of the Bank of Greece. Its main tasks consist of supporting the work done by CCISC and providing help to the Bank in terms of its climate and sustainability strategy.

In the academic sector, several Greek universities and research centers have developed important studies and provided essential insights on CA and its financing. For instance, the Athens University of Economics and Business (AUEB) and the National Technical University of Athens (NTUA) are key players.

[39] Ministry of the Environment and Energy - Gov.gr (www.gov.gr)
[40] Ministry of Climate Crisis and Civil Protection - Gov.gr (www.gov.gr)
[41] Αποκεντρωμένη Διοίκηση Αττικής -Αποκεντρωμένη Διοίκηση Αττικής (apdattikis.gov.gr)
[42] Bank of Greece
[43] CCISC (bankofgreece.gr)
[44] Climate Change and Sustainability Centre (bankofgreece.gr)

As for the financial sector, several key stakeholders can be identified[45], starting with venture capital firms such as Big Pi Ventures[46]. This company is focused on investing in startups and teams offering innovative technologies in specific branches of interest, one of which is climate technology. Another example of venture capital is Metavallon[47], which invests in early-stage startups from different sectors. At the European level, and as already mentioned for DS2, Invest Europe is a key player to consider also for DS3.

Business incubators are also very relevant when looking for financing CA projects and, in the case of Greece, there are some organizations specialized in this matter. Some examples include, Found.ation[48] or Impact Hub Athens[49].

Still in the financial sector, business accelerators are helpful in providing assistance for SMEs and startups in order to enhance their growth. Relevant for DS3, the National Bank of Greece has a branch dedicated to business banking known as Business Seeds[50], which provides financial aid to those firms developing innovative products. Additionally, other accelerators include Reload Greece[51] or Envolve Entrepreneurship[52], amongst others.

At the European level, the European Investment Bank[53] also supposes a key stakeholder in this case, given that it offers guidance and financial aid for climate-related projects with the aim of enhancing mitigation and adaptation. In addition, the European Commission should also be considered, as it has recently provided financial aid to Greece for its recovery and resilience plan[54].

3.4.3. Results of the workshop and conclusions

3.4.3.1. Key actors

When considering the key stakeholders for financing CA in DS3, the partners identified mainly government research agencies, as well as both regional and national authorities. These results indicate that most of the financing is mainly brought by public stakeholders. However, EU agencies and local authorities were considered less relevant. On the other hand, the private sector was attributed a lower importance for financing CA opportunities. Amongst the private actors mentioned, there are clusters and other SME associations and, at an even lower relevance, venture capitals and incubators.

Some examples of key stakeholders for financing CA solutions that were provided include, for instance, the Green Fund[55], the European Investment Bank (EIB)[56] and the EU-funded LIFE Programme[57]. Additionally, at a national level, partners also mentioned the National Bank of Greece[58], the Attika Prefecture and the Ministry of Environment[59]. Equifund[60], a platform aimed at helping investors find early-stage opportunities, was also mentioned. Lastly, considering the private sector, the partners identified EYDAP[61], the Athens Water Supply and Sewage Company. It was also stated that regional

[45] Greece-State-of-Climate-Tech-2022.pdf (climate-kic.org)
[46] Big Pi Ventures
[47] Growing Innovation Companies - Metavallon VC
[48] FOUND.ATION - Join an ecosystem of pure innovation (thefoundation.gr)
[49] Impact Hub Athens | A local and international connected network for positive social impact.
[50] NBG Business Seeds - Business Funding Program
[51] Home - Reload Greece
[52] Home | Envolve (envolveglobal.org)
[53] Homepage | European Investment Bank (eib.org)
[54] Commission endorses Greece's plan (europa.eu)
[55] Homepage | Green Climate Fund
[56] Homepage | European Investment Bank (eib.org)
[57] LIFE - European Commission (europa.eu)
[58] NBG | Banking Today
[59] Ministry of the Environment and Energy - Gov.gr (www.gov.gr)
[60] Unlock the Wealth Building Power of Private Equity | Equifund
[61] ΕΥΔΑΠ-HOME (eydap.gr)

authorities, as well as local ones, should showcase their willingness to implement CA solutions in their territory, which could channel funding from the EU or other programmes.

3.4.3.2. DS3 policy and financing challenges for exploitation

As for the **challenges** in the policy field, the respondents highlighted the difficulties involved in achieving more engagement from regional and local authorities, as well as local communities. In this sense, it was considered that there is a current **lack of incentives** from such key stakeholders for accepting and implementing CA solutions.

On the other hand, in the financial field, partners commented the **lack of financial resources** and **lack of knowledge** when it comes to the **development of adaptation investment plans**.

3.4.3.3. Financial instruments and access and leveraging finance barriers

Considering the financial instruments most commonly used, the partners identified mainly grants with a score of 4 out of 5. Taxes were the next source to receive a higher score (2.5). Then, with lower scores, blended finance in the form of public-private partnerships and private equity or venture capital were also commonly used in this DS. Lastly, loans, bonds and vouchers, and crowdfunding were considered more rare forms of financing and, as for the least relevant ones, these were derivatives such as insurance and risk pooling.

The main barriers to access finance for CA were the **political, institutional and governance types**. More specifically, partners considered that adaptation needs are not prioritized by financial decision-makers. This barrier received a score of 4, with 5 meaning critical and 1 meaning irrelevant. In addition, the lack of understanding regarding available funding opportunities scored 3.3 and was also considered a critical knowledge and awareness barrier. Following this order, the partners mentioned some economic barriers in the form of a lack of capacity to identify, quantify and attract financial resources. Lastly, the less relevant barriers were technological and socio-cultural, respectively.

As for the barriers considered for leveraging financial resources, the socio-cultural ones showed the highest score. These include an **inaccurate budgeting, as well as the lack of capacity for forming public-private funding partnerships.** Next, the partners considered the **difficulty in creating viable investment projects and mobilizing stakeholders for funding** with a score of 2.7, and the **ineffective identification of key stakeholders** as well as inadequate planning and monitoring of investment projects, which scored 2.3. Lastly, with the same score of 1.7, there are the technological and political, institutional and governance barriers. These include, on the one hand, the lack of innovative firms and systems aimed at implementing complex and transformational adaptation solutions and, on the other hand, the mismanagement of available funds leading to inefficiencies.

3.4.3.4. DS3 Policy and financing needs for exploitation

According to DS3 partners, one of the needs for the exploitation of the CA solutions included more policy flexibility in order to fund such solutions. In this sense, they considered that most of the current funding is channeled to mitigation policies and suggested that some of it should also go to adaptation. Additionally, in line with policy needs, it was noted that, since the DS3 is related to water recycling, further regulations regarding water quality and obligations to use recycled water are needed. As for the financing needs, it was mentioned that a possibility to create more CA funds could be to pool different sources, such as international donors, government budgets and private investors.

The results from this workshop indicate that there currently are existent financial mechanisms and key actors for CA projects in Greece, most of which are in the public sector. Nonetheless, several challenges and needs arise regarding the policy and financing framework, starting with the need for local authorities

and communities to further engage in CA, the lack of sufficient and diverse financial instruments, and the lack of knowledge regarding the design of adequate investment plans. This inadequate understanding can result in a lack of incentives from the private sector to invest and finance such projects, which poses another challenge. Furthermore, there is the pressing need of shifting some of the focus from mitigation to adaptation measures, and more policy flexibility to facilitate the funding of solutions aimed more specifically at adaptation.

3.4.4. Policy analysis for DS3

In the case of DS3, the policy mapping exercise also illustrates some of the conclusions that were reached during the workshop. During such exercise, a total of 38 different policies addressing mitigation and adaptation were identified in Greece, where DS3 is located.

To start with, one of the challenges in terms of policymaking identified during the workshop exercise was regarding the difficulties in achieving engagement from local and regional authorities. In this sense, the policy mapping for DS3 further reaffirms this issue, given that all the policies listed are implemented at the national level. This lack of subsidiarity, as commented in the workshop, can ultimately lead to a lack of incentives for the local and regional authorities to implement CA solutions.

Additionally, it was mentioned during the workshop that most of the financing was directed for mitigation actions, leaving less finance for CA solutions. In this line, there is a significant difference in the number of policies directed at mitigation as opposed to the ones that address adaptation, which is much larger for the first case. Overall, both the results obtained from the workshop and the policy mapping indicate that, in Greece and more particularly in DS3, more focus is set on CM policies rather than on CA policies.

This lack of policies for CA may result in a more difficult implementation of the solutions proposed for DS3, such as the sewer mining technology. Additionally, as mentioned in the workshop, another challenge is related to a lack of policy flexibility when it comes to financing such solutions.

4. Conclusions and next steps

The present deliverable, D6.4 collects the main outcomes of the activities carried out and planned for task T6.1 within the IMPETUS project, as well as the empirical analysis of the key results.

This section contains the preliminary guidelines for public agencies and administrations derived from this analysis (4.1), which will be updated in D6.5 and D6.10 (policy brief). It also details, in the form of next step, how the future work will be oriented to produce the final recommendations and to further strengthen the analysis outlined in this deliverable (4.2).

4.1. Policy recommendations and guidelines

As described in section 2 of this deliverable, the methodology behind the development of the recommendations is rooted in a rigorous, multi-step, evidence-based process designed to ensure that policy advice is well-informed and actionable. As a summary, the steps followed to get to the policy recommendations and guidelines are the following:

- **Policy Mapping and Analysis**: The process began with a thorough mapping and evaluation of existing policies. This step involved identifying relevant CM and CA policies, frameworks, and regulations. This contextual understanding was helpful for highlighting gaps, challenges, and opportunities in the current policy landscape.

- **DS Workshops**: Following the policy analysis, workshops with DS2 and DS3 partners were organized. These workshops provided a platform for further identifying gaps and challenges when it comes to implement CA solutions from a policy perspective. The information gathered from these workshops has been used to ensure the recommendations are comprehensive and address real-world concerns, specific from the DS contexts.

- **Social Cost Benefit Analysis (SCBA):** To provide a strong analytical foundation, the recommendations have been also informed by a Social Cost Benefit Analysis. By applying SCBA, the deliverable ensures that the recommendations not only address specific issues but also demonstrate economic and social value, helping to prioritize actions that yield the most benefit for the community.

In summary, the methodology followed in this deliverable combines qualitative and quantitative approaches, ensuring that the recommendations are built on a solid base of evidence, stakeholder input, and economic analysis. This structured approach ensures that the recommendations are actionable, relevant, and aligned with both current policy environments and long-term societal goals.

The first set of recommendations is outlined as follows:

1. Integrate Ecosystem Services Valuation and Market-based Instruments to Assess the Environmental and Social Impacts of CA solutions (SCBA)

- **Objective:** Quantify environmental and social impacts of Climate Adaptation (CA) solutions.
- **Action:** Conduct detailed assessments of ecosystem services, integrating both market and non-market benefits into financial planning. Utilize market-based tools like subsidies, taxes, and payment-for-ecosystem-services schemes to incentivize sustainable ecosystem management.
- **Outcome:** Enhanced prioritization of adaptation projects based on their economic and societal returns.

2. Balance Mitigation and Adaptation Efforts

- **Objective**: Strengthen long-term resilience to climate risks.
- **Action:** Balance mitigation efforts (reducing emissions) with adaptation (preparing for climate impacts), ensuring local benefits are considered. Tailor solutions to specific climate hazards and economic conditions in each region.
- **Outcome**: More comprehensive climate action that addresses both immediate and long-term threats.

3. Promote Preventive Adaptation and Early Action

- **Objective:** Reduce risks through proactive measures.
- **Action:** Invest in early warning systems, disaster risk reduction, and adaptive infrastructure like flood defenses and water management. Scale up proven solutions, such as those developed in the IMPETUS project.
- **Outcome:** Reduced long-term costs and risks through early intervention.

4. Mainstream Climate Adaptation Across All Policy Areas

- **Objective:** Ensure adaptation is embedded in all sectors.
- **Action:** Incorporate climate risk considerations into urban planning, infrastructure development, health, and agriculture. Ensure hazard data is integrated into decision-making processes for infrastructure and resource management.
- **Outcome:** Stronger, more resilient systems capable of addressing climate impacts across multiple sectors.

5. Implement Continuous Monitoring and Adaptive Policy Frameworks

- **Objective**: Ensure policies remain relevant and effective.
- **Action:** Establish continuous monitoring and evaluation frameworks to track the effectiveness of adaptation measures. Regularly adjust policies based on feedback and new climate data.
- **Outcome**: Policies stay aligned with evolving risks and new opportunities for improvement.

6. Empower Local Governments and Communities

- **Objective**: Make climate planning, decision-making and action more local.
- **Action**: Decentralize adaptation planning by providing local authorities with financial resources and technical support. Offer grants, subsidies, and regulatory flexibility for community-driven adaptation solutions.
- **Outcome**: Adaptation measures tailored to specific local needs, resulting in more effective and regionally appropriate actions.

7. Support Community-Based Adaptation Efforts

- **Objective**: Enhance resilience through local knowledge.
- **Action**: Encourage community-based projects that use local knowledge and practices, such as water management, sustainable agriculture, and ecosystem-based adaptation.
- **Outcome**: Increased resilience at the grassroots level, with solutions grounded in local expertise.

8. Facilitate Multi-Stakeholder Collaboration and Policy Coherence

- **Objective**: Strengthen coordination between sectors.

- **Action**: Foster transition towards nexus governance (adopt a nexus system thinking approach) to foster cross-sectoral collaboration across public, private, and civil sectors, and ensure policy coherence Align policies between national, regional, and local governments to ensure consistency. Establish platforms for knowledge exchange and co-creation of solutions.
- Outcome: A coordinated and unified approach to climate adaptation, reducing fragmentation and increasing policy effectiveness.

9. Mobilize Private Sector Investment in Adaptation

- **Objective**: Leverage private funding for large-scale adaptation projects.
- **Action**: Develop incentives for private sector investments through tax breaks, green bonds, and public-private partnerships. Demonstrate financial returns from adaptation projects to attract investors.
- **Outcome**: Increased private sector participation and funding, enabling broader and more ambitious adaptation efforts.

10. Strengthen Public-private Coordination for Climate Financing

- **Objective**: Boost resource mobilization through partnerships.
- **Action**: Promote public-private partnerships (PPPs) to fund large-scale adaptation projects. Set up shared investment frameworks to pool resources and share risks across sectors.
- **Outcome**: Better-funded projects and more sustainable financing models.

11. Communicate the Benefits and Urgency of Adaptation

- **Objective**: Build public and political support for climate adaptation.
- **Action**: Conduct awareness campaigns that emphasize the economic, social, and environmental benefits of proactive adaptation. Showcase successful projects to build momentum.
- **Outcome**: Increased public awareness and stronger political will to implement adaptation strategies.

12. Leverage data and technology for informed decision-making

- **Objective**: Make data-driven decisions to improve adaptation planning.
- **Action**: Use climate models, data analytics, and geospatial technologies to inform local decision-making. Ensure climate data is accessible to policymakers, communities, and the private sector for evidence-based actions.
- **Outcome**: Improved accuracy and effectiveness of adaptation policies, driven by solid data and technological insights.

13. Support SMEs with blended finance[62] and information

- Objective: Enable small businesses to adapt to climate impacts.
- Action: Provide SMEs with blended finance options and easy access to climate risk data. Offer resources to help them adapt to changing regulations and prepare for future climate hazards.
- Outcome: Empower SMEs to implement adaptive measures, ensuring their sustainability and contribution to broader adaptation efforts.

[62] https://www.csis.org/analysis/small-and-medium-sized-enterprises-blended-finance-and-climate-change-sub-saharan-africa

4.2. Next steps

This deliverable will be updated going forward in D6.5 - *Guidelines for decision-makers for business opportunities, financing mechanisms and policy and market instruments v3*, to include the following content:

- The results of the workshops conducted for each of the remaining DS.
- An updated policy mapping and policy analysis conducted for each of the remaining DS, considering the aspects laid out in section 2.1.1.
- Fine-tuning of the current DS included
- The SCBA will be performed for the pending CA solutions

As explained in section 2.1.1, the policy mapping exercise will be validated with partners and relevant external stakeholders (although many policies were already validated in D1.3), expanded as needed and its results evaluated against recognized literature. As much as possible, the robustness of the policy mapping methodology will be strengthened, by making it consistent across the DS. Moreover, more focus will be given to local and regional policies with the contribution of DS partners and stakeholders, and the policy analysis will be expanded to consider how these policies have been implemented and their effectiveness.

Regarding on the SCBA, the analysis for the two case studies will be refined based on the updated data in relation to the costs (CAPEX, OPEX) and the business model for the interventions. Moreover, the analysis will be expanded to cover each of the remaining DS.

Also, AUEB will significantly improve the WTP estimates for the ecosystem services by breaking down the ES categories (Supporting, Provisioning, Regulating), into subcategories focusing on more granular assets (for instance: Provisioning – Food, Provisioning – Wood, etc.).

Finally, the preliminary guidelines presented in this version will be validated with partners and relevant external stakeholders and compared with recognized literature. Similarly, they will be updated with the results of the workshops and the conclusions derived from the policy analysis of each DS, making them more tailored to the DS regions' needs. It will also be considered whether the final guidelines should be differentiated per DS since they might be tailored to different biogeographical locations and local conditions.

All these considerations will be taken into account for the drafting of both the D6.10 – *Policy Brief* and D6.5.

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6. Annex

6.1. Annex I: Policy mapping exercise

Table 17. Policy mapping exercise

DM Country	Territorial Scope	Title (English)	Description (English, 2-3 lines)	Policy by ultimate goal	Policy by type of instrument	Beneficiary by sector	Implementation of EU Directive?	Responsible authority	Name of the authority	Implementation start date
EU	European Union	EU Next Generation funds	€750 billion recovery package established in 2021 to help EU member states recover from the COVID-19 pandemic. The funds aim to support economic resilience, green and digital transitions, and social inclusion across the EU, with key investments planned to be disbursed by 2026. The Funds support climate mitigation and adaptation through significant investments in green technologies, renewable energy, and sustainable infrastructure. At least 37% of each member state's allocation must be dedicated to climate-related projects, including reducing greenhouse gas emissions, enhancing energy efficiency, promoting circular economy practices, and building resilience against climate impacts. These efforts are aligned with the EU's broader goals under the European Green Deal to achieve climate neutrality by 2050	Climate mitigation & adaptation	Multiple instruments / Framework policy	Multiple sectors	N	European authority	European Commission	2021
EU	European Union	European Green Deal	The EU Green Deal is a comprehensive strategy launched in December 2019 to make the EU climate-neutral by 2050. It aims to transform the EU's economy by reducing greenhouse gas emissions, promoting sustainable resource use, and protecting biodiversity. The deal sets intermediate targets for 2030, including a 55% reduction in emissions compared to 1990 levels.	Climate mitigation & adaptation	Multiple instruments / Framework policy	Multiple sectors	N	European authority	European Commission	2019
EU	European Union	European Social Fund (ESF+).	The European Social Fund Plus (ESF+) is the updated and merged version of the European Social Fund, launched for the 2021-2027 programming period. ESF+ aims to support employment, education, social inclusion, and health, with a focus on addressing the impacts of the COVID-19 pandemic, reducing inequalities, and promoting social cohesion across the EU. The ESF+ supports EU climate goals by funding initiatives that promote green skills, sustainable	Climate mitigation & adaptation	Multiple instruments / Framework policy	Multiple sectors	N	European authority	European Commission	2021

			employment, and social inclusion in the transition to a low-carbon economy. This includes training programs for jobs in renewable energy, energy efficiency, and sustainable industries, as well as supporting vulnerable groups affected by the shift to a greener economy.							
EU	European Union	European Regional Development Fund (FEDER)	The ERDF supports regional development by investing in infrastructure, innovation, and sustainable growth, with a strong emphasis on reducing regional disparities. It plays a key role in the EU's climate strategy by funding projects that promote energy efficiency, support renewable energy, and foster sustainable urban development. This helps regions transition to greener practices and contribute to the EU's climate neutrality goals.	Climate mitigation & adaptation	Multiple instruments / Framework policy	Multiple sectors	N	European authority	European Commission	2021
EU	European Union	European territorial cooperation (Interreg) 2021-2027.	Interreg enhances cross-border, transnational, and interregional cooperation to tackle shared challenges, including climate change. It funds joint projects that address environmental issues, improve climate resilience, and support the development of green infrastructure. By fostering collaboration across regions, Interreg helps implement integrated climate action strategies and promotes innovative solutions for sustainability.	Climate mitigation & adaptation	R&D funding and programmes ; promotion of innovative technologies	Multiple sectors	N	European authority	European Commission	2021
EU	European Union	LIFE program.	The LIFE program directly supports environmental and climate action initiatives, including projects that address climate change mitigation and adaptation. It funds efforts to protect biodiversity, reduce greenhouse gas emissions, and implement innovative solutions for environmental sustainability. LIFE projects are integral to achieving the EU Green Deal's climate targets and enhancing the EU's overall environmental resilience.	Climate mitigation & adaptation	R&D funding and programmes ; promotion of innovative technologies	Multiple sectors	N	European authority	European Commission	2021
EU	European Union	The European Investment Bank Climate Bank Roadmap	The EIB Climate Bank Roadmap outlines the bank's strategic commitment to climate action. It includes plans to align its operations with the goals of the Paris Agreement, aiming to support up to €1 trillion of investments in climate action and environmental sustainability by 2030. The roadmap focuses on	Climate mitigation & adaptation	Economic and fiscal instruments	Multiple sectors	N	European authority	European Investment Bank	2021

			increasing financing for projects that mitigate climate change, enhance climate resilience, and support the transition to a low-carbon economy.							
EU	European Union	European Agricultural Fund for Rural Development (EAFRD)	The EAFRD contributes to climate goals by funding projects that promote sustainable agricultural practices, improve land management, and enhance rural environmental stewardship. It supports measures such as soil conservation, water management, and biodiversity preservation, all of which help mitigate climate change and adapt rural areas to its impacts.	Climate mitigation & adaptation	Multiple instruments / Framework policy	Agriculture, Fisheries and Rural Development	N	European authority	European Commission	2021
EU	European Union	European Maritime, Fisheries and Aquaculture Fund (FEMPA)	The EMFAF supports sustainable practices in the maritime, fisheries, and aquaculture sectors. It funds initiatives that promote the conservation of marine ecosystems, enhance resource efficiency, and support the transition to sustainable fisheries and aquaculture. These efforts are crucial for mitigating the impacts of climate change on marine environments and ensuring the resilience of coastal and marine economies.	Climate mitigation & adaptation	Multiple instruments / Framework policy	Agriculture, Fisheries and Rural Development	N	European authority	European Commission	2021
GR	National	LIFE program - Title of the project ??	To reach at least 60% share of renewable energy sources (RES) in gross final electricity consumption, in line with the National Energy and Climate Plan (NECP).	Climate mitigation	R&D funding and programmes; promotion of innovative technologies	Energy supply and consumption	N	National government	Independent Electricity Transmission System Operator; Hellenic Electricity Distribution Network Operator; Regulatory Authority for Energy; Ministry of Environment and Energy	1994

GR	National	Replacement of passenger vehicles and commercial fleets with new low emissions and high energy efficiency models	This measure is mentioned in both the National Energy and Climate Plan (NECP) and the National Strategic Transport Plan (NSTP). More information can be found in the EPEDAR.	Climate mitigation	Direct investment in assets and physical infraestructure	Transport and mobility	N	National government	Ministry of Finance; Ministry of Environment and Energy; Ministry of Infrastructure and Transport	2020
GR	National	Improving railroad infrastructure and completion of train electrification	Measures related to the expansion and promotion of electrification in rail transport included in the NSTP.	Climate mitigation	Direct investment in assets and physical infraestructure	Transport and mobility	N	National government	Ministry of Infrastructure and Transport	2020
GR	National	Operation of desulphurisation units in Hellenic Public Power Corporation lignite plants	Operation of desulfurization units in lignite-fired power plants of the Public Power Corporation (PPC).	Climate mitigation	R&D funding and programmes; promotion of innovative technologies	Energy supply and consumption	N	National government	Hellenic Public Power Corporation	2005
GR	National	Need for vehicles to comply with EURO 6.3 emissions standard	Since January 2021, by decision of the European Union, new vehicles being introduced into circulation should comply with the Euro 6.3 emissions standard, which mandates even lower pollutant gas emissions.	Climate mitigation	Regulatory instruments	Transport and mobility	Y	National government	Ministry of Infrastructure and Transport	2021
GR	National	Implementation of the Directive 94/63/EC on the control of volatile organic compound (VOC) emissions resulting from the storage of petrol and its distribution from terminals to service stations and the Directive 2009/126/EC on Stage II petrol vapour recovery during refuelling of motor vehicles at service stations	Directive 94/63/EC provides for the control of emissions of volatile organic compounds (VOCs) arising from the storage of petrol and its distribution from terminals to service stations, establishing requirements to prevent evaporation losses during loading, unloading, storage, and transportation processes. Directive 2009/126/EC, concerning the recovery of petrol vapors during the refueling of motor vehicles at service stations, mandates a minimum recovery rate of 85% by systems installed in both old and new stations. These directives have been incorporated into national legislation through Joint Ministerial Decisions No. 10245/713 (B'311) and No. 21523/763 (B'1439), respectively.	Climate mitigation	Regulatory instruments	Energy supply and consumption	Y	National government	Ministry of Transport and Infrastructure; Ministry of Environment and Energy	1997

GR	National	Implementation of the Directive 2010/75/EU on industrial emissions (integrated pollution prevention and control)	Directive 2010/75/EU, which was harmonized with Joint Ministerial Decision No. 36060/1155/E.103/13.6.2013 (B' 1450), establishes rules to prevent and, where that is not possible, reduce emissions into the air, water, and soil, as well as to prevent the generation of waste, in order to achieve a high level of environmental protection as a whole. It applies to the industrial activities mentioned in Chapters II to VI, such as energy industries, the production and processing of metals, the mineral products industry, the chemical industry, and waste management.	Climate mitigation	Regulatory instruments	Industry	Y	National government	Ministry of Environment and Energy	2014
GR	National	Limitation of sulfur content in fuels (shipping)	According to Ministerial Decision No. 128/2016 (Government Gazette B' 3958), there is a provision for reducing the sulfur content in maritime fuels. From June 18, 2014, the sulfur content must be less than 3.5%, and from January 1, 2020, it must be less than 0.5%. For ships at berth, the sulfur content must be less than 0.1%.	Climate mitigation	Regulatory instruments	Transport and mobility	N	National government	Independent Authority for Public Revenue, Directorate of Energy, Industrial, and Chemical Products	2020
GR	National	Implementation of the Common Agricultural Policy	The institutional framework of the Common Agricultural Policy refers to climate change and environmental protection both in the direct payments regime (Regulation (EU) No 1307/2013), primarily through the establishment of obligations for implementing environmentally and climate beneficial agricultural practices (greening), and in the support regime for Rural Development (Regulation (EU) No 1305/2013), by introducing Priority 5, which promotes resource efficiency and supports the transition to a low-carbon economy resilient to climate change in the sectors of food agriculture and forestry. This framework also includes the analysis of individual measures.	Climate mitigation	Regulatory instruments	Agriculture	Y	National government	Ministry of Rural Development and Food	2015
GR	National	Implementation of Common Agricultural Policy (EE) 1306/2013, 604/2014 and 809/2014.	The multiple compliance (Ministerial Decision No. 1791/74062/2.7.2015) describes the obligations of producers regarding the application and management of fertilizers and the management of livestock waste. For more information, please refer to the EPEDAR.	Climate mitigation	Regulatory instruments	Agriculture	Y	National government	Ministry of Rural Development and Food	2015

GR	National	Implementation of the Directive 2004/42/CE on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain paints and varnishes and vehicle refinishing products and amending Directive 1999/13/EC	Directive 2004/42/EC, harmonized with Ministerial Decision No. 437/2005/24.10.2006 (Government Gazette B' 1641), for the first-time imposed restrictions on the composition, i.e., qualitative specifications, of products for wide consumption such as paints, varnishes, and vehicle refinishing products, aiming to achieve environmental objectives.	Climate mitigation	Regulatory instruments	Industry	Y	National government		2007
GR	National	Increase the proportion of natural gas usage in industry and in domestic-tertiary sector	The primary objective is to achieve greater involvement of natural gas across all sectors of final consumption, essentially aiming to replace a portion of current petroleum product consumption in these areas. Developing the necessary infrastructure for transportation and distribution is essential to enable greater access to natural gas for final consumers in the building sector. Additionally, increasing its use in industry and transportation are priorities for the upcoming period. A quantitative target for this priority is to increase direct use of natural gas in final consumption sectors by at least 50% compared to 2017 levels.	Climate mitigation	Regulatory instruments	Industry	N	National government		1996
GR	National	Promotion of alternative fuels and liquified gas in transport sector (automobiles, shipping)	In the National Energy and Climate Plan (NECP), measures are proposed to promote electrification in road transport, the use of natural gas either as Compressed Natural Gas (CNG) for passenger and light vehicles (especially within urban areas), or as Liquefied Natural Gas (LNG) for heavy vehicles (especially on national roads). Similar efforts are being made to promote alternative fuels, including the utilization of biomethane (either as a replacement or blend with natural gas), hydrogen use, and the development of sustainable urban mobility plans. For further information, please refer to the NECP.	Climate mitigation	Direct investment in assets and physical infraestructure	Transport and mobility	N	National government		2020

GR	National	Implementation of EU Directives	Implementation of European Directives 2015/2193/EU on the limitation of emissions of certain pollutants into the air from medium combustion plants, 2010/75/EU on industrial emissions (integrated pollution prevention and control), 2017/1442/EU on establishing best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council, for large combustion plants	Climate mitigation	Regulatory instruments	Industry	Y	National government		2013
GR	National	Improving energy efficiency	Improvement of energy efficiency of conventional electricity generation units and decommissioning of old units - Decommissioning of lignite-fired electricity generation units (by the year 2028) - Interconnection of autonomous island systems (and in cases where interconnection of small and remote electricity systems is not technically and economically feasible, innovative energy applications will be implemented within these systems as part of hybrid system development and policies for "smart" islands) - Promotion of natural gas as an intermediate fuel for decarbonizing the energy system. For more information, refer to chapters 2.5 and 3.5 of the ESEK and to EPEAR.	Climate adaptation	Multiple instruments / Framework policy	Energy supply and consumption	N	National government		1996
GR	National	Implementation of the Council Directive 1999/31/EC on the landfill of waste	The necessity to reduce the quantities of biodegradable waste entering landfills is recognized by Ministerial Decision No. 29407/3508/2002 (Government Gazette B'1572), in accordance with Directive 1999/31/EC. Additionally, Directive (EU) 2018/850 amending Directive 1999/31/EC on the landfilling of waste sets a target for only 10% of municipal solid waste produced to be landfilled by 2035. The National Waste Management Plan (NSMP) was approved on August 31, 2020.	Climate mitigation	Regulatory instruments	Waste and Water management	Y	National government		2002
GR	National	Electrification of ships during their mooring	Commission Recommendation of 8 May 2006 on the promotion of shore-side electricity for ships at berth in ports of the Community L/15238/12.05.2006. More information is available in the EPEAR.	Climate mitigation	Direct investment in assets and physical infraestructure	Transport and mobility	Y	National government		2025

GR	National	Rural Development Programme	The program focuses on enhancing the sustainability and competitiveness of agricultural enterprises, conserving and strengthening ecosystems, and promoting local development in rural areas by aiming to: • Increase organic farming. • Reduce the use of synthetic nitrogen fertilizers. • Implement environmentally friendly livestock farming methods and improve management of animal waste. • Enhance energy efficiency, production, and use of renewable energy, including biomass. • Improve soil management (maintaining agricultural activities in mountainous areas, green cover, and permanent grasslands), and increase carbon sequestration.	Climate adaptation	Multiple instruments / Framework policy	Agriculture and Rural Development	N	National government		2015
GR	National	Improving energy efficiency	In the context of energy efficiency dimension, the National Plan for Energy and Climate (ΕΣΕΚ) sets targets for improving energy efficiency in final energy consumption. Additionally, there is a target regarding the cumulative energy savings achieved during the period 2021-2030 in accordance with Article 7 of Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 (L 315/1), concerning energy efficiency obligations. Furthermore, there is a target for annual energy renovation of the total area of the thermal zone of buildings in the central public administration. For more detailed information, please refer to ΕΠΕΑΡ.	Climate adaptation	Regulatory instruments	Energy supply and consumption	Y	National government		2008
GR	National	Improving the inspection procedures for vehicle"s emissions	All vehicles are required on an annual basis to undergo emission testing, and subsequently receive an emissions control card from ΚΤΕΟ (Vehicle Technical Inspection Centers) or certified vehicle repair shops. This measure will be reviewed and refined within the framework of developing the Operational Plan for Combating Atmospheric Pollution in Athens.	Climate mitigation	Regulatory instruments	Transport and mobility	N	National government		2020

GR	National	Electromobility	According to the National Energy and Climate Plan (Ministry of Environment and Energy, December 2019), specific measures will be adopted to encourage the penetration of electromobility. Law No. 4710/2020 (Government Gazette A'142) "Promotion of Electromobility and other provisions" includes specific measures to encourage the penetration of electromobility. The penetration of alternative fuels and electric energy in transport, the rapid reduction of unit energy consumption per vehicle type, the penetration of second-generation biofuels, full electrification of railway infrastructure, and increased participation of rail transport in freight transport will completely transform the technological structure and fuel mix in the transport sector by the end of the next decade. More information is available at EPEAR.	Climate adaptation	Multiple instruments / Framework policy	Transport and mobility	N	National government		2020
GR	National	European Union Emissions Trading System	The SEED restricts emissions from energy-consuming installations (power plants and industrial facilities) and airlines operating flights between EU countries. It covers approximately 45% of greenhouse gas emissions in the EU. More information is available in the National Air Pollution Control Program.	Climate mitigation	Economic and fiscal instruments	Energy supply and consumption	Y	National government		2005
GR	National	Traffic management measures	The measure of the "green belt," implemented since 1980, will be reassessed within the framework of the project "Operational Plan for Combating Atmospheric Pollution in Athens." This includes the issuance of Technical Guidelines for creating temporary pedestrian paths, temporary bicycle lanes, and the temporary creation of areas or roads with reduced speed limits to 30 km/h on local roads or residential areas, as outlined in the approval document YPEN/DMEAAP/57298/225. The ongoing Sustainable Urban Mobility Plans (SUMP) of municipalities, along with their remaining planning efforts for the redevelopment of public spaces within their administrative boundaries, are expected to lead to a reassessment of the hierarchy of urban roads and the categorization of the road network. This step follows research on the environmental resilience of urban areas, particularly at the level of the city's	Climate adaptation	Multiple instruments / Framework policy	Transport and mobility	N	National government		2012

			arterial road network. For more information, refer to ΕΠΕΑΡ.							
GR	National	Promotion and further improvement of public transportation	Based on the scheduled projects for the expansion of the metro in Athens, the operation of the Thessaloniki metro (https://www.ametro.gr/?page id=269), the extension of the suburban railway, as well as the improvement of railway transportation, according to the references in the National Strategic Transport Plan, a shift towards the use of Mass Transit Systems is expected, accompanied by a corresponding reduction in emissions from road transport. Additionally, the renewal of the bus fleet with low-emission vehicles and/or alternative fuels will further reduce pollution emissions.	Climate mitigation	Direct investment in assets and physical infraestructu re	Transport and mobility	N	National government		2020
GR	National	Reduction of lignite mining for power production	Reduction of lignite mining for power production	Climate mitigation	R&D funding and programmes ; promotion of innovative technologies	Energy supply and consumption	N	National government		2008
GR	National	Restriction of sulphur content in fuels (fixed combustion fireplaces)	According to Ministerial Decision No. 128/2016 (Government Gazette B' 3958), which incorporates Directive 2016/802/EU, the use of heavy fuel oil with a sulfur content exceeding 1.00% by mass is prohibited. Additionally, the use of gasoil (diesel) with a sulfur content exceeding 0.10% by mass is also prohibited.	Climate mitigation	Regulatory instruments	Multiple sectors	Y	National government		2003

GR	National	Implementation of the Council Directive 1999/13/EC on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain activities and installations	The Directive 1999/13/EC, which was harmonized with Ministerial Decision No. 11641/1942/26.6.2002 (Government Gazette B' 832), aimed to limit emissions of volatile organic compounds resulting from the use of organic solvents in activities such as solvent consumption for coatings, dry cleaning activities, shoe manufacturing and processing, pharmaceutical production, printing, vehicle refinishing, wood processing, and others as described in Annex 1 of the directive. Directive 1999/13/EC was repealed by Directive 2010/75/EU as of January 7, 2014.	Climate mitigation	Regulatory instruments	Industry	Y	National government		2001
GR	National	Implementation of CO2 emission ceilings for automobile manufactures	On April 17, 2019, the European Parliament and the European Council adopted Regulation (EU) 2019/631 (L 111/13), which sets CO2 emission standards for new passenger cars and light commercial vehicles (vans) in the EU after 2020. Starting from January 1, 2020, the emission limit of 95 g/km will apply to 95% of each manufacturer's fleet with the lowest emissions. From 2021 onwards, the average emissions of all new vehicles from a manufacturer must be below the 95 g/km threshold. For more detailed information, you can visit the European Commission's webpage on vehicle emissions policies at https://ec.europa.eu/clima/policies/transport/vehicles/cars_en.	Climate mitigation	Regulatory instruments	Transport and mobility	Y	National government		2020
ES	National	National Climate Change Adaptation Plan (PNACC) (2021-2030)	It promotes coordinated action with the aim of addressing the climate change impacts in Spain. It aims at avoiding and reducing the present or future damage caused by climate change.	Climate adaptation	Multiple instruments / Framework policy	Multiple sectors	N	National government	Ministry for the Ecological Transition and the Demographic Challenge	2021
ES	National	Climate Law (Law 7/2021)	It aims to ensure compliance with the objectives in the Paris Agreement, facilitate the decarbonisation of the Spanish economy, promote climate adaptation and to implement a sustainable development model that generates good employment and reduces inequalities.	Climate adaptation	Regulatory instruments	Multiple sectors	N	National government	General Courts	2021

ES	Regional	Catalan Strategy for Adapting to Climate Change (ESCACC) (2021-2030)	It is a planning element of the climate adaptation policies, which serve as the basis for the sectorial action plans developed by the different departments of the Generalitat. It aims at improving adaptation to climate change in Catalonia.	Climate adaptation	Regulatory instruments	Multiple sectors	N	Regional government	Government of Catalonia	2021
ES	National	Coastal Law (Law 2/2013)	This law is aimed at seeking a balance between the environmental protection of the Spanish Coastline with sustainable economic development. It also amends law 22/1988 on Coasts. Some of the amendments made include: the redefinition of the maritime-terrestrial public domain, new demarcation provisions that favour a regime of economic revaluation, a temporary extension of the concessions granted under the previous regulations and the modification of easements to preserve the martime-terrestrial public domain.	Climate mitigation & adaptation	Regulatory instruments	Multiple sectors	N	National government	Spanish government, Maritime Terrestrial Public Domain	2019
ES	National	Strategy for Adaptation to Climate Change on the Spanish Coast	Its main goals are to increase resilience of the Spanish Coast to climate change and to integrate adaptation to climate change in the planning and management of the Spanish Coast.	Climate adaptation	Regulatory instruments	Multiple sectors	N	National government	Ministry of Agriculture and Fisheries, Food and Environment	2016
ES	National	Committee of Experts on Climate Change and Energy Transition	It is a committee responsible for evaluating and making recommendations about policies and measures related to climate change and energy transition.	Climate mitigation	Informational, non-mandatory instruments	Energy supply and consumption	N	National government	Ministry for the Ecological Transition and the Demographic Challenge	2022
ES	National	Citizens' Climate Change Assembly (in Spain)	It gathers Spanish citizens in order to provide information and debate about topics regarding climate change. Its main objectives are to propose recommendations and solutions in order to address climate change issues.	Climate mitigation	Informational, non-mandatory instruments	Multiple sectors	N	National government	Spanish government, Ministry for the Ecological Transition and the Demographic Challenge	2021
ES	Regional	Citizens' Climate Change Assembly (in Catalonia)	It is composed of between 100 and 150 citizens which represent the Catalan population, and aims at encouraging citizen debate on areas related to climate change such as energy, mobility or water	Climate mitigation	Informational, non-mandatory instruments	Multiple sectors	N	Regional government	Government of Catalonia	2023

			resources. It enables to make the development of environmental policy more participatory and democratic.							
ES	Regional	Climate fund	It is a public fund created by Law 16/2017 on climate change which supports the implementation of policies and actions related to climate change mitigation and adaptation.	Climate mitigation	Economic and fiscal instruments	Multiple sectors	N	Regional government	Government of Catalonia	2017
ES	National	Third Cycle Hydrological Plans	It is aimed at modernizing the water management during the period 2022-2027. This version also takes into account and incorporates climate change scenarios, and forecasts the possibility of water scarcity due to climate change. Large investments are expected to be made with this plan on different areas such as the construction of infrastructure, sanitation and treatment of water, water supply improvements or flood risk management.	Climate mitigation & adaptation	Regulatory instruments	Waste and Water management	N	National government	Ministry for the Ecological Transition and the Demographic Challenge	
ES	National	Just Transition Strategy	It is a strategy aimed at ensuring that people and territories take advantage of the opportunities that arise from the ecological transition in an egalitarian way, without leaving anyone behind. It provides and regulates aid for coal mine closures, and for exceptional costs and to boost mining areas.	Climate mitigation	Regulatory instruments	Energy supply and consumption	N	National government	Ministry for the Ecological Transition and the Demographic Challenge	2020
ES	National	Spanish Science, Technology and Innovation Strategy 2021-2027	It is an instrument that seeks to ensure coordination of the scientific and technical research and innovation policies of the State and the Autonomous Communities. It also coordinates the policies with the EU's Horizon Europe science and innovation framework programme for the period 2021-2027. One of its strategic lines is for climate, energy and mobility.	Climate mitigation & adaptation	Regulatory instruments	Multiple sectors	Y	National government	Ministry of Science, Innovation and Universities	2021
ES	National	Environmental Impulse Plan for Adaptation to Climate Change (PIMA)	It is a tool that implements a set of measures aimed at adapting to climate change and improving environmental conditions. At the same time, these measures have a positive effect on economic development and promote employment.	Climate adaptation	Regulatory instruments	Multiple sectors	N	National government	Ministry for the Ecological Transition and the Demographic Challenge	2015
ES	Regional	Law 16/2017 on Climate Change	It establishes measures to address climate change and to promote sustainability. Its main objectives are to reduce greenhouse gas emmissions and to	Climate mitigation	Regulatory instruments	Multiple sectors	N	Regional government	Government of Spain,	2017

			promote the transition to a neutral-emission economy.						Government of Catalonia	
ES	Regional	Consortium for the development of Baix Ebre and Montsià regions	It addresses climate change and promotes sustainable socioeconomic development in the area of the Ebro Delta. Its main objective is promoting economic activity and improving quality of life in rural areas, through strategies that promote economic diversification and innovation.	Climate mitigation & adaptation	Multiple instruments / Framework policy	Agriculture and Rural Development	N	Regional government	Baix Ebre County Council	2016
DE	National	German Strategy for Adaptation to Climate Change	It is a strategy aimed at preparing for the effects of climate change and at reducing climate risks. It was initially implemented in 2008, and updated in 2015 and 2020. In this last update, there were action plans designed for the period 2020-2024 which include different themes such as water, infrastructure, land, health, economy and cross-cutting actions.	Climate adaptation	Multiple instruments / Framework policy	Multiple sectors	N	National government	German Federal government, Federal Environment Industry, German Environment Agency	2008
DE	National	Urban Development Support Programme	It is a funding programme for activities that have a positive impact on municipalities and that foster urban development. The funding is spread across three programmes: social cohesion, vibrant centres, and growth and sustainable urban renewal.	Climate mitigation & adaptation	Economic and fiscal instruments	Multiple sectors	N	National government	German government	2018
DE	National	Federal Action Plan on Nature-based Solutions for Climate and Biodiversity	It aims to preserve and strengthen the general conditions of ecosystems in Germany that have been affected by climate change. It does so by applying a range of nature-based solutions that support biodiversity conservation and climate action at the same time.	Climate mitigation	Multiple instruments / Framework policy	Multiple sectors	N	National government	German Federal government, Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection	2022
DE	National	German Climate Preparedness Portal (KLiVO)	The KLiVO Portal collects data regarding climate change and offers services that consist of providing guidance about precautionary measures that can be taken against the effects of climate change. Therefore, it provides climate-related information and climate adaptation services.	Climate adaptation	Informational, non-mandatory instruments	Multiple sectors	N	National government	German Federal government	2018

DE	Regional	Berlin Energy and Climate Protection Programme (BEK 2030)	It contains strategies and measures for climate adaptation and mitigation in different fields for the city of Berlin, which include urban development, industry, energy supply or buildings, among others. One of its main objectives the reduction of GHG emissions by 70% in 2030 compared to 1990 and to achieve climate neutrality by 2045.	Climate mitigation	Regulatory instruments	Multiple sectors	N	Regional government	Senate Department for Urban Mobility, Transport, Climate Action and the Environment	2018
DE	Regional	Berlin Climate Protection and Energy Transition Act (EWG BIn)	It sets the legal framework for the different actions that want to be implemented in the State of Berlin related with climate protection. Its purpose is to set climate protection targets, such as reducing GHG emissions, and implementing instruments in order to achieve them. The law also contains binding regulations on climate adaptation and protection. In 2021, an amendment was made in order to increase the climate protection targets that were initially set	Climate mitigation	Regulatory instruments	Multiple sectors	N	Regional government	Senate Department for Urban Mobility, Transport, Climate Action and the Environment	2016
DE	Regional	Berlin Programme for Sustainable Development (BENE)	It provides funding for projects and initiatives that contribute to climate neutrality in the state of Berlin and it is financed by the European Regional Development Fund (ERDF). More recently, in 2023, a second phase of this programme has been aproved, with the name of Berlin Programme for Sustainable Development II (BENE II). Its aim is to support the reduction of CO2 emissions and to achieve climate neutrality by 2045.	Climate mitigation	R&D funding and programmes ; promotion of innovative technologies	Energy supply and consumption	N	Regional government	Senate Department for Urban Mobility, Transport, Climate Action and the Environment	2023
DE	National	Urban Development Plan for Climate 2.0 (StEP Klima)	It describes the spatial and urban planning of the city of Berlin in order to achieve the objective of climate neutrality by 2045. It is the version 2.0, as it updates the initial version which was originally made in 2011. Its main focuses include adapting new and existing buildings and infrastructures to better handle climate impacts, sustainable urban growth and heat and water management.	Climate adaptation	Direct investment in assets and physical infraestructu re	Multiple sectors	N	Regional government	Senate Department for Urban Developmen t, Building and Housing	2022
DE	Regional	Master Plan on Water in Berlin	It is a strategic initiative implemented in the city of Berlin with the aim of ensuring a sustainable water management, while also ensuring it is resilient to issues such as climate change, population growth or structural changes in the region. Some key goals are to provide safe drinking water supply, improved	Climate mitigation	Regulatory instruments	Waste and Water managemen t	N	Regional government	Senate Department for Mobility, Transport, Climate Protection	2022

			water protection and the expansion and modernization of wastewater disposal.						and the Environment	
DE	National	Implementation of the EU Taxonomy Complementary Climate Delegated Act	The EU Taxonomy Complementary Climate Delegated Act was implemented in order to guide private investment towards activities contributing to climate adaptation and mitigation. It therefore establishes screening criteria to determine the contribution of economic activities to climate mitigation and adaptation.	Climate mitigation	Economic and fiscal instruments	Multiple sectors	Y	National government	European Commission	2022
NL	National	Delta Programme	It is an initiative that has the objective of protecting the Netherlands from flooding and high water while also ensuring a sustainable supply of water and a climate-resilient and water-robust planning for the country. The main focuses of the programme are on flood safety, freshwater management and spatial planning.	Climate adaptation	Multiple instruments / Framework policy	Waste and Water management	N	National government	Dutch government, Ministry of Infrastructure and Water Management	2012
NL	National	Environment and Planning Act	It regulates the environment in which people live and develop their day-to-day activities, and it combines several rules and regulations on different topics such as spatial planning, housing, nature, infrastructure, the environment and water.	Climate mitigation & adaptation	Regulatory instruments	Multiple sectors	N	National government	Ministry of Housing and Spatial Planning	2024
NL	National	Water Act	It is a regulatory Act for water management in the Netherlands, and addresses issues such as flooding that have arised in the country due to climate change.	Climate mitigation & adaptation	Regulatory instruments	Waste and Water management	N	National government	Ministry of Transport, Public Works and Water Management	2010
NL	National	National Climate Adaptation Strategy (NAS)	It addresses climate change impacts, and was implemented due to the requirement from the European Commission to all member states of introducing adaptation strategies before 2017. The strategy identifies the main climate risks in the Netherlands and proposes measures to minimize or adapt to them. A new version of this strategy is planned for 2026.	Climate adaptation	Multiple instruments / Framework policy	Multiple sectors	Y	National government	Dutch government, Ministry of Infrastructure and Water Management	2016

NL	Regional	Provincial Climate Adaptation Strategy (KasZ)	It is a set of strategies implemented by the different provinces that will enable the Netherlands to achieve their main objective of being climate-proof and water resilient by 2050. The specific province relevant for the demo-site in the Netherlands is Zeeland, and the main purposes of the provinces are regarding spatial planning.	Climate adaptation	Multiple instruments / Framework policy	Multiple sectors	N	Regional government	Provincial government of Zeeland	2021
NL	National	Delta Plan for Spatial Adaptation	It describes all the measures that will be implemented to achieve the goal of being climate-proof and water resilient by 2050. It takes into account the strategies for municipal and provincial authorities, as well as for water authorities and the national government and the coordination between all these actors. The measures implemented are in order to combat urban flooding, heat stress, drought or waterlogging.	Climate adaptation	Multiple instruments / Framework policy	Multiple sectors	N	National government	Dutch government	2015
NL	Regional	Covenant Climate Adaptation Strategy Zeeland	It is the strategy for climate adaptation that has been specifically designed for the climate risks observed in the province of Zeeland, which consist of water nuisance, heat, droughts and coastal flooding. It promotes the collaboration between different partners from the region such as municipalities, the water board and the province to jointly carry out several actions.	Climate adaptation	Multiple instruments / Framework policy	Multiple sectors	Y	Regional government		2021
NL	National	Climate Act	It sets targets for the reduction of GHG emissions in the Netherlands, also according to international agreements such as the Paris Agreement. One of its main goals is to achieve carbon neutrality by 2050, and the act defines the measures and policies across different sectors in order to achieve these targets.	Climate mitigation	Regulatory instruments	Energy supply and consumption	Y	National government	Dutch government	2019
NL	National	National Climate Agreement	It defines the different set of actions and measures in different sectors that will enable to achieve the national targets of reducing GHG emissions in the Netherlands, as well as the targets set at a European level.	Climate mitigation	Regulatory instruments	Energy supply and consumption	Y	National government	Dutch government	2019
NL	National	Integrated National Energy and Climate Plan for 2021-2030 (NECP)	It contains the main priorities for energy and climate policy for the period 2021-2030 and defines the set of measures that will allow to achieve the target of 49% of CO2 reduction by 2030. It also contains policies arising from European obligations.	Climate mitigation	Regulatory instruments	Energy supply and consumption	Y	National government	Ministry of Economic Affairs and Climate Policy	2021

NO	National	Green Alliance	Norway has aligned its climate policies to the EU Green Deal, despite not being in the EU, with the purpose of enhancing cooperation on issues regarding climate, environment, energy and clean industry. The EU Green Deal has the main objective of achieving climate neutrality in the EU by 2050.	Climate mitigation	Regulatory instruments	Multiple sectors	N	National government	European Commission , Government of Norway	2023
NO	National	Climate Action Plan for 2021-2030	It is a plan that was implemented with the aim of meeting different climate targets set in the Paris Agreement and promoting green growth, as well as partnering with the EU in order to align Norway's policies with the EU Green Deal. It also includes the target of becoming climate neutral by 2030, and the measures implemented in different sectors to achieve this target.	Climate mitigation	Regulatory instruments	Multiple sectors	N	National government	Government of Norway, Ministry of Climate and Environmen	2021
NO	National	National Planning and Building Act (PBA)	The Act promotes sustainable development across the country, and it facilitates the coordination between the central government, regional and municipal authorities.	Climate mitigation & adaptation	Regulatory instruments	Multiple sectors	N	National government	Ministry of Local Government and Regional Developmen t	2008
NO	Regional	Regional Planning Strategy (RPS) for Troms and Finnmark 2021-2024	In this strategy, the County council determines long-term goals for development in the region and the thematic plans that are to be developed in the future. The key areas of the startegy are: sustainable development, economic growth, infrastructure, and cultural and social development.	Climate mitigation & adaptation	Multiple instruments / Framework policy	Multiple sectors	N	Regional government	Troms and Finmark County Council	2021
NO	Regional	Climate, Environment and Energy Plan 2018-2025	It sets targets and initiatives related with the reduction of GHG emissions and the promotion of sustainable energy practices. Its main objectives are to reduce greenhouse gas emissions in Tromsø by 50% by 2025 and 85% by 2030 and to achieve sustainable urban growth. While it mainly focuses on mitigation, there is a section on climate adaptation that quanitifies the benefits of the measures in terms of financial saving on potential damages.	Climate mitigation	Regulatory instruments	Multiple sectors	N	Regional government	Tromsø municipality	2018
NO	Regional	Municipal Sub-Plan for Water and Sewage 2021-2023	It indicates the set of strategies and measures for managing water and sewage systems in Tromsø, and highlights topics regarding sustainability, efficiency in the use of water resources and climate change adaptation.	Climate adaptation	Regulatory instruments	Waste and Water managemen t	N	Regional government	Tromsø municipality, Section for Water and Sewage	2021

NO	Regional	Municipal Sub-Plan for Surface Water 2019-2032	Its purpose is to manage surface water in Tromsø, and the issues it addresses include increased rainfall, higher frequency and intensity of storms, longer snowmelt periods and flooding from streams.	Climate mitigation & adaptation	Regulatory instruments	Waste and Water management	N	Regional government	Tromsø municipality	2019
NO	Regional	2022-2033 National Transport Plan - Urban Growth Agreement	The National Transport Plan has the goal of achieving a 50% reduction of emissions from the transport sector by 2030 and it includes an Urban Growth Agreement in Tromsø. The main objective of the agreement is to reduce GHG emissions, congestion, air pollution and noise in the city. The plan also includes investment in public transport, cycling and walking infrastructure, and the government covers part of these investments.	Climate mitigation	Regulatory instruments	Transport and mobility	N	Regional government	Tromsø municipality, Ministry of Transport	2022
NO	National	Creation of the Directorate for civil protection and emergency planning	It is a government agency with the role of maintaining an overview of the risks and vulnerabilities in the society. Some of its main responsibilities include ensuring emergency preparedness and planning, fire and electrical safety or product and consumer safety.	Climate mitigation	Other	Multiple sectors	N	National government	Ministry of Justice and Public Security	XXXX
NO	National	Norwegian Water Resources and Energy Directorate (NVE)	It is a directorate under the Norwegian Ministry of Energy and has the purpose of managing the water and energy resources in Norway. They reduce the risks associated with landslides and flooding, and ensure that the energy and water systems are efficient. It is mentioned in the D1.3 deliverable report that this directorate provides funding for climate adaptation, more specifically, it is mentioned that municipalites can apply for up to 80% funding for measures to secure buildings from flooding or landslides.	Climate adaptation	R&D funding and programmes ; promotion of innovative technologies	Multiple sectors	N	National government	Ministry of Petroleum and Energy	1921
NO	National	Norwegian Environment Agency (MD)	It is under the Ministry of Climate and Environment and the main goals of the Agency are to reduce GHG emissions, manage Norwegian nature and reduce and prevent pollution. Some of its actions include communicating environmental information and proposing climate and environmental policies. It is mentioned in the IMPETUS deliverable report D1.3 that municipalities can receive funding from this agency for projects aimed at increasing knowledge about climate change and the need for climate adaptation.	Climate mitigation	Informational, non-mandatory instruments	Multiple sectors	N	National government	Ministry of Climate and Environment	2013

LV	National	National Climate Change Adaptation Strategy until 2030	It describes Latvia's climate adaptation strategy in terms of the different measures and regulations that will be implemented, and the current situation regarding the different climate change impacts that have occurred in the country. These impacts are mainly related with air temperature, precipitation, sea and river levels, wind speed, or extreme weather.	Climate adaptation	Regulatory instruments	Multiple sectors	Y	National government	Ministry of Environmental Protection and Regional Development	2016
LV	National	National Plan for Adaptation to Climate Change until 2030	It describes the climate change impacts that have been observed in Latvia and proposes a set of measures for adaptation to these climate changes. The adaptation measures are focused on different areas: landscape planning and tourism, biodiversity and ecosystem services, civil protection and disaster management, building and infrastructure planning, health and welfare, agriculture and forestry. Its main objective is to reduce the vulnerabilities associated with climate change impacts.	Climate adaptation	Regulatory instruments	Multiple sectors	Y	National government	Ministry of Environmental Protection and Regional Development	2019
LV	National	Climate Change Adaptation Expert Working Group		Climate adaptation	Informational, non-mandatory instruments		N			
LV	National	Inter-institutional Working Group on Adaptation to Climate Change		Climate adaptation	Informational, non-mandatory instruments		N			
LV	National	National Energy and Climate Plan 2021-2030	It defines Latvia's strategy to address issues related to climate change and energy. It sets targets and measures in different sectors, such as the reduction of GHG emissions, the increase of the share of renewable energy sources or the improvement of energy efficiency.	Climate mitigation	Regulatory instruments	Energy supply and consumption	Y	National government	Latvian Government, Ministry of Economics	2021
LV	Regional	Sustainable Development Strategy for 2015-2030	It is implemented in the Zemgale planning region, and focuses on 4 different areas: bioeconomy and agriculture, management of natural resources, manufacturing and tourism. It defines the strategy for long term development of the economic sectors in the region, which is aimed at achieving an efficient and sustainable resource exploitation, and increasing innovation and competitiveness.	Climate mitigation	Regulatory instruments	Multiple sectors	N	Regional government	Zemgale Planning Region	2015

LV	Regional	Zemgale Planning Region Development Programme 2021-2027	It is a programme implemented in the Zemgale planning region, with the objectives of promoting sustainable economic development and limiting climate change by ensuring a rational use and management of energy resources. It also has other objectives in other areas, such as ensuring a high-quality education for citizens, promoting innovation and competitiveness, and developing energy-efficient mobility and infrastructure. In this plan, climate change is mentioned as one of the development priorities.	Climate mitigation	Regulatory instruments	Multiple sectors	N	Regional government	Zemgale Planning Region	2021
LV	Local	Sustainable Energy and Climate Action Plans	Some municipalities in the Zemgale region have developed these plans, with the objective of reducing GHG emissions in order to achieve the goal of 20% CO2 reduction. They define climate change risks faced by the municipalities and the different measures implemented to minimize or adapt to these risks.	Climate mitigation & adaptation	Multiple instruments / Framework policy		N	Local government		
IT	National	Italian National Climate Change Adaptation Strategy (SNACC)	It explains the climate change impacts observed in Italy, some of which concern water management and extreme weather, and how they impact different sectors such as agriculture and tourism. It provides this information in order to identify the national adaptation actions that must be implemented. The strategy focuses specifically on Alpine and Appenine regions, as they are considered to be very vulnerable to climate change. https://www.mase.gov.it/sites/default/files/archivio/allegati/clima/documento_SNAC.pdf	Climate adaptation	Regulatory instruments	Multiple sectors	Y	National government	Ministry of the Environment and Protection of Land and Sea	2015
IT	National	National Climate Change Adaptation Plan (PNACC)	It identifies climate risks at a regional level, sectorial risks and actions for climate adaptation, and the responsibilities and coordination between different authorities and governments. It defines a set of sectorial adaptation actions and specifies to which region they apply, and they focus on different topics: geological, hydrological and hydraulic instability, coastal zone management, biodiversity and urban settlements. It is the plan in order to implement the National Climate Change Adaptation Strategy (SNACC) and its first draft was presented in 2018.	Climate adaptation	Regulatory instruments	Multiple sectors	Y	National government	Ministry of the Environment and Protection of Land and Sea	2023

IT	National	National Sustainable Development Strategy	It defines the strategic framework for economic, social and environmental development in Italy, and addresses issues such as climate change, the promotion of a circular economy and social inequalities. It coordinates actions at the national and regional levels and seeks to promote cooperation between the different actors, such as governments, companies and citizens. It aligns the national policy with the UN 2030 sustainable development agenda.	Climate mitigation & adaptation	Regulatory instruments	Multiple sectors	N	National government	Ministry of the Environment and Energy Security	2017
IT	National	Ecological Transition Plan	It is a national multi-sectorial plan for the period 2022-2050 which sets the target of a 55% reduction in emissions by 2030, compared to the levels of 1990. Another target included in the Plan is for Italy to achieve climate neutrality by 2050. Its main objective is to coordinate the policies and measures that will lead to an energy transition in accordance with the objectives and targets set at an international level.	Climate mitigation	Regulatory instruments	Energy supply and consumption	Y	National government	Ministry of Ecological Transition	2022
IT	National	NextGen EU-funded National Plan for Recovery and Resilience	It defines the reforms and objectives to carry out in Italy in order to mitigate the socio-economic impacts of Covid19. One of its areas of intervention is Green Revolution and Ecological Transition. It aims to make the country greener and more inclusive and with a competitive, dynamic and innovative economy.	Climate mitigation & adaptation	Regulatory instruments	Multiple sectors	Y	National government	Italian government, Ministry of Economy and Finance	2022
IT	National	Integrated National Energy and Climate Plan	It outlines Italy's strategy to address issues related to energy and climate change. Its key dimensions are: decarbonisation, energy efficiency, energy security, internal energy market, and research, innovation and competitiveness.	Climate mitigation	Regulatory instruments	Energy supply and consumption	Y	National government	Ministry of Economic Development, Ministry of the Environment and Protection of Natural Resources and the Sea, Ministry of Infrastructure and Transport	2019

IT	Regional	Provincial Strategy for Sustainable Development (SproSS)	It promotes integrated territorial development in the province of Trentino as well as cohesion between policies and actors. It defines 20 sustainability provincial goals and sets out the UN 2030 Agenda and the National Sustainable Development Strategy in Trentino. One of its objectives is to reduce GHG emissions.	Climate mitigation	Regulatory instruments	Multiple sectors	N	Regional government	Provincial government	2019
IT	Regional	"Trentino Clima 2021-2023" Programme	It is a policy act that defines the path to develop and adopt a Provincial Strategy for Mitigation and Adaptation to Climate Change.	Climate mitigation & adaptation	Regulatory instruments	Multiple sectors	N	Regional government	Provincial Agency for Environmental Protection, Provincial government	2021
IT	Regional	Provincial Environmental and Energy Plan 2021-2030	It is a strategy aimed at achieving the region's transition to sustainable energy and environmental practices. It defines 12 strategic lines to achieve the targets of reducing emissions by 2030 and being climate neutral by 2050. For this purpose, it includes a set of measures for climate change mitigation.	Climate mitigation	Regulatory instruments	Energy supply and consumption	Y	Regional government	Provincial government, Provincial Agency for Water Resources and Energy	2021
IT	Local	Sustainable Energy Action Plan	Plan developed by three former Municipalities of Valle dei Laghi and submitted in 2015 under the Covenant of Mayors initiative. The Plan aims at cutting CO2 emissions by at least 40% by 2030 and increasing resilience to climate change.	Climate mitigation	Multiple instruments / Framework policy	Multiple sectors	N	Local government	The former municipalities of Valle del Laghi	2015
IT	Local	Urban Plan of Madruzzo Municipality	It is a plan for the development and land use within the Madruzzo municipality. It defines different aspects of urban development, such as infrastructure projects and zoning regulations, and aims at balancing urban growth with sustainability. It includes an Energy Attatchment that includes measures with the objective of enhancing the energy performance of historic buildings.	Climate mitigation	Regulatory instruments	Multiple sectors	N	Local government	Provincial council	2022

6.2. Annex II: Benefit Transfer Function – Variables Description

This Annex provides detailed descriptions of all variables included in the analysis. Table A.6.2.1 presents the descriptive statistics of our sample.

Dependent variable:

Willingness to Pay: This continuous variable represents the average annual willingness to pay (in euros) for ecosystem services. If the willingness to pay was originally provided in a currency other than the euro, the exchange rate for the year the study was conducted was used for conversion. In studies where willingness to accept was calculated, these values were converted to willingness to pay by assuming equivalence between the two. Similarly, consumer surplus values in other studies were treated as equivalent to willingness to pay. In the analysis, the willingness to pay variable will be used as the dependent variable.

Explanatory variables:

Ecosystem: This is a categorical variable that classifies the types of ecosystems being valued, following the MAES categorization. The categories include Forest (42 studies), Cropland (18), Heathland and Shrub (1), Sparsely Vegetated Land (1), Inland Wetlands (3), Rivers and Lakes (14), Urban (15), Grassland (6), and Marine (65). This variable is further divided into three dummy variables: Terrestrial (assigned a value of 1 if the ecosystem is Forest, Cropland, Heathland and Shrub, Sparsely Vegetated Land, Urban, Grassland, or Inland Wetlands, and 0 otherwise), Freshwater (value of 1 if the ecosystem is Rivers and Lakes, and 0 otherwise), and Marine (value of 1 if the ecosystem is Marine and Coastal, and 0 otherwise).

Cultural, Provisioning, Regulating, supporting: These are dummy variables that indicate the type of ecosystem services, based on the MA Reporting categories. Each variable takes a value of 1 if the study assigns a monetary value to the respective service, and 0 if not.

Survey design: This categorical variable describes the methods used for data collection in the surveys, including: a) Computer-aided individual home interviews, b) Computer-assisted personal interviews, c) Dataset, d) Focus groups, e) Online interviews, f) Personal interviews, g) Mail surveys, h) Map layers, i) Phone questionnaires, l) Online questionnaires, m) In-person questionnaires, n) On-site questionnaires, and o) Workshops. This variable is further divided into three dummy variables: Interview (value of 1 when the survey design is a, b, d, f, m, n, o, and 0 otherwise), Questionnaire online (value of 1 when the survey design is e, g, h, i, l, and 0 otherwise), and Secondary data (value of 1 if the survey design is c, and 0 otherwise).

Valuation method: This is a categorical variable that identifies the method used in the analysis, such as Contingent Valuation, Choice Experiment, Actual Expenditure/Market Price, Count Data Model, Hedonic Price Method, Hedonic Property, Meta-analysis, Replacement Costs, and Travel Cost Method. In our final dataset, there are 76 Choice Experiment (CE) studies, 67 Contingent Valuation Method (CVM) studies, and 22 studies using revealed preferences. We created three dummy variables: one for CE (1 for CE and 0 otherwise), one for CVM (1 for CVM and 0 otherwise), and one for Revealed Preference studies (1 for Revealed and 0 otherwise).

Location: This categorical variable indicates the geographical area where the analysis was conducted.

Country: This categorical variable specifies the European country where the analysis took place.

Biogeographical and marine regions of the European Union: This refers to dummy variables representing specific biogeographical and marine regions of the European Union where the study was conducted. These regions include Alpine, Atlantic, Black Sea, Boreal, Continental, Macaronesian, Mediterranean, Pannonian, Steppic, Marine Atlantic, Marine Black Sea, Marine Baltic, Marine Macaronesian, and Marine Mediterranean. The categorization follows the Habitats Directive (92/43/EEC) and the EMERALD Network established under the Bern Convention.

Value elicitation methodology: This is a categorical variable that specifies the type of elicitation method used in the study.

Also, the following socioeconomic variables were considered:

Age: This is a continuous variable representing the average age of the sample population, expressed in years. For studies where data was provided in groups, it was assumed that the open-ended classes have the same width. The midpoint for each class was calculated and then multiplied by the class frequency. The sum of these results was divided by the total frequencies to obtain the mean age. In cases with missing values, the mean age for each country and the specific year, as provided by EUROSTAT, was used as a proxy.

Income: This continuous variable indicates the average annual income of the sample population in euros. For studies with grouped data, the open-ended classes were assumed to have the same width. The midpoint for each class was calculated, multiplied by the class frequency, and the sum of these results was divided by the total frequencies to determine the mean income. When studies provided monthly income, the amount was multiplied by twelve to get the annual figure. If income was reported in a currency other than euros, the exchange rate for the year the study was conducted was used for conversion. For studies lacking income data, we used Eurostat data from EU-SILC and ECHP surveys, which provide mean equivalized net income by year.

Gender: This variable represents the percentage of males and females in the sample population, with females coded as 1. Due to 68 missing values, this variable was eventually excluded from our regression analysis. However, descriptive statistics are provided for the 97 available values.

Education: This variable indicates the percentage of the sample population with a higher education level, with a university degree coded as 1. When data on educational levels were not available, we used Eurostat data on Population by Educational Attainment Level, Sex, and Age (%), focusing on tertiary education (levels 5-8) as defined by the International Standard Classification of Education (ISCED 2011).

Table A. 6.2.1 Descriptive Statistics

Variable	Mean	SE mean	St. dev	Minimum	Q1	Median	Q3	Maximum
WTP	76.80	12.90	165.70	0.00	9.30	23.40	64.40	1404.60
ES terrestrial	0.52	0.04	0.50	0.00	0.00	1.00	1.00	1.00
ES marine	0.39	0.04	0.49	0.00	0.00	0.00	1.00	1.00
ES fresh water	0.09	0.02	0.28	0.00	0.00	0.00	0.00	1.00
Cultural	0.59	0.04	0.49	0.00	0.00	1.00	1.00	1.00
Provisioning	0.27	0.04	0.44	0.00	0.00	0.00	1.00	1.00
Supporting	0.44	0.04	0.50	0.00	0.00	0.00	1.00	1.00
Regulating	0.33	0.04	0.47	0.00	0.00	0.00	1.00	1.00
SD interview	0.67	0.04	0.47	0.00	0.00	1.00	1.00	1.00
SD questionnaire online	0.33	0.04	0.47	0.00	0.00	0.00	1.00	1.00
SD secondary data	0.05	0.02	0.22	0.00	0.00	0.00	0.00	1.00
CE	0.46	0.04	0.50	0.00	0.00	0.00	1.00	1.00
CVM	0.40	0.04	0.49	0.00	0.00	0.00	1.00	1.00
REVEALED	0.14	0.03	0.35	0.00	0.00	0.00	0.00	1.00
Alpine	0.13	0.03	0.34	0.00	0.00	0.00	0.00	1.00
Atlantic	0.24	0.03	0.43	0.00	0.00	0.00	0.00	1.00
Boreal	0.14	0.03	0.35	0.00	0.00	0.00	0.00	1.00
Continental	0.2 12	0.03	0.41	0.00	0.00	0.00	0.00	1.00
Macaronesia	0.01	0.01	0.08	0.00	0.00	0.00	0.00	1.00
Mediterranean	0.28	0.04	0.45	0.00	0.00	0.00	1.00	1.00
Steppic	0.01	0.01	0.08	0.00	0.00	0.00	0.00	1.00
Marine Atlantic	0.18	0.03	0.38	0.00	0.00	0.00	0.00	1.00
Marine Black Sea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Marine Baltic	0.04	0.02	0.20	0.00	0.00	0.00	0.00	1.00
AGE	44.22	0.62	6.30	28.62	40.09	43.00	49.35	58.00
INCOME	27,969	1,210	5,160	2,398	18,267	24,512	35,371	104,030
GENDER	0.49	0.01	0.09	0.17	0.46	0.51	0.54	0.64
EDUC	0.55	0.18	2113.00	0.10	0.27	0.36	0.46	25.40

6.3. Annex III: Ecosystem Services & Economic Impacts mapping exercise

Table A6.3.1 Ecosystem Services By Hazard

Hazard	Ecosystem Services			
	Provisioning	**Regulating**	**Supporting**	**Cultural**
Sea Level Rise	Fisheries:	Coastal Protection:	Biodiversity Habitat:	Recreation and Tourism:
	Coastal and marine ecosystems provide vital habitats for fish and shellfish. Sea level rise can alter these habitats, impacting fish populations and commercial fisheries.	Ecosystems like mangroves, salt marshes, and coral reefs provide natural barriers against storm surges and erosion. Sea level rise can diminish their effectiveness and extent.	Coastal and marine ecosystems support a wide variety of species. Sea level rise can lead to habitat loss, affecting biodiversity and disrupting ecological balance.	Coastal areas are popular for recreational activities and tourism. Sea level rise can affect beach access, water sports, and the aesthetic value of coastal landscapes, impacting local economies.
	Aquaculture:	Water Regulation:	Nutrient Cycling:	Cultural Heritage:
	Changes in salinity and habitat availability can affect aquaculture operations, influencing the production of seafood.	Coastal wetlands help regulate water levels and quality, filtering pollutants and absorbing excess nutrients. Sea level rise can inundate these areas, altering their capacity to perform these functions.	Coastal ecosystems facilitate nutrient cycling. Changes in inundation patterns due to sea level rise can alter these processes, impacting ecosystem health.	Many coastal communities have historical and cultural ties to their environments. Rising seas can threaten cultural sites, leading to loss of heritage and community identity.
	Freshwater Supply:	Climate Regulation:		Aesthetic Value:
	Rising sea levels can lead to saltwater intrusion into coastal freshwater aquifers, compromising drinking water quality and availability.	Coastal ecosystems play a role in carbon sequestration. Loss of these ecosystems due to rising sea levels can reduce their ability to capture and store carbon, contributing to increased atmospheric CO2 levels.		Coastal landscapes provide aesthetic enjoyment and inspiration. Changes in these landscapes due to sea level rise can diminish their beauty and cultural significance.
Flooding Risk	Agricultural Productivity (destroy crops and degrade soil quality, reducing agricultural yields and food security)	Flood Regulation (reduce the effectiveness of Water Regulation)	Soil Formation (Erode Soil)	Recreation (Reduce attractiveness)
	Freshwater resources (availability and quality)	Water Purification (water quality)	Nutrient Cycling (Disrupt Nutrient Cycles)	Tourism (Reduce Accessibility)

		Climate Regulation - Carbon Sequestration (Wetlands, Forests)	Biodiversity (Habitat Loss, species distribution)	Cultural Heritage (Cultural and Historical sites near Water Bodies)
Water Scarcity	Freshwater Supply (availability of freshwater for drinking, agriculture, industry, and personal use)	Water Purification (reduce the ability of wetlands and riparian zones to filter and purify water)	Biodiversity (Habitat Loss, Species Distribution)	Recreation and Tourism (Rivers and Lakes - fishing, boating, swimming)
	Agricultural Production (crop irrigation, reducing agricultural yields and food security)	Climate Regulation (loss of vegetation and reduced evaporative cooling, contributing to higher temperatures)	Nutrient Cycling (Disrupt Nutrient transport Cycles - impacting Soil Fertility and productivity)	Tourism (attactiveness and accessibility)
	Fisheries and Aquaculture (Stock Population and Health of Freshwater Ecosystems - rivers and lakes-)	Flood Regulation (reduce the effectiveness of Water Regulation - health of floodplains and wetlands, which absorb excess water during heavy rains and mitigate flooding)	Soil Formation (Erode Soil)	Spiritual (communities have cultural, spiritual, and historical connections to water bodies)
				Aesthetic (Reduce scenic beauty of landscapes)
Marine Storms (hurricanes, typhoons,	Fisheries and Aquaculture (Fishing Infrastructure, fish Population, alter habitats, leading to reduced fishery	Coastal Protection (coral reefs, mangroves, and wetlands protect coastlines from storm surges and wave action. Marine storms can degrade these	Biodiversity (Coastal and marine habitats support diverse species. Marine storms can cause habitat destruction and fragmentation, threatening biodiversity)	Recreation and Tourism (Coastal areas are popular for recreational activities and tourism. Marine storms can damage infrastructure, beaches,

and cyclones)	yields and affecting aquaculture operations)	ecosystems, reducing their protective capabilities)		and natural attractions, reducing their appeal and accessibility)
	Freshwater Resources (Saltwater intrusion into freshwater systems - contaminate freshwater supplies, impacting drinking water and agriculture)	Water Purification (Wetlands and coastal vegetation filter pollutants and sediments. Storms can disrupt these areas, reducing their ability to purify water)	Nutrient Cycling (Coastal wetlands and estuaries play key roles in nutrient cycling. Storms can alter these processes, impacting the productivity of marine and coastal ecosystems)	Cultural (Many coastal communities have cultural and historical sites that are vulnerable to storm damage. Storms can lead to the loss of these sites, affecting community identity and heritage)
		Climate Regulation (Loss of Carbon Storage Capacity of Marine and coastal ecosystems like mangroves and seagrasses)	Soil Formation (Coastal vegetation, like mangroves and salt marshes, helps stabilize soil and prevent erosion. Storms can lead to increased erosion and loss of soil stability)	Aesthetic Value (Scenic coastal landscapes attract visitors and residents. Storm damage can reduce the aesthetic value of these areas)
Fires	Timber and Non-Timber Forest Products: Fires can destroy timber resources and other forest products such as fruits, nuts, and medicinal plants, reducing their availability.	Climate Regulation: Forests and other vegetation play a crucial role in sequestering carbon dioxide. Fires release stored carbon back into the atmosphere, contributing to climate change.	Habitat for Biodiversity: Fires can destroy habitats, leading to the loss of biodiversity. However, some ecosystems depend on periodic fires to maintain ecological balance and biodiversity.	Recreation and Tourism: Fires can damage natural landscapes and recreational areas, reducing their attractiveness and accessibility for tourism and outdoor activities.
	Freshwater Resources: Fires can impact the quality and quantity of water by increasing runoff and sedimentation in water bodies, affecting	Air Quality Regulation: Fires produce smoke and release pollutants such as particulate matter, carbon monoxide, and volatile organic compounds, degrading air quality and impacting human health.	Nutrient Cycling: Fires can both disrupt and enhance nutrient cycling. While intense fires can deplete soil nutrients, moderate fires can help release nutrients from vegetation back into the soil.	Cultural and Spiritual Values: Many communities have cultural, spiritual, and historical connections to forests and natural landscapes. Fires can

	drinking water and agricultural irrigation.			threaten these sites and affect cultural practices.
		Water Regulation: Vegetation helps regulate the flow of water within ecosystems. Fires can disrupt this balance, leading to increased runoff, erosion, and reduced water infiltration.	Soil Formation: Vegetation contributes to soil formation and maintenance. Fires can degrade soil quality and reduce its capacity to support plant life.	Aesthetic Value: Scenic landscapes and natural beauty can be severely impacted by fires, reducing their aesthetic appeal.
		Erosion Control: Vegetation stabilizes soil and prevents erosion. Fires can strip the land of vegetation, increasing the risk of erosion and landslides.		
Biodiversity Loss	Food Production: Biodiversity contributes to the variety and stability of food supplies, including crops, livestock, fisheries, and wild foods. Loss of biodiversity can reduce food security and agricultural productivity.	Climate Regulation: Diverse ecosystems, such as forests, grasslands, and oceans, play a crucial role in carbon sequestration and climate regulation. Biodiversity loss can reduce these ecosystems' ability to store carbon and mitigate climate change.	Nutrient Cycling: Biodiverse ecosystems play a key role in nutrient cycling, which supports plant growth and ecosystem productivity. Loss of biodiversity can disrupt these cycles, reducing ecosystem resilience and productivity.	Recreation and Tourism: Natural landscapes and wildlife are major attractions for tourism and recreation. Biodiversity loss can reduce the appeal and economic benefits of these activities.
	Medicinal Resources: Many pharmaceuticals are derived from natural compounds found in diverse ecosystems. Biodiversity loss can limit the discovery of new medicines and reduce the availability of traditional medicinal resources.	Pollination: Many crops and wild plants rely on animal pollinators. Declines in pollinator species can lead to reduced crop yields and biodiversity in natural plant communities.	Habitat Provision: Biodiversity provides critical habitat for numerous species. Loss of biodiversity can lead to the degradation of habitats, making ecosystems less able to support diverse species.	Cultural and Spiritual Values: Many cultures have deep connections to biodiversity and specific species. Loss of biodiversity can erode cultural heritage and spiritual practices.

	Raw Materials: Forests, grasslands, and other ecosystems provide raw materials like timber, fibers, and resins. Reduced biodiversity can diminish the availability and quality of these materials.	Pest and Disease Control: Biodiverse ecosystems support natural predators and parasites that help control pest populations and disease outbreaks. Loss of biodiversity can increase the prevalence of pests and diseases, affecting agriculture and human health.	Primary Production: The presence of diverse species contributes to higher primary productivity in ecosystems. Biodiversity loss can reduce the overall productivity and stability of ecosystems.	Aesthetic Value: Biodiverse ecosystems are often more visually appealing and provide a sense of well-being. Loss of biodiversity can diminish the aesthetic value of natural landscapes.
	Freshwater Resources: Diverse ecosystems, particularly wetlands and forests, help maintain the quantity and quality of freshwater supplies. Biodiversity loss can compromise these systems, affecting water availability.	Water Regulation: Ecosystems like forests and wetlands regulate water cycles, including groundwater recharge and flood control. Biodiversity loss can disrupt these processes, leading to increased flooding and water scarcity.		
		Soil Fertility and Erosion Control: Diverse plant communities contribute to soil formation, fertility, and structure. Biodiversity loss can lead to soil degradation and increased erosion, impacting agriculture and ecosystem health.		
Health Diseases	Freshwater Supply: Ecosystems like forests and wetlands provide clean and safe drinking water, reducing exposure	Disease Regulation:	Nutrient Cycling: Healthy ecosystems maintain soil fertility and nutrient cycling, ensuring productive agriculture and the availability of nutritious food,	Recreation and Physical Health: Access to natural environments encourages physical activity, which can help prevent diseases such as obesity, diabetes,

	to waterborne pathogens and diseases.		which is crucial for preventing diseases related to malnutrition.	cardiovascular diseases, and certain cancers.
	Food Security: Diverse ecosystems support agriculture and fisheries, providing a stable and varied diet that is essential for preventing malnutrition and related diseases.	Vector Control: Healthy ecosystems regulate populations of disease vectors such as mosquitoes, ticks, and rodents, reducing the incidence of diseases like malaria, dengue fever, Lyme disease, and hantavirus.	Pollination: Many crops rely on pollinators like bees, which support the production of fruits, vegetables, and nuts. A diverse and nutritious diet helps in preventing various chronic diseases and supports overall health.	Mental Health and Well-being: Natural environments provide psychological benefits, reducing stress, anxiety, and depression, which are linked to overall health and disease prevention.
		Biodiversity's Dilution Effect: High biodiversity can dilute disease risk by reducing the transmission efficiency of pathogens, as seen in Lyme disease where diverse mammal communities can lower infection rates.		
		Water Purification: Wetlands, forests, and riparian zones filter pollutants and pathogens from water sources, reducing the incidence of waterborne diseases like cholera, dysentery, and giardiasis.		
		Air Quality Regulation: Trees and vegetation filter airborne pollutants, reducing respiratory diseases such as asthma, chronic obstructive pulmonary disease (COPD), and bronchitis.		
		Water Purification: Wetlands, forests, and riparian zones filter pollutants and pathogens from water sources, reducing the incidence of waterborne diseases like cholera, dysentery, and giardiasis.		
		Climate Regulation: Ecosystems that sequester carbon and influence local		

		climate conditions help mitigate climate-related health risks. For example, reducing extreme heat can lower heatstroke incidents and cardiovascular problems.		
Temperature Increase	Food Production:	Climate Regulation:	Nutrient Cycling: Higher temperatures can alter decomposition rates and nutrient cycling processes in ecosystems, affecting soil fertility and plant growth.	Recreation and Tourism: Temperature increases can impact recreational activities and tourism, especially in areas dependent on specific climate conditions, such as skiing in mountainous regions or coral reef tourism.
		Carbon Sequestration: Higher temperatures can affect the capacity of forests, wetlands, and oceans to sequester carbon. For example, warmer temperatures can lead to increased forest fires, releasing stored carbon into the atmosphere.		
	Agriculture: Higher temperatures can affect crop yields, altering growing seasons, and increasing the prevalence of pests and diseases.	Feedback Loops: Melting permafrost releases methane, a potent greenhouse gas, which can further accelerate temperature increases.	Primary Production: Temperature increases can affect the growth rates of primary producers (plants and phytoplankton), impacting the entire food web and ecosystem productivity.	Cultural and Spiritual Values: Many communities have cultural and spiritual connections to their local environments. Changes in temperature can affect the natural landscapes and ecosystems that hold cultural significance.
	Fisheries: Warmer waters can lead to shifts in fish populations and impact the productivity of	Air Quality Regulation: Increased temperatures can exacerbate air pollution, including ground-level ozone, which impacts respiratory health.		

	fisheries, affecting food security.			
		Water Regulation: Higher temperatures can reduce snowpack and glacier melt, affecting water flow in rivers and impacting water availability for ecosystems and human use.	Habitat Provision: Changes in temperature can alter habitats and lead to shifts in species distributions, affecting biodiversity and ecosystem stability.	Aesthetic Value: Changes in temperature can alter landscapes, affecting the scenic beauty of natural areas and their value for recreation and tourism.
	Freshwater Supply: Increased temperatures can lead to higher evaporation rates, reducing freshwater availability and impacting drinking water supplies and irrigation for agriculture.	Disease Regulation: Warmer temperatures can expand the range of disease vectors like mosquitoes and ticks, increasing the incidence of diseases such as malaria, dengue fever, and Lyme disease.		
Avalance Increase	Water Supply:	Erosion Control and Soil Stability:	Habitat Provision:	Recreation and Tourism:
		Soil Retention: Avalanches can strip vegetation and soil from slopes, leading to increased erosion and loss of soil stability, which affects downstream land fertility and can lead to landslides.		Winter Sports: Avalanches pose a significant risk to winter recreational activities such as skiing, snowboarding, and mountaineering, which can impact local economies reliant on tourism.
	Freshwater Resources: Avalanches can impact water sources by depositing large amounts of snow and ice into rivers and streams, potentially affecting the	Water Regulation:	Biodiversity: Avalanches can disrupt habitats for various plant and animal species, altering the composition and structure of ecosystems. While some species may benefit from the newly	Landscape Aesthetics: Avalanches can alter the scenic beauty of mountainous areas, which can affect their attractiveness for tourism and recreational activities.

	timing and quantity of water flow and availability for human consumption, agriculture, and industry.		created habitats, others may be negatively impacted.	
		Flood Control: The rapid melting of snow from avalanches can contribute to sudden increases in water flow, leading to potential flooding downstream. Intact ecosystems can help moderate these effects by absorbing and slowly releasing water.		Cultural and Spiritual Values:
		Climate Regulation:	Nutrient Cycling:	Cultural Heritage: Many communities have cultural and spiritual connections to mountainous regions. Avalanches can threaten these culturally significant landscapes and sites, impacting cultural practices and heritage.
		Albedo Effect: Snow and ice have high albedo (reflectivity), and avalanches can temporarily increase the albedo of mountain areas. However, the longer-term effect can be a reduction in snow cover due to changes in vegetation and soil exposure, influencing local and regional climate.		
			Soil Fertility: Avalanches can redistribute soil and organic matter, potentially affecting nutrient availability in both the affected and adjacent areas.	
	Food Production:	Climate Regulation:	Nutrient Cycling:	Recreation and Tourism:

Extreme Storms				
	Agriculture: Extreme storms can damage crops, reduce yields, and affect the availability and quality of food. They can also lead to soil erosion and loss of arable land.	Carbon Sequestration: Storms can damage forests and other vegetation that sequester carbon, potentially releasing stored carbon back into the atmosphere and reducing future carbon sequestration capacity.	Soil Fertility: Extreme storms can disrupt nutrient cycling by eroding topsoil and reducing soil fertility, impacting plant growth and agricultural productivity.	Natural Landscapes: Extreme storms can damage landscapes and natural features that are important for recreation and tourism, affecting local economies that rely on these activities.
	Fisheries: Storms can disrupt marine and freshwater fisheries by damaging habitats like coral reefs and mangroves, affecting fish populations and reducing fishery productivity.			
		Water Regulation:	Primary Production:	Cultural and Spiritual Values:
	Freshwater Supply:			
	Water Quality and Availability: Storms can lead to contamination of water supplies with pollutants, sediments, and pathogens. Flooding can also affect the infrastructure that supplies drinking water.	Flood Control: Wetlands, forests, and riparian zones help absorb and slow down stormwater, reducing the impact of flooding. Extreme storms can overwhelm these natural systems, reducing their effectiveness.	Plant Growth: Damage to vegetation and disruption of ecosystems can affect primary production, influencing the entire food web.	Heritage Sites: Many natural and cultural heritage sites can be damaged or destroyed by extreme storms, impacting cultural identity and spiritual practices.
		Erosion Control:		Aesthetic Value:
		Soil Retention: Vegetation helps hold soil in place, preventing erosion. Extreme storms can strip vegetation		Scenic Beauty: The destruction of natural landscapes and ecosystems can reduce their

		from the land, leading to increased soil erosion and sedimentation in waterways.		aesthetic value and the benefits they provide to human well-being.
		Pollution Control:		
		Water Purification: Natural systems like wetlands and riparian buffers filter pollutants from runoff. Extreme storms can increase pollutant loads and overwhelm these systems, reducing their capacity to purify water.		
		Pest and Disease Regulation:		
		Vector Control: Storms can alter habitats and breeding sites for disease vectors such as mosquitoes, potentially increasing the spread of vector-borne diseases like malaria and dengue fever.		

Table A 6.2.2 ***Socio-Economic Impacts By Hazard***

Hazard	Socio-Economic Impact	
Sea Level Rise	Coastal Communities (Displacement, Economic Loss, Increased vulnerability to extreme weather events)	
	Infrastructure (roads, buildings and ports)	
Flooding Risk	Urban Areas (significant damage to infrastructure, homes, and businesses, leading to economic losses and displacement)	
	Agricultural Lands (Damage Crops, soil degradation, food production and livelihoods)	
	Infrastructure (roads, buildings and utilities)	

Water Scarcity	Agricultural Communities (Farmers and rural communities dependent on irrigation can face severe economic and social challenges due to reduced water availability)	
	Urban Areas (water rationing, reduced water quality, and increased competition for water resources in cities)	
	Industries (Water-intensive industries, such as manufacturing and energy production - reduced output and economic losses)	
Marine Storms (hurricanes, typhoons, and cyclones)	Coastal Communities: Marine storms can cause displacement, economic losses, and increased vulnerability to future storms.	
	Infrastructure: Coastal infrastructure such as roads, buildings, and ports can be severely damaged by storms, requiring costly repairs and adaptations.	
	Economic Activities: Tourism, fishing, and other coastal economic activities can be disrupted, leading to significant economic losses.	
Fires	Communities and Infrastructure: Fires can destroy homes, buildings, and infrastructure, leading to economic losses and displacement.	
	Health: Smoke from fires can cause respiratory and cardiovascular issues, especially in vulnerable populations.	
	Economic Activities: Agriculture, forestry, and tourism can be severely impacted by fires, leading to economic losses.	
Biodiversity Loss	Food Security: Reduced agricultural productivity and fishery yields due to biodiversity loss can threaten food security.	
	Health: Reduced availability of medicinal resources and increased prevalence of pests and diseases can impact human health.	
	Economic Activities: Sectors like agriculture, forestry, and tourism can suffer economic losses due to reduced ecosystem services and biodiversity.	
Health Diseases	Respiratory Diseases: Improved air quality from forested areas and urban green spaces can reduce respiratory conditions such as asthma and COPD.	
	Waterborne Diseases: Access to clean water from healthy freshwater ecosystems reduces diseases like cholera, dysentery, and giardiasis.	
	Vector-borne Diseases: Biodiverse ecosystems can control populations of disease vectors, reducing the incidence of diseases such as malaria, dengue fever, and Zika virus.	
	Nutritional Deficiencies: Ecosystem services that support diverse and productive agriculture help prevent malnutrition and associated health problems.	
Temperature Increase	Heat-Related Illnesses: Increased temperatures can lead to more frequent and severe heatwaves, causing heat stress, heatstroke, and other heat-related illnesses.	
	Respiratory Diseases: Higher temperatures can worsen air quality, leading to an increase in respiratory conditions like asthma and COPD.	

	Vector-Borne Diseases: Temperature increases can expand the range and activity period of disease vectors, increasing the incidence of diseases like malaria, dengue, and Lyme disease.	
	Water and Food Security: Reduced water availability and changes in agricultural productivity can threaten food and water security, impacting human health and nutrition.	
Avalance Increase	Safety and Mortality:	
	Direct Threats: Avalanches pose direct threats to human life, causing injuries and fatalities among residents, workers, and tourists in mountainous areas.	
	Infrastructure Damage:	
	Property and Infrastructure: Avalanches can destroy homes, roads, railways, and other infrastructure, leading to economic losses and disruption of services.	
	Water Quality:	
	Sediment and Pollutants: Avalanches can introduce large amounts of sediment and pollutants into water bodies, affecting water quality and ecosystem health.	
Extreme Storms	Direct Threats:	
	Injuries and Fatalities: Extreme storms pose direct risks to human life through flooding, high winds, and storm surges.	
	Waterborne Diseases:	
	Contamination of Water Supplies: Flooding from storms can contaminate drinking water supplies with pathogens, leading to outbreaks of diseases such as cholera and dysentery.	
	Vector-borne Diseases:	
	Increased Habitat for Vectors: Storms can create breeding sites for disease vectors like mosquitoes, increasing the risk of diseases such as malaria and dengue fever.	
	Mental Health:	
	Stress and Trauma: The destruction and disruption caused by extreme storms can lead to stress, anxiety, and long-term mental health issues.	

Table A 6.3.3 ***Description of Ecosystem Services***

Ecosystem Services			
Provisioning	**Regulating**	**Supporting**	**Cultural**

These are the products obtained from ecosystems, including:	These are the benefits obtained from the regulation of ecosystem processes, including:	Supporting services are those that are necessary for the production of all other ecosystem services. They differ from provisioning, regulating, and cultural services in that their impacts on people are either indirect or occur over a very long time, whereas changes in the other categories have relatively direct and short-term impacts on people. (Some services, like erosion control, can be categorized as both a supporting and a regulating service, depending on the time scale and immediacy of their impact on people.)	These are the nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences, including:
Food and fiber. This includes the vast range of food products derived from plants, animals, and microbes, as well as materials such as wood, jute, hemp, silk, and many other products derived from ecosystems.	Air quality maintenance. Ecosystems both contribute chemicals to and extract chemicals from the atmosphere, influencing many aspects of air quality.	For example, humans do not directly use soil formation services, although changes in this would indirectly affect people through the impact on the provisioning service of food production.	Cultural diversity. The diversity of ecosystems is one factor influencing the diversity of cultures.
Fuel. Wood, dung, and other biological materials serve as sources of energy.	Climate regulation. Ecosystems influence climate both locally and globally. For example, at a local scale, changes in land cover can affect both temperature and precipitation. At the global scale, ecosystems play an important role in climate by either sequestering or emitting greenhouse gases.	Similarly, climate regulation is categorized as a regulating service since ecosystem changes can have an impact on local or global climate over time scales relevant to human decision-making (decades or centuries), whereas the production of oxygen gas (through photosynthesis) is categorized as a supporting service since any impacts on the concentration of oxygen in the atmosphere would only occur over an extremely long time	Spiritual and religious values. Many religions attach spiritual and religious values to ecosystems or their components.
Genetic resources. This includes the genes and genetic information used for animal and plant	Water regulation. The timing and magnitude of runoff, flooding, and aquifer recharge can be strongly influenced by changes in land	Some other examples of supporting services are primary production, production of atmospheric oxygen, soil formation and retention, nutrient cycling, water cycling, and provisioning of habitat.	Knowledge systems (traditional and formal). Ecosystems influence the types of knowledge

breeding and biotechnology.	cover, including, in particular, alterations that change the water storage potential of the system, such as the conversion of wetlands or the replacement of forests with croplands or croplands with urban areas.		systems developed by different cultures.
Biochemicals, natural medicines, and pharmaceuticals. Many medicines, biocides, food additives such as alginates, and biological materials are derived from ecosystems	Erosion control. Vegetative cover plays an important role in soil retention and the prevention of landslides.		Educational values. Ecosystems and their components and processes provide the basis for both formal and informal education in many societies.
Ornamental resources. Animal products, such as skins and shells, and flowers are used as ornaments, although the value of these resources is often culturally determined. This is an example of linkages between the categories of ecosystem services.	Water purification and waste treatment. Ecosystems can be a source of impurities in fresh water but also can help to filter out and decompose organic wastes introduced into inland waters and coastal and marine ecosystems.		Inspiration. Ecosystems provide a rich source of inspiration for art, folklore, national symbols, architecture, and advertising.
Fresh water. Fresh water is another example of linkages between categories—in this case, between provisioning and regulating services.	Regulation of human diseases. Changes in ecosystems can directly change the abundance of human pathogens, such as cholera, and can alter the abundance of disease vectors, such as mosquitoes.		Aesthetic values. Many people find beauty or aesthetic value in various aspects of ecosystems, as reflected in the support for parks, “scenic drives,” and the selection of housing locations.

	Biological control. Ecosystem changes affect the prevalence of crop and livestock pests and diseases.		Social relations. Ecosystems influence the types of social relations that are established in particular cultures. Fishing societies, for example, differ in many respects in their social relations from nomadic herding or agricultural societies.
	Pollination. Ecosystem changes affect the distribution, abundance, and effectiveness of pollinators.		Sense of place. Many people value the “sense of place” that is associated with recognized features of their environment, including aspects of the ecosystem.
	Storm protection. The presence of coastal ecosystems such as mangroves and coral reefs can dramatically reduce the damage caused by hurricanes or large waves.		Cultural heritage values. Many societies place high value on the maintenance of either historically important landscapes (“cultural landscapes”) or culturally significant species.
			Recreation and ecotourism. People often choose where to spend their leisure time based in part on the characteristics of the natural or cultivated landscapes in a particular area.
			Cultural services are tightly bound to human values and behavior, as well as to human institutions and patterns of social, economic, and political organization. Thus perceptions of cultural services are more

			likely to differ among individuals and communities than, say, perceptions of the importance of food production.