KNOWLEDGE DEVELOPMENT AND APPLICATION CONCERNING COSTS OF ADAPTATION COMPARED TO COSTS OF INACTION

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RAMBOLL

Bright ideas.
Sustainable change.

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FINAL REPORT

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1. INTRODUCTION

1.1 Economic aspects of climate change adaptation in the EU

Climate change represents a major threat to economic stability, public health, and environmental sustainability across Europe. Ongoing and increasing climate events such as floods, heatwaves, droughts, and wildfires have underscored the immediacy and scale of climate impacts, highlighting the urgent need for effective adaptation measures (Ramboll, 2022). While the European Union (EU) has recognised climate adaptation as a strategic priority, e.g. demonstrated by the upcoming European Climate Change Adaptation Plan (ECAP), understanding the economic dimensions remains critical for informed decision-making.

The necessity of evaluating these economic aspects is emphasised by the European Environment Agency (EEA), noting that despite recent improvements in national-level adaptation data, comprehensive and systemic economic assessments of adaptation programmes are lacking (EEA, 2023).

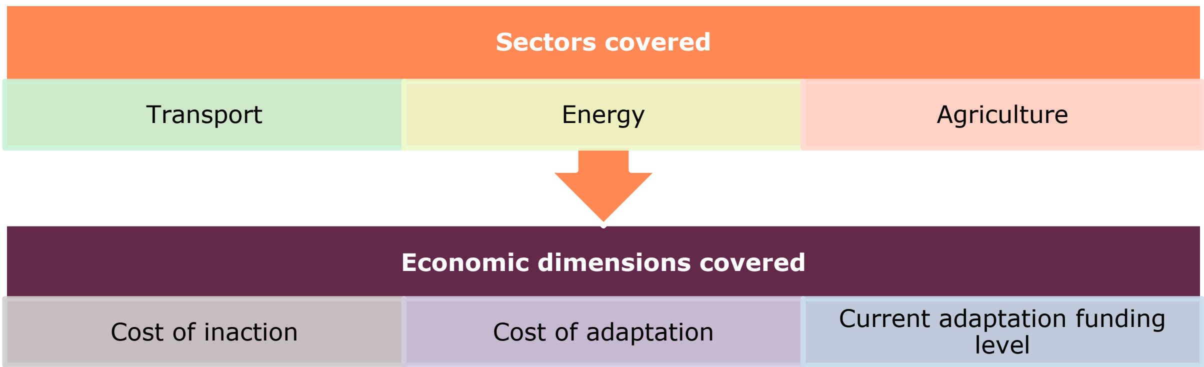
Also, a recent World Bank report highlights that comprehensive and comparable adaptation costing data are currently limited and often fragmented across sectors and countries, leading to significant knowledge gaps and inconsistencies in estimating adaptation investment needs. These gaps complicate the process of accurately assessing the true scale of required adaptation financing, creating challenges in securing necessary resources and making informed policy decisions (World Bank, 2024).

1.2 Aim, scope, and overall approach of the project

The aim of the project is to contribute to the understanding of the economic implications associated with climate change adaptation.

This is done by analysing and comparing the costs of adaptation, the costs of inaction, and the current adaptation funding, across EU Member States, specifically within the transport, energy, and agriculture sectors.

Figure 1.1 Overview of scope of project



For the costs of inaction, the project relies on existing estimates from prior research projects.

For the costs of adaptation, the project develops own estimates through a bottom-up approach, using existing national studies on adaptation finance needs rather than relying on a broader modelling approach. This bottom-up method involves directly compiling, analysing, and calibrating detailed sector-specific data from individual countries' studies, allowing for accounting to some extent insights into local conditions and practices. The primary benefit of this approach is its grounded nature, reflecting to the extent possible real-world conditions and specific adaptation contexts, which can be lost in more aggregated modelling approaches. However, this method also presents limitations, notably its dependence on the availability, consistency, and quality of national studies, leading to large data gaps or inconsistencies across regions. To mitigate these challenges, the project calibrates national findings to standardised scenarios and assumptions, aiming at greater comparability across Member States. For countries without dedicated national studies, the study uses calibrated data to derive average sector-specific unit costs, which we then extrapolate using relevant exposure metrics.

Finally, for assessing the current adaptation funding levels, the report takes a top-down approach, developing estimates based on a variety of different data sources and assumptions.

1.3 Definition of main concepts

The key concepts used in this report are described below.

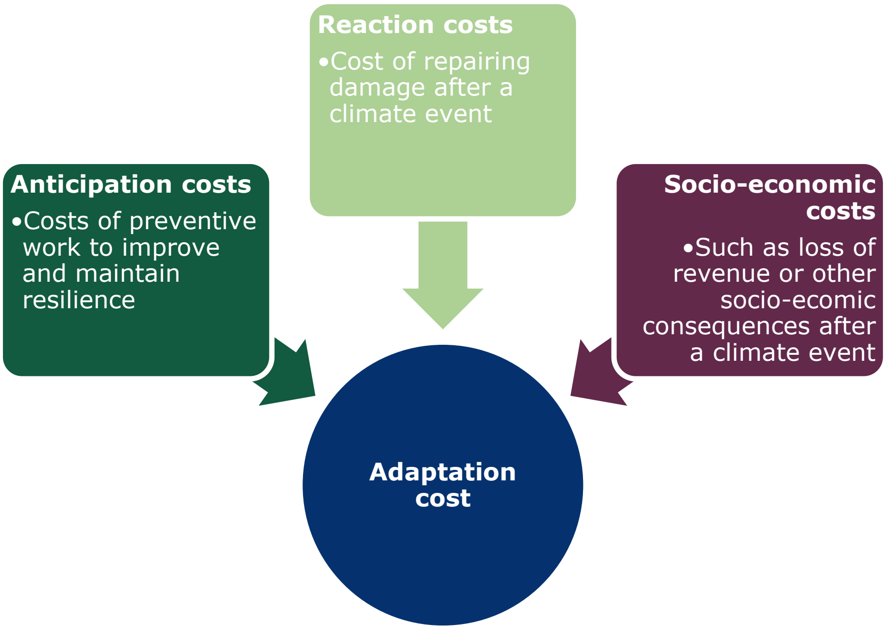
Adaptation

Adaptation refers to "the process of adjusting to current or expected climate conditions and their effects, aiming to moderate harm or exploit beneficial opportunities. Adaptation can be anticipatory or reactive, planned or autonomous, and public or private." (Ramboll, 2022, p.6; IPCC Fifth Assessment Report, 2014).

Estimated adaptation finance needs

The estimated adaptation finance needs include all expenditures necessary to plan, implement, and maintain measures aimed at reducing vulnerability to climate change impacts. These costs can be classified into several types as shown in the Figure below.

Figure 1.2 Different types of adaptation costs that together constitute the finance needs



Source: Own illustration altered after I4CE (2024) Anticipating the impacts of a 4°C warming: what is the cost of adaptation?

Inaction

Inaction can be defined as "the failure to implement adaptation measures, representing a scenario where no new or additional actions are taken beyond current policies or practices, resulting in increasing vulnerability and potential damages from climate change." (Ramboll, 2022, p.16).

Cost of inaction

The cost of inaction represents "the economic, social, and environmental damages or losses that occur when adaptation measures are not implemented, including both direct costs (physical damages) and indirect costs (economic losses and broader societal impacts)." (Ramboll, 2022 p.16).

Current funding levels for adaptation

Current funding levels for adaptation are defined as the total resources currently mobilised by governments and other entities specifically for adaptation measures, often significantly lower than the calculated adaptation needs. These include actual expenditures recorded annually, committed funds not yet disbursed, and tracked allocations in adaptation plans or budgets (Ramboll, 2022, p33).

Information from comparing adaptation finance needs vs. cost of inaction

Comparing adaptation finance needs with inaction costs provides crucial insights into "the economic benefits of proactive adaptation measures versus reactive or delayed responses, quantifying the potential savings and avoided damages achievable through timely investment in adaptation." It clarifies the efficiency and urgency of investing in adaptation measures (Ramboll, 2022, pp.63-64).

Information from comparing adaptation finance needs with current funding levels

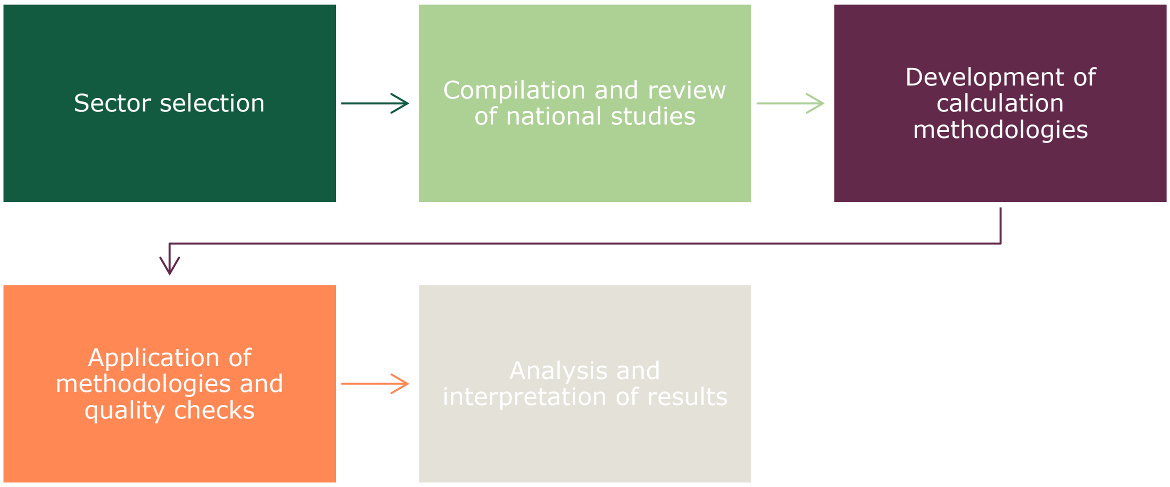
Comparing adaptation finance needs with current funding levels helps identify the "adaptation funding gap," clarifying the extent to which existing resources fall short of estimated needs. This comparison informs policymakers about necessary additional resource mobilisation, funding priorities, and financial planning strategies to close the gap (Ramboll, 2022, pp.31-33).

2. METHODOLOGY

2.1 Main steps followed in the project

The steps taken in the project are depicted in the Figure below and then described in more detail.

Figure 2.1 Overview of project steps



- **Sector selection** :
  - Survey for cost-of-adaptation studies: A structured survey was circulated to all EU Member States to identify national studies containing quantitative adaptation-cost figures.
  - Screening EU inaction-cost literature: In parallel, we reviewed major EU-wide cost-of-inaction studies to find out which sectors were already covered with reliable damage estimates.
  - Combining the survey returns and the literature screen showed that transport, energy and agriculture had sufficient data on both adaptation finance needs and inaction costs; these three sectors were therefore selected for detailed analysis.
- **Compilation and review of national studies**: All national adaptation-cost studies obtained via the survey (and additional desk-research) were collated in a master database. Key characteristics - sector scope, climate scenario, adaptation scenario, hazards, time horizon, cost types - were recorded, and basic quality checks performed.
- **Development of calculation methodologie**s:
  - Cost of adaptation: A bottom-up approach using calibration factors (scenario, hazard, time horizon) plus extrapolation for countries without studies.
  - Cost of inaction: Values were derived from existing modelling studies
  - Current funding levels: A top-down framework combining EU budget lines, national budgets, and indicative private spending shares.
- **Application of methodologies and quality checks**: Calibrated national adaptation finance needs were aggregated and extrapolated; inaction costs were allocated to Member States; funding estimates were compiled. Sensitivity tests and plausibility checks were applied to all outputs before final EU-level results were produced.
- **Analysis and interpretation of results**: The results were analysed and interpreted, as presented in chapter 3.

2.2 Sector scoping

As mentioned above, transport, energy and agriculture were selected as focus sectors in this study.

Overall, sector definitions in this study are intentionally broad, because the underlying source material varies widely in what it covers (e.g., some studies focus on a single asset type, while others report an aggregate "sector total" without a detailed breakdown). To avoid introducing false precision, we therefore classified studies at a high level, while retaining the study-specific scope notes in the underlying sector tables.

Transport

For transport, the adaptation-cost evidence from the national studies base primarily concerns transport infrastructure. The emphasis here is on land transport networks, notably road assets (and in some cases also bridges/rail elements), and measures such as climate-proofing upgrades during rehabilitation/replacement cycles as well as selective reinforcement of vulnerable sections (e.g., flood protection, drainage/culverts, and heat resilience of assets).

By contrast, the cost of inaction source used for transport is more narrowly defined: COACCH quantifies river-flood damages to road infrastructure, and does not cover the full transport system (e.g., rail/urban transport) or the full hazard spectrum (e.g., heat, storms). See Box 2.3 for more information on this.

For current funding, the study relies on top-down envelopes and allocation assumptions, which can capture relevant spending such as "climate-proofing roads, rail, ports… against floods, heat, storms", but cannot be cleanly and consistently decomposed by sub-mode or asset class.

Energy

The adaptation-cost sources span the energy system, typically including generation and network infrastructure (and, where addressed by the underlying studies, upgrades to substations/lines and other hardening measures).

The cost of inaction source used for energy (see also Box 2.4) is largely defined around demand-side impacts (heating/cooling needs) and supply-side changes affecting generation potentials (hydro, wind, solar, thermal/nuclear constraints), and is explicitly not a complete accounting of extreme-event damages to grids and wider cascading impacts.

For current funding, the report again uses a top-down approach and notes that energy investments are often mitigation-heavy (e.g., grid modernisation), with adaptation/climate-proofing not always separable as a standalone category.

Agriculture

The adaptation-cost sources are mainly anticipatory measures and are comparatively narrower and more heterogeneous across countries, e.g., focusing on technical solutions, sometimes excluding parts of agriculture (e.g., livestock) and, in one case, covering very specific measures such as subsurface drainage and ditch maintenance.

The cost of inaction source for agriculture (see also Box 2.4) is based on modelling of crop yield and production impacts with market adjustments, and is partial in coverage (e.g., it does not fully capture extreme-event losses and omits several impact channels).

For current funding, agriculture is treated broadly as CAP- and rural-development-relevant adaptation spending (e.g., irrigation, soil conservation, water management), recognising that budget lines can bundle mitigation and adaptation objectives.

2.3 Deriving values for cost of adaptation

To derive the cost of adaptation for each Member State and sector, the study employed a bottom-up aggregation approach using the data from national studies. Rather than relying on a single top-down model, this method builds EU-level estimates from the "ground up" by combining country-specific findings. The advantage of this bottom-up approach is that it incorporates detailed, context-specific information from each country's analysis (for example, local infrastructure costs or specific adaptation measures), providing a more nuanced picture of adaptation needs.

The studies currently included as input for the calculations as listed in Box 2.1 below. It should be noted that the calculation sheets have been designed in a way that new source studies can be added at a later stage, with the overall results updating automatically. Thus, while at the current stage only the studies in the box have been included, this can be expanded in the future.

Box 2.1 Overview of national studies used as basis for deriving values for cost of adaptation

Transport

Confederation of Swedish Enterprise. (2024). Klimatanpassning av transport-infrastruktur. [SWEDEN]

Cour des comptes. (2024). L'action publique en faveur de l'adaptation au changement climatique ? [FRANCE]

I4CE. (2024). Anticiper les effets d'un réchauffement de +4°C : quels coûts de l'adaptation [FRANCE]

Ministero delle Infrastrutture e della Mobilità Sostenibili. (2022). Cambiamenti climatici, infrastrutture e mobilità sostenibile: Rischi climatici per le infrastrutture di trasporto. [ITALY]

Ministry of Environment and University of Tartu (2015). Assessment of climate change impacts and development of adaptation measures in spatial planning, land use, human health, and rescue capacity [ESTONIA]

National Institute of Economic Research. (2017). Kostnader och intäkter i Sverige av långsiktiga klimatförändringar – en litteraturöversikt (Specialstudie nr 60) [SWEDEN]

Perrels, A., Haakana, J., Hakala, O., Kujala, S., Láng-Ritter, I., Lehtonen, H. (2022). Kustannusarviointi ilmastonmuutokseen liittyvästä toimimattomuudesta (KUITTI) [Assessment of the cost of inaction regarding climate change (KUITTI)] (Valtioneuvoston selvitys- ja tutkimustoiminnan julkaisusarja, 2022:37). Helsinki, Finland. [FINLAND]

Steininger, K. W., König, M., Bednar-Friedl, B., Kranzl, L., Loibl, W., & Prettenthaler, F. (Eds.). (2015). Economic evaluation of climate change impacts: Development of a cross-sectoral framework and results for Austria. [AUSTRIA]

Universitatea din București, Garda Națională de Mediu, & Administrația Națională de Meteorologie. (n.d.). Proiect „Consolidarea capacității instituționale și a resurselor umane pentru implementarea măsurilor de adaptare la schimbările climatice în România". [ROMANIA]

Energy

Cour des comptes. (2024). L'action publique en faveur de l'adaptation au changement climatique ? [FRANCE]

Feyen, L., Ciscar, J. C., Gosling, S., Ibarreta, D., & Soria, A. (Eds.). (2020). Climate change impacts and adaptation in Europe: JRC PESETA IV final report (EUR 30180 EN). Publications Office of the European Union. https://doi.org/10.2760/171121 [FRANCE and SPAIN]

Fondazione per lo Sviluppo Sostenibile. (2019). Relazione sullo stato della green economy 2019: Focus sugli impatti economici dei cambiamenti climatici in Italia. [ITALY]

Forzieri, G., Bianchi, A., Batista e Silva, F., Marin Herrera, M. A., Leblois, A., Lavalle, C., … Feyen, L. (2018). Escalating impacts of climate extremes on critical infrastructures in Europe. *Global Environmental Change, 48*, 97–107. https://doi.org/10.1016/j.gloenvcha.2017.11.007 [BELGIUM and ITALY]

Ministry of Environment and University of Tartu (2015). Assessment of climate change impacts and development of adaptation measures in spatial planning, land use, human health, and rescue capacity [ESTONIA]

Ministry of Environmental Protection and Green Transition. (2017). Climate change adaptation strategy in the Republic of Croatia for the period up to 2040 with a view to 2070. [CROATIA]

Steininger, K. W., König, M., Bednar-Friedl, B., Kranzl, L., Loibl, W., & Prettenthaler, F. (Eds.). (2015). Economic evaluation of climate change impacts: Development of a cross-sectoral framework and results for Austria. [AUSTRIA]

World Bank Group. (2024). Climate adaptation costing in a changing world. [CROATIA and ROMANIA]

Agriculture

Federation of Swedish Farmers. (2023). Costs of the green transition in agriculture: A Swedish example (Food Policy Report No. 1). Retrieved from https://www.lrf.se/media/tmsnxv15/ny_eng_gron_omstallning_webb.pdf

I4CE. (2024). Anticiper les effets d'un réchauffement de +4°C : quels coûts de l'adaptation [FRANCE]

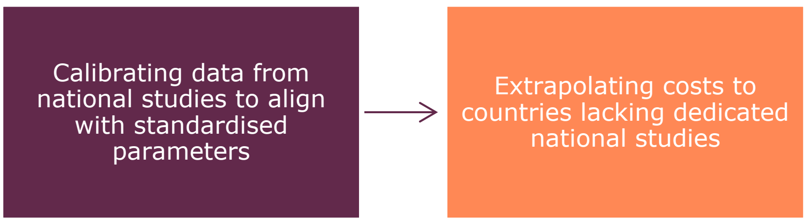
Steininger, K. W., König, M., Bednar-Friedl, B., Kranzl, L., Loibl, W., & Prettenthaler, F. (Eds.). (2015). Economic evaluation of climate change impacts: Development of a cross-sectoral framework and results for Austria. [AUSTRIA]

However, because the collected studies differed in scope and assumptions, the project introduced a calibration step to harmonise these diverse inputs. In essence, each national study's results were adjusted to a common set of reference assumptions – notably aligning them to consistent climate scenarios, adaptation ambition levels, covered hazards, and time frames.

Once calibrated, these results were aggregated, and for countries where no suitable study was available, the team extrapolated values using proxy metrics, ensuring no Member State or sector was left out.

This process is summarised in the Figure below.

Figure 2.2 Overall process and methodology of the study



This calibrated and extrapolated compilation yielded an approximate annual adaptation cost for each country in the transport, energy, and agriculture sectors, under both a moderate emissions scenario and a high emissions scenario (reflecting different levels of future climate change). The following sub-section details the technical steps of this methodology.

2.3.1 Calibration of National Adaptation Cost Studies for EU-Level Aggregation

2.3.1.1 Introduction

Overview of parameters used for calibration

Each collected national adaptation cost estimate was first aligned to common assumptions before comparison or summation. Four key parameters were standardised during calibration:

- Climate change / emission scenarios
- Adaptation scenarios
- Hazard coverage
- Time horizons

We chose those as calibration parameters because these dimensions significantly influence the results reported by national adaptation cost studies.

Emission scenarios are essential for calibration because varying emission pathways (such as different SSP-RCP combinations) directly impact climate projections and consequently adaptation needs. Without harmonising emission scenarios, cost comparisons across studies would reflect methodological differences rather than actual adaptation requirements.

Similarly, adaptation scenarios differ substantially between studies, ranging from incremental to transformational measures, affecting the scale and type of investments considered. Harmonising these assumptions allows consistent assessment of adaptation responses over time. In fact, as pointed out in I4CE (2024), the choice and definition of the adaptation scenario may overall have the most important impacts on the cost of adaptation in the end.

Hazard coverage was also selected as a parameter because studies frequently address only subsets of relevant climate hazards, thus necessitating standardisation to ensure all pertinent climate risks are consistently evaluated.

Finally, we included time horizons as a calibration parameter to distinguish clearly between medium-term and long-term adaptation requirements, given the evolving nature and scale of climate impacts and adaptation responses over different periods.

For each of these parameters, specific target values were chosen to achieve methodological harmonisation.

Disclaimer

It is important to highlight that definitive, universally applicable numerical coefficients for calibrating climate change adaptation finance needs across diverse studies is not feasible without an in-depth, project-specific empirical analysis of those studies and relevant sectoral/regional impact literature. The values of such coefficients are highly context dependent.

All calibration coefficients presented in this analysis have been developed based on the best available data and well-founded assumptions. We acknowledge that alternative approaches are possible, and that the results should be interpreted with appropriate caution.

Accordingly, the estimates presented here are best viewed as order-of-magnitude indicators of adaptation needs rather than precise monetary requirements.

To reflect underlying uncertainties, ranges have been provided for all coefficients where applicable, and the assumptions underpinning each calibration are documented transparently. This ensures that the analysis remains traceable, consistent, and open to future refinement.

Parameters not used for calibration

Conversely, the project opted not to apply the same calibration approach for parameters such as the coverage of different types of adaptation and sector definitions or scopes.

We excluded the calibration of types of cost adaptation (e.g., some studies only cover anticipation costs and others only reaction costs) due to their inherent variability in local contexts and difficulties in establishing universally applicable standardisation criteria.

Similarly, sector definitions and scopes were deliberately left uncalibrated because these are typically driven by national policy contexts, data availability, and sector-specific nuances, making standardisation impractical within the limited resources available in the project and potentially distorting local realities.

Focusing calibration efforts on the previously identified parameters provided the optimal balance between methodological consistency and practical applicability, yielding robust and comparable adaptation cost assessments across Member States.

2.3.1.2 *Emissions Pathway Calibration*

Situation

Studies use climate scenarios from the Shared Socioeconomic Pathways (SSPs) and Representative Concentration Pathways (RCPs), particularly SSP1-2.6 (low-emission, Paris Agreement-aligned) and SSP3-7.0 (high-emission, fossil fuel-reliant). Some studies use older RCP-based frameworks (e.g., RCP4.5, RCP8.5).

Target

The goal was to calibrate results from all studies to two different scenarios;

- A moderate emissions scenario, and
- High-emission, fossil fuel-intensive scenario

We selected a moderate emissions scenario and a high-emission scenario to capture a realistic range of potential future climate conditions, providing a robust basis for comparing adaptation needs across different plausible climate futures.

Approach

Adaptation finance needs rise steeply with higher warming. Available EU analyses suggest that annual adaptation investment needs double going from 1.5°C to 2°C, and roughly quadruple by 3-4°C. As stated by the EEA (based on Peseta IV[1] and COACCH):

"In the scenario of limiting the global temperature increase to 1.5°C, the estimated adaptation investments are around EUR 40 billion per year (for the EU-27 and the UK). In the scenario with a 2°C global temperature rise, the total investment needs are estimated at around EUR 80-120 billion per year. In the scenarios with an increase of 3-4°C, the investment needs will increase to EUR 175-200 billion per year".[2]

[1] PESETA IV estimates additional annual welfare losses (i.e., modelled 'cost of inaction' from selected impacts) for the EU+UK of €42 bn at 1.5°C, €83 bn at 2°C and €175 bn at 3°C (PESETA IV economic analysis, Table 7 / summary results). In line with the interpretation by EEA (see below), this methodology uses these values as a proxy for the scale and scaling of the economic losses that adaptation would need to avoid/contain (and thus an indicative benchmark for investment needs), noting however they are not direct estimates of adaptation expenditure.

[2] See: https://www.eea.europa.eu/publications/assesing-the-costs-and-benefits-of

This implies large scaling between scenarios: studies under moderate pathways should be scaled down when aligning to Paris-compliant scenario and scaled up when aligning to high emission scenarios.

Based on the estimates shown above, we use the calibration factors as presented in the Figures below.

Figure 2.3 Emissions Pathway Calibration towards moderate scenario

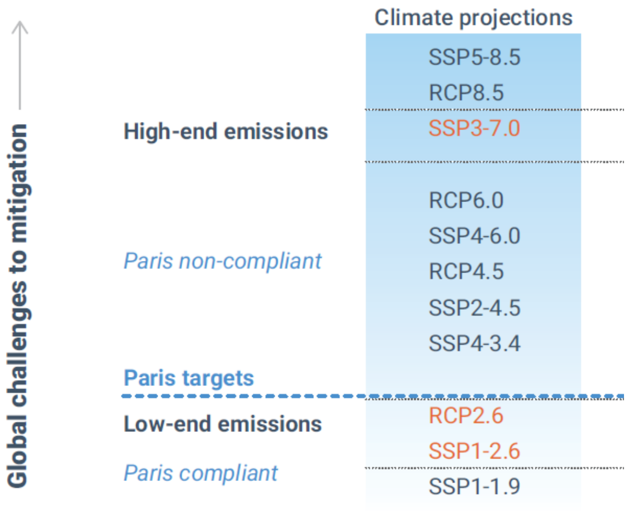
From	To	Conversion factors	
		Lower range	**Upper range**
Paris (RCP2.6/SSP1-2.6)	Moderate (RCP4.5/SSP2-4.5)	2.0	3.0
Moderate (RCP4.5/SSP2-4.5)	Moderate (RCP4.5/SSP2-4.5)	1.0	1.0
High (RCP8.5/SSP5-8.5/SSP3-7.0)	Moderate (RCP4.5/SSP2-4.5)	0.4	0.7
Unknown	Moderate (RCP4.5/SSP2-4.5)	1.0	1.0

Figure 2.4 Emissions Pathway Calibration towards high scenario

From	To	Conversion factors	
		Lower range	**Upper range**
Paris (RCP2.6/SSP1-2.6)	High (RCP8.5/SSP5-8.5/SSP3-7	4.4	5.0
Moderate (RCP4.5/SSP2-4.5)	High (RCP8.5/SSP5-8.5/SSP3-7	1.5	2.5
High (RCP8.5/SSP5-8.5/SSP3-7.0)	High (RCP8.5/SSP5-8.5/SSP3-7	1.0	1.0
Unknown	High (RCP8.5/SSP5-8.5/SSP3-7	1.5	2.5

For the classification of the scenarios into low, moderate, high, the classification of "cornerstone scenarios" provided by EUCRA as shown in the Figure below was used.

Figure 2.5 EUCRA cornerstone scenarios



Source: EEA (2024)

Approach when no information on the scenario could be derived from the source study

In those cases where the scenario is unknown, it is assumed that the study used a moderate scenario.

2.3.1.3 *Adaptation Scenario Calibration*

Situation

Adaptation cost estimates depend on the assumed level of protection, i.e. the adaptation scenario.

Existing studies take different approaches in defining adaptation scenarios (if even stated), including

- Baseline or 'Business as usual' scenario: Some studies quantify the costs of climate change assuming no or minimal adaptation, including current adaptation policies without additional efforts, providing a reference point for assessing adaptation benefits;
- Incremental adaptation: Many studies focus on moderate, gradual adjustments to infrastructure, policies, or behaviours (e.g., improving drainage systems, enhancing early warning systems)
- Mixed adaptation: Some studies explore a combination of incremental and transformational adaptation, with incremental measures dominating in the mid-term and a mix of incremental and transformational approaches applied in the long term (until 2100).

Under IPCC definitions[3], incremental adaptation makes modest changes to maintain existing systems (e.g. improved irrigation, new crop varieties), whereas transformational adaptation changes fundamental system attributes (e.g. shifting livelihoods or migrating).

Target

A standardised adaptation assumption - incremental adaptation in the medium term (up to 2050) and mixed or transformational adaptation in the long term (between 2050 and 2100) - was chosen to reflect typical policy planning horizons and realistic progression from current policies towards necessary transformative measures as climate impacts intensify.

Thus, the target policy assumes incremental adaptation up to 2050 and mixed/transformational adaptation 2050–2100.

Selecting incremental adaptation through to 2050 reflects the near-term focus of most national policies and the pragmatic improvements - such as upgraded drainage, enhanced early-warning systems and revised building codes - that can be planned and financed within existing institutional frameworks. Beyond mid-century, it is assumed that the scale and irreversibility of climate impacts will outstrip what incremental measures alone can address; hence, a shift to mixed/transformational adaptation between 2050 and 2100 is expected to be both necessary and inevitable.[4]

However, it should be noted that most published studies so far have focused on incremental measures.

[3] See: https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-Chap14_FINAL.pdf

[4] See also e.g. Bloemen et al. (2018) which mention that a wide range of adaptation pathways analysed by the authors agreed "on the need to switch, at some time in the future, from incremental to transformational strategies". Regarding the timeline, following IPCC AR6 framing, the methodology uses 2050 as a practical boundary between mid-term and long-term horizons (mid-term up to 2050; long-term from 2050 onward)

Approach

Disclaimer

The calibration of adaptation scenarios in this analysis is based on generalised interpretations of common categories such as "no adaptation", "incremental adaptation", and "transformational adaptation". However, it is important to note that these categories are not consistently or clearly defined across studies, and often reflect varying assumptions about timing, scope, ambition, and sectoral coverage. This lack of standardisation introduces an additional layer of uncertainty into the calibration process. To mitigate these limitations, we have applied broad ranges to the proposed calibration coefficients and transparently documented the underlying assumptions. Nonetheless, the results must be interpreted with care, as differences in how adaptation is conceptualised and modelled across studies may influence outcomes beyond what can be fully adjusted through scaling.

As starting point for the calculations in the study, baseline adaptation is understood as current practices with only partial uptake of adaptation measures. Most adaptation is reactive or limited in scope.

Incremental adaptation is understood as climate-proofing existing systems through gradual adjustments, maintaining the same basic structures and functions. By contrast, transformational adaptation are fundamental, systemic changes or rapid overhauls in anticipation of climate change.[5]

In practical terms, incremental measures are typically integrated into routine asset management – for example, upgrading infrastructure to resilient standards at the end of its normal life – whereas transformational strategies aim to accelerate or leap-frog these cycles to drastically reduce climate vulnerabilities.

Using this assumption, a bottom-up way to calibrate the scenarios is by using asset lifespans (L) to estimate annual replacement or upgrade rates.

Under an incremental scenario, adaptation is woven into standard renewal cycles, roughly replacing or retrofitting about 1/L of assets per year.

The Box below presents reflections on lifespans and replacement rates per sector.

Box 2.2 Estimates for lifespans and replacement rates per sector

Transport

Major transport infrastructure often has very long service lives – e.g. bridges are designed for 50–100 years, and rail tracks 50 years, and road surfaces might be renewed every 10–20 years[6]. This means a large share of transport assets will still be in service for decades before normal renewal.

In the baseline scenario, with only partial and reactive adaptation, a relatively small fraction of the total network might be climate-proofed by a given time (many assets won't yet be upgraded or are upgraded to only minimal standards).

In the incremental scenario, every time a road, bridge, or rail is due for replacement or major rehabilitation, it is upgraded with full adaptation measures (e.g. higher design standards for floods/heat).

However, even this scenario only rolls out as fast as assets come up for renewal – constrained by long lifespans. The mixed scenario goes further by selectively fast-tracking or overhauling the most climate-vulnerable transport infrastructure even if it is not yet due for replacement (for example, relocating a frequently flooded road segment or constructing new flood defences for key rail lines). These transformative measures add cost above the incremental level.

[5] See box 3 in https://civil-protection-knowledge-network.europa.eu/system/files/2024-05/EDPP2_C2%20CCA%20Cost%20report.pdf

[6] [See https://www.ucs.org/sites/default/files/attach/gw-smart-infrastructure-table-life-expectancy.pdf]

Energy

Energy infrastructure also has multi-decade lifespans. Power generation facilities and grid components often last on the order of 30–50 years (e.g. transformers 40 years, transmission lines 50 years[7]).

In the baseline case, some adaptation is happening (e.g. new power plants might consider future climate to some extent, and some critical grid upgrades are made), but it is uneven.

The incremental scenario assumes that all scheduled asset replacements or new installations in the energy sector are built to climate-resilient standards – for instance, new substations are elevated or better cooled, and all new lines are hardened against storms. Over a few decades, this could climate-proof a large portion of assets, especially as the energy sector is rapidly evolving (retiring old coal plants, adding renewables, etc.).

The mixed scenario adds transformative actions for high-risk elements: e.g. relocating facilities from flood-prone sites, building additional redundancy (backup power lines, energy storage) specifically to handle extreme events, or other major shifts. These selective investments raise the cost beyond incremental integration.

Agriculture

Many agricultural adaptation measures have much shorter cycle times. Cropping decisions are made seasonally, and farm equipment or practices might update on a scale of years. Thus, adaptation in agriculture can occur relatively quickly compared to heavy infrastructure – for example, switching to drought-resistant crop varieties or improving on-farm water management can be done within a few years.

In a baseline scenario, however, only partial adoption occurs – perhaps large commercial farms adopt new practices while others continue with current methods, or only cheap, no-regret measures are taken.

Incremental adaptation scenario implies near-full integration of climate adaptation into agricultural practices and investment cycles: essentially all farmers and agribusinesses routinely incorporate climate considerations (such as soil conservation, efficient irrigation, climate-smart crop choices) as they update their operations. Because of faster turnover and the pressing need to respond to climate variability each season, the gap between baseline and full (incremental) adoption in agriculture is narrower than in infrastructure sectors.

The mixed scenario for agriculture would involve transformational steps in the most vulnerable areas – for instance, building new large-scale irrigation infrastructure or fundamentally changing land use (like transitioning some cropland to a different use or relocating agriculture away from areas that become untenable). These measures are costly and go beyond normal farm-level adjustments, but they would only be done selectively where absolutely necessary.

Incremental adaptation would thus upgrade roughly 1–3% of stock per year in transport and energy (matching these long lifespans), and perhaps a higher fraction in agriculture (shorter-lived assets). This leverages “opportunistic” adaptation – taking advantage of scheduled renewals to add resilience at marginal extra cost.

Under a transformational scenario, one assumes a compressed timeline – for example, replacing or climate-proofing the entire capital stock within 10 years. This implies an annual replacement rate on the order of 10% of assets per year, far above normal depreciation.

Mixed adaptation accelerates some adaptation efforts by integrating both incremental measures and some upfront investments for systemic improvements but does not fully replace the entire system in a single decade. Splitting the difference, for mixed adaptation it can be assumed that 5–7% of the capital stock is upgraded per year, reflecting both ongoing renewal and targeted upgrades for high-risk areas.

[7] [Idem]

Based on the above assumptions, the table below presents the proposed coefficients between scenarios for each sector, based on the sector-specific considerations above.

For example, a factor of 1.4 for baseline → incremental in transport means the fully integrated (incremental) adaptation scenario costs about 40% more than the baseline partial-adaptation scenario for transport, reflecting the higher uptake of adaptation measures.

In contrast, a factor of 0.83 for mixed → incremental (the inverse of 1.2) means the mixed scenario costs 17% more than incremental for that sector (so incremental costs are 0.83 of mixed costs).

The Figures below present the derived coefficients based on those considerations.

Figure 2.6 Adaptation scenario calibration towards 2050

From	To	Transport conversion factors		Energy conversion factors		Agriculture conversion factors	
		Lower	Upper	Lower	Upper	Lower	Upper
No adaptation (baseline)	Incremental / medium adaptation	1.3	1.5	1.2	1.4	1.0	1.2
Incremental / medium adaptation	Incremental / medium adaptation	1.0	1.0	1.0	1.0	1.0	1.0
Mix of incremental and transformative	Incremental / medium adaptation	0.8	0.9	0.8	1.0	0.8	0.9
Unknown	Incremental / medium adaptation	1.0	1.0	1.0	1.0	1.0	1.0

Figure 2.7 Adaptation scenario calibration between 2050 and 2100

From	To	Transport Conversion factors		Energy conversion factors		Agriculture conversion factors	
		Lower	Upper	Lower	Upper	Lower	Upper
No adaptation (baseline)	Mix of incremental and transformative	1.6	1.8	1.4	1.6	1.1	1.3
Incremental / medium adaptation	Mix of incremental and transformative	1.1	1.3	1.1	1.3	1.0	1.2
Mix of incremental and transformative	Mix of incremental and transformative	1.0	1.0	1.0	1.0	1.0	1.0
Unknown	Mix of incremental and transformative	1.1	1.3	1.1	1.3	1.0	1.2

Approach when no information on the scenario could be derived from the source study

In those cases where the scenario is unknown, it is assumed that the study used an incremental / medium adaptation.

2.3.1.4 *Hazard Scope Calibration*

Situation

National studies often cover a subset of climate hazards.

Target

Try to account for as many hazards as possible.

Approach

Disclaimer

The hazard-calibration factors used in this study are indicative and should be interpreted with caution. They were derived under data constraints and incorporate several simplifying assumptions:

- Reliance on sector-specific proxy sources: Because no single, EU-wide dataset exists that quantifies adaptation finance needs by hazard and by sector, we combined different studies for each sector (Forzieri et al. 2018 for transport and energy; EAFRD insurance data for agriculture). These sources employ varying methodologies, time-frames and hazard definitions, which may introduce inconsistencies across sectors.
- Static weights based on past or modelled impacts: The hazard shares reflect historical losses or current-generation risk assessments. They do not capture future shifts in hazard frequency or intensity under climate change, nor do they account for spatial variations in hazard relevance within a Member State.
- Conservative 50 % multiplier for uncovered hazards: Where a national study excluded certain hazards, we added the missing share but applied a 0.5 reduction factor to avoid over-estimating costs. This blanket adjustment may still overstate or understate needs in specific contexts, depending on local infrastructure sensitivity and the effectiveness of multi-hazard measures.
-

To aggregate up to EU-wide risk, we scale results to represent a multi-hazard portfolio.

In calibrating for hazard coverage, we apply a scaling approach that accounts for the share of relevant climate hazards included in each study. Rather than assuming equal importance across all hazards, we sought to weight them according to their relative impact on each sector. While historical damage data by hazard - such as those published by the European Environment Agency (EEA) - were initially considered as a basis, these data are not disaggregated by sector. Given the substantial differences in how individual hazards affect sectors such as transport, energy and agriculture, relying solely on aggregated damage data was deemed inappropriate.

Instead, sector-specific proxy data were identified from relevant literature. For the energy and transport sectors, we drew on the study by Forzieri et al. (2018)[8], which assesses climate risk to certain sectors across Europe broken down by hazard.

For the agriculture sector, we based our hazard distribution on the European Agricultural Fund for Rural Development (EAFRD) report titled "Insurance and Risk Management Tools for Agriculture in the EU"[9]. This comprehensive analysis compiled data from insurance schemes and public risk management instruments across the EU, mapping out the relative importance of different climate hazards - such as droughts, floods, hailstorms, and frost - based on farmers' reported claims and payouts. The study captures sector-specific realities by integrating economic impacts on crop yields, livestock health, and overall farm productivity.

While it would have been preferable to identify a single, consistent study covering hazard distributions across all sectors - thereby ensuring methodological coherence between transport, energy, and agriculture - no such comprehensive assessment was found. Therefore, sector-specific studies have been used, which, while still consistent and comparable, might introduce minor differences in hazard definitions or assessment methods across sectors.

From each study, we derived the relative shares of different hazards in terms of their observed or modelled impact on the respective sector. These sector-specific distributions serve as the basis for our hazard-weighting methodology.

[8] Escalating impacts of climate extremes on critical infrastructures in Europe https://www.sciencedirect.com/science/article/pii/S0959378017304077

[9] See: https://www.fi-compass.eu/sites/default/files/publications/EAFRD_AGRI_Insurance_Risk_MA.pdf

It is important to recognise why certain hazards may not be included in individual studies. In many cases, exclusions are due to methodological or data limitations - such as insufficient exposure mapping or a lack of models to capture specific hazard types. Our approach seeks to compensate for these gaps by scaling the results in proportion to the estimated importance of the hazards that were not originally addressed.

In some cases, however, certain hazards may genuinely be irrelevant for the specific assets, geographies or systems covered by a study. For instance, heatwaves may not be as pertinent in Northern countries as in southern EU countries. Applying a full hazard-scaling factor in such cases could overstate adaptation needs. Moreover, several adaptation measures - such as upgrading drainage infrastructure or strengthening building standards - can mitigate multiple hazards simultaneously, thus reducing the incremental cost of addressing each hazard in isolation.

To reflect these nuances, we apply a conservative adjustment to our scaling method: the contribution of any hazards not originally covered in a study is reduced by 50%, acknowledging both the possibility of their partial irrelevance and the likely overlap in adaptation benefits.

This 0.5 multiplier is applied only to the uncovered share of sector-specific hazard exposure, while maintaining full weight for hazards already included in the study. The final scaling factor is structured such that it never reduces the adaptation cost reported in the original study, but instead moderates the potential increase implied by extending hazard coverage in a more realistic, proportionate way.

Figure 2.8 Hazard scope calibration - Transport

Coverage					
82%	0.3%	17%			
Heatwaves	**Droughts**	**River floods**	**Percentage**	**Before 0.5 multiplier**	**After 0.5 multiplier**
y	y	y	100%	1.0	1.0
y	y		83%	1.2	1.1
y			82%	1.2	1.1
	y	y	18%	5.7	1.7
		y	17%	5.8	1.7
y		y	100%	1.0	1.0
	y		0%	327.6	2.0

Figure 2.9 Hazard scope calibration – Energy

Coverage					
29%	63%	9%			
Heatwaves	**Droughts**	**River floods**	**Percentage**	**Before 0.5 multiplier**	**After 0.5 multiplier**
y	y	y	100%	1.0	1.0
y	y		91%	1.1	1.0
y			29%	3.5	1.6
	y	y	71%	1.4	1.2
		y	9%	11.4	1.8
y		y	37%	2.7	1.5
	y		63%	1.6	1.2

Figure 2.10 Hazard scope calibration – Agriculture

Coverage						
54%	9%	21%	16%			
Drought	Hail	Heavy rain	Frost	Percentage	Before 0.5 multiplier	After 0.5 multiplier
y	y	y	y	100%	1.0	1.0
y	y	y		84%	1.2	1.1
y	y		y	79%	1.3	1.1
y	y			63%	1.6	1.2
y		y	y	91%	1.1	1.0
y		y		75%	1.3	1.1
	y	y	y	46%	2.2	1.4
y			y	70%	1.4	1.2
	y	y		30%	3.3	1.5
y				54%	1.9	1.3
	y		y	25%	4.0	1.6
	y			9%	11.1	1.8
		y	y	37%	2.7	1.5
		y		21%	4.8	1.7
			y	16%	6.3	1.7

2.3.1.5 Combining different calibration factors

The mathematical approach chosen to combine different calibration coefficients is to multiply them. This is standard practice in modelling when adjusting a base value for multiple, independent scaling factors.

Benefits of this approach include the following:

- **Independence**: Each coefficient adjusts the result based on a separate dimension. Multiplication maintains the independence of effects.
- **Proportionality**: If a cost should be double due to more severe climate scenarios, and increase by 30% due to broader hazard coverage, the combined effect should be multiplicative
- **Scalability**: This allows for straightforward scaling and sensitivity analysis by varying one coefficient at a time.

The general formula used is thus as follows:

Adjusted cost = Original cost × emission pathway coefficient x adaptation scenario coefficient x hazard coefficient

However, it is also acknowledged that applying several calibration factors multiplicatively can amplify uncertainty.

To mitigate compounding bias, the study took the following steps:

- **Preserve proportionality:** We ensured that the total scaling factor stays in a plausible range. If the product of factors exceeds 5 this is highlighted in the calculation matrix, and it was assessed on a case by case basis if the calibration can still be considered proportional
- **Document each step:** In the calculation matrix of the project, we clearly note each calibration applied (e.g. "Study X was scaled ×0.5 for emission scenario and ×2.3 for hazards, total ×1.15") and the rationale.
- **Consistency:** We apply the same calibration logic to all studies in the EU ensemble
- **Sensitivity checks:** We systematically vary the coefficients within plausible ranges to assess how changes affect the overall results benefits and thereby test the robustness of the conclusions

- **Uncertainty communication:** When presenting the cost estimates, we show the span of calibrated values (min–max) and note that much of the spread comes from the applied coefficients.

2.3.2 Extrapolation to countries without national studies

2.3.2.1 Introduction

For countries lacking dedicated adaptation-cost studies, we first calibrate all existing national results to our common EU target (using the defined emissions, adaptation and hazard coefficients) as described in the last chapter.

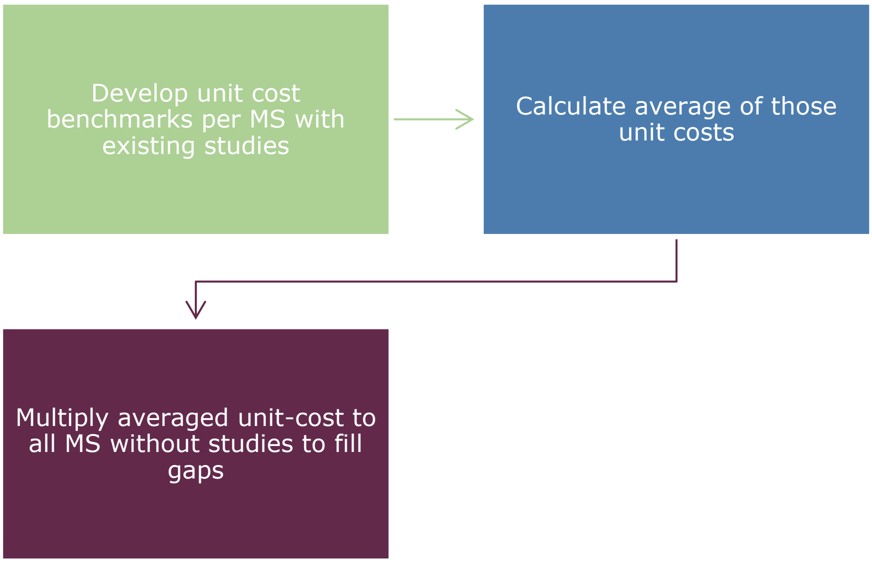
Then, we derive "unit-cost" benchmarks that can be extrapolated to the missing Member States. Specifically, once each study has been adjusted, we divide its total calibrated cost by a relevant metric which will then provide us with a unit cost.

We then obtain a simple arithmetic average of those unit costs across all Member States with studies, yielding an averaged benchmark figure for the outputs per sector (e.g. for different target emission pathways, associated high/low bounds).

Then, the averaged unit-cost is multiplied by the respective metric in each country lacking a study to produce an extrapolated sectoral cost estimate fully consistent with our methodology.

The process is summarised in the Figure below.

Figure 2.11 Overview of extrapolation process



By clearly documenting this "calibrate-then-average unit cost-then-extrapolate" workflow, we ensure transparency, methodological consistency and a replicable basis for future updates.

2.3.2.2 Metrics used for extrapolation

For the metric used to derive unit costs and subsequently extrapolate adaptation finance needs to countries without studies, the study team initially considered using sector-specific exposure metrics. These included total utilised agricultural area (UAA) in hectares for agriculture, installed generation capacity in megawatts for energy, and total length of the transport network in kilometres for the transport sector. These metrics, combined with calibrated unit costs, would allow for a straightforward, sector-by-sector extrapolation.

However, this approach presented some notable shortcomings. First, the use of different metrics for each sector resulted in inconsistencies in how adaptation finance needs were normalised, which complicated comparisons across sectors. Second, the lack of a consistent, economy-based exposure metric made it challenging to integrate results into a coherent EU-wide assessment.

To address these challenges, the study eventually uses Gross Value Added (GVA) per sector as the metric for extrapolation. This harmonised, monetary-based approach ensures methodological consistency between sectors, while also capturing the relative economic importance of each sector within each Member State.

Existing studies in various countries such as France (I4CE, 2024) and the UK (Watkiss, 2023) tend to show that there is a certain proportionality between the economic weight of a sector (which can be estimated by its GVA) and the resources required for adaptation in that sector. Such a relationship seems logically consistent: the greater the economic weight of a sector affected by climate change, the greater the risk of loss. The willingness to invest in reducing vulnerability upstream and limiting risk will therefore be greater. In other words, people are logically willing to pay more to protect what is more valuable. Of course, this reasoning must be adjusted according to the level of risk: people are also willing to pay more to protect what is more vulnerable or more exposed because the chances that this investment will be useful are higher. In a logic of incremental adaptation, the need for adaptation often corresponds to a fraction (which varies from sector to sector) of existing investment flows in the sector. For infrastructure, for example, this involves additional costs to ensure that renewal and modernisation programs are resilient by design. Unless we consider truly transformative adaptation scenarios, adaptation rarely disrupts the existing balance in terms of resource allocation. All other things being equal (in particular, considering that there are no major differences in risk levels), it is therefore consistent to use an economic indicator as a proxy to extrapolate adaptation needs for a given sector.

The concrete datasets used per sector are the following:[10]

- **Transport**: Value added, gross; current prices, million euro; NACE code H49 "Land transport and transport via pipelines"; data from 2022 (latest complete dataset available)
- **Energy**: Value added, gross; current prices, million euro; NACE code D35 "Electricity, gas, steam and air conditioning supply"; data from 2022 (latest complete dataset available)
- **Agriculture**: Value added, gross; current prices, million euro; NACE code A01 "Crop and animal production, hunting and related service activities"; data from 2022 (latest complete dataset available)

The Figure below shows the used values as derived from EUROSTAT.

[10] All can be accessed on EUROSTAT under the following link:
https://ec.europa.eu/eurostat/databrowser/view/nama_10_a64__custom_16961107/default/table?lang=en

Figure 2.12 Metric used for extrapolation

Country	Metric		
	GVA Transport	GVA Energy	GVA Agriculture
Austria	10,338 MEUR	8,180 MEUR	4,503 MEUR
Belgium	9,958 MEUR	9,629 MEUR	3,772 MEUR
Bulgaria	2,208 MEUR	6,419 MEUR	2,808 MEUR
Croatia	1,413 MEUR	933 MEUR	1,949 MEUR
Cyprus	171 MEUR	261 MEUR	276 MEUR
Czech Republic	7,039 MEUR	9,937 MEUR	4,662 MEUR
Denmark	5,008 MEUR	4,154 MEUR	2,672 MEUR
Estonia	846 MEUR	1,649 MEUR	469 MEUR
Finland	4,856 MEUR	6,729 MEUR	1,922 MEUR
France	42,945 MEUR	29,636 MEUR	41,985 MEUR
Germany	59,179 MEUR	74,584 MEUR	35,641 MEUR
Greece	3,092 MEUR	9,876 MEUR	6,913 MEUR
Hungary	4,140 MEUR	1,763 MEUR	4,951 MEUR
Ireland	4,224 MEUR	3,616 MEUR	5,430 MEUR
Italy	38,383 MEUR	33,259 MEUR	34,532 MEUR
Latvia	1,211 MEUR	944 MEUR	902 MEUR
Lithuania	4,788 MEUR	1,385 MEUR	2,067 MEUR
Luxembourg	1,561 MEUR	487 MEUR	181 MEUR
Malta	115 MEUR	393 MEUR	53 MEUR
Netherlands	15,483 MEUR	16,474 MEUR	15,770 MEUR
Poland	22,516 MEUR	18,784 MEUR	16,385 MEUR
Portugal	4,301 MEUR	1,767 MEUR	3,089 MEUR
Romania	14,537 MEUR	11,878 MEUR	8,719 MEUR
Slovakia	3,652 MEUR	613 MEUR	1,284 MEUR
Slovenia	1,701 MEUR	1,480 MEUR	627 MEUR
Spain	28,114 MEUR	43,032 MEUR	29,341 MEUR
Sweden	10,512 MEUR	15,252 MEUR	3,689 MEUR

2.4 Deriving values for cost of inaction

2.4.1 Introduction

In contrast to adaptation finance needs, the cost of inaction was derived based on existing large-scale studies and models. The cost of inaction refers to the projected economic damages and losses that would occur in the absence of additional adaptation efforts – essentially, the price of doing nothing extra to prepare for climate change. Rather than calculating these figures anew, the project used prior research that has modelled climate change impacts on the European economy and specific sectors.

Using existing studies ensured that the inaction costs are grounded in comprehensive climate-impact modelling that accounts for complex interactions (e.g. how extreme weather might disrupt economic activity).

The methodology here involved extracting or compiling the relevant results from these studies for the transport, energy, and agriculture sectors, and then standardising them for use in the project since different studies focus on different hazards or time horizons. This ensured that the data from the studies align with the project’s scenarios.

2.4.2 Data Sources

The project identified the best available estimates of inaction costs from recent studies, namely:

- COACCH (2021) for the transport sector
- Ramboll, SEURECO & Ecologic Institute (2024) for the energy and agriculture sectors

The methodologies used in the two studies are shortly summarised in the two Boxes below.

Box 2.3 Overview of COACCH methodology for cost of inaction in the transport sector

The COACCH study estimated the "costs of inaction" in the transport sector using a sector-specific, hazard-driven approach focused on climate extremes. Regarding transport, it assessed damages to road transport infrastructure primarily from river flooding (identified as a key climate risk to transport alongside other extremes like heatwaves, droughts and storms). A continental-scale flood risk model was developed to simulate flood impacts on European roads, using climate projections under selected emissions and socioeconomic scenarios (notably RCP2.6, RCP4.5 with SSP2, and a high-end RCP8.5 with SSP5 scenario).

Expected annual damage (EAD) to road infrastructure was calculated in monetary terms for the EU as a whole, incorporating projected increases in exposed assets from socio-economic growth. These inaction costs represent direct physical damage with no adaptation measures assumed – i.e. a future in which transport networks are not additionally reinforced against climate hazards. Results were reported as EU-wide totals (undiscounted, in current prices) at mid-century and end-century. No country-level breakdown were available for transport, only aggregate EU damage estimates, although the study noted that impacts vary widely by region (with countries like Germany, France and Italy facing the highest road flood damages).

Box 2.4 Overview of the Ramboll methodology for cost of in action in the energy and agriculture sectors

Agriculture

The Ramboll study calculated inaction costs for the agriculture sector by examining climate change impacts on crop yields and agricultural production across EU Member States. It considered a range of climate hazards affecting agriculture, especially gradual temperature and precipitation shifts and an increased frequency of extremes such as droughts and heatwaves (including the effect of extreme heat on farm labour productivity). The approach drew on multiple specialised models and data sources. In particular, biophysical crop models were used to project yield changes for key crops, and these were combined with an agro-economic model (the European CAPRI model) to account for market responses and price effects. This allowed the estimation of economic losses due to climate-induced yield impacts, factoring in some autonomous adaptation (e.g. farmers altering crop varieties or planting dates in response to climate and market signals). Notably, the modelling included the beneficial effect of CO_2 fertilisation on crop growth in the biophysical simulations.

The inaction scenario for agriculture assumed no new proactive adaptation policies beyond such endogenous adjustments – for example, no expansion of irrigation or infrastructure beyond what was already considered in the baseline.

Under these conditions, the study produced Member State-specific projections of yield and output changes for future periods (e.g. 2030, 2050). The results indicated a wide range of possible outcomes, with median changes in EU crop yields that are relatively small but highly uncertain. These national-level impact estimates served as inputs to the macroeconomic analysis, representing the cost of inaction in the agriculture sector for each Member State.

Energy

For the energy sector, the Ramboll study evaluated climate inaction costs by looking at both energy demand and supply impacts due to global warming. On the demand side, rising average temperatures reduce the need for heating in colder months and increase the need for cooling in hotter months. Using a suite of energy-economy studies, the study derived changes in final energy demand for EU countries attributable to climate change. Overall, a net reduction in total energy demand is projected under inaction, as the decrease in winter heating outweighs the increase in summer air-conditioning. These demand-side impact estimates were based on scenario analyses under mid-range and high warming (e.g. RCP4.5 and RCP8.5), and were compiled with an assumption of no policy action to counteract increased cooling needs (aside from normal market-driven efficiency improvements).

On the supply side, the study considered how inaction in mitigating climate effects would impact energy production capacity and costs. Key climate stressors include changes in water availability (affecting hydropower generation and cooling water for thermal plants), temperature extremes (which can reduce power plant efficiency and transmission capacity), and altered wind and solar patterns. Ramboll synthesised findings from several technical studies on power generation potential under climate change – covering hydro, wind, solar, nuclear and thermal generation outputs. The overall expectation was that EU-wide effects on energy supply would be modest on average by mid-century, but with considerable uncertainty and regional variation.

The inaction cost assessment for energy did not assume any new adaptive measures like upgrades to infrastructure or changes in the generation mix beyond baseline trends. Nevertheless, the modelling inherently allowed some adaptive responses (for example, the energy market could invest in different capacity if one source becomes less reliable), so the "no adaptation" baseline here refers to the absence of explicit climate adaptation policies. The study provided Member State-specific estimates for these energy impacts, highlighting notable geographical differences – for example, Southern European regions were projected to face the largest increases in cooling demand (e.g. Greece's and Spain's power systems seeing strong summer peaks), whereas countries reliant on hydropower could experience varied outcomes depending on changes in rainfall patterns.

As can be seen, although both studies estimate "inaction costs" of climate change, their methodologies differ, affecting comparability.

The COACCH transport analysis is a bottom-up, impact-focused assessment of direct physical damages from a specific hazard (river flooding) on a single sector's infrastructure. It provides a narrow but concrete estimate of climate damage, albeit one that likely understates total transport-related costs since indirect effects (e.g. travel disruption, wider economic knock-ons) and other hazards (heat, storms, etc.) were only qualitatively noted.

In contrast, the Ramboll study takes a broader systems perspective for agriculture and energy: it aggregates numerous climate impact pathways (from gradual yield changes to energy supply shifts) and integrates them via economic models. This yields a richer picture of sectoral impacts – including market-mediated and second-order effects – and offers country-specific granularity, but it also introduces more uncertainty and complexity. Indeed, Ramboll's inputs came from different models and scenarios, resulting in wide ranges for possible outcomes (for example, EU crop yield projections diverging from significant losses to slight gains under various scenarios).

Assumptions around adaptation also differ: COACCH's transport cost projections explicitly assume no adaptation and report the reduction in damages in a separate optimal adaptation case, whereas Ramboll's sector analyses mostly assume no new adaptation beyond autonomous adjustments already captured in the models, and then examine adaptation benefits at a macro level. These distinctions imply that the two datasets should be used with caution when compared. The COACCH data provide high-resolution insight into infrastructure vulnerability but are limited in scope, while the Ramboll data cover a wider impact scope with internally consistent economic feedbacks, yet rely on cross-study synthesis.

For the project's purposes, this means any aggregation of inaction costs across sectors must account for the methodological gap – e.g. recognising that transport figures (COACCH) are conservative, direct-damage estimates, whereas agriculture and energy figures (Ramboll) reflect broader impact mechanisms with inherent uncertainties. All results should be interpreted in context, acknowledging their assumptions and uncertainty ranges, to ensure robust and credible conclusions for climate adaptation planning.

2.4.3 Deriving the values

Because the underlying sources differ by sector and by level of geographical detail, we adopted the most straightforward, transparent treatment possible for each case as summarised in the Table below.

Table 2.1 Overview of methodologies for deriving the values from the sources

Sector	Source & scenario	Temporal coverage in source	How we converted to annual Member-State series
Transport	COACCH project, *no-adaptation* scenario (expected-annual-damage values)	Two data points only: "2050s" and "2080s"	• No attempt was made to interpolate a full trajectory from just two observations since doing so would have been too speculative; instead, the reported mid-century and late-century figures are carried straight into the results as representative annual losses for those horizons. • Figures were only available at EU 27 level; to obtain country-level values the methodology prorated the EU total by each Member State's share of EU transport GVA, mirroring the extrapolation method used on adaptation finance needs.
Agriculture and energy	Ramboll (2024), *no-further-adaptation* scenario	Five-year intervals from 2020 to 2060, MS detail provided	• Linear interpolation fills in the intervening years • Because the study is delivered by country, no additional down-scaling was required.

2.5 Deriving values for current funding levels

2.5.1 Introduction

Accurately quantifying how much finance is presently directed to climate-change adaptation remains challenging: reporting frameworks are uneven, sectoral tags are rarely consistent, and private flows are only partially documented. To nevertheless deriver numbers, the study adopted a top-down approach that relies on published budget envelopes and transparent assumptions.

The study first identified the principal sources through which adaptation resources are channelled: EU-level instruments (e.g. the multi-annual budget, recovery facilities, cohesion and rural-development funds, dedicated climate programmes), public financial institutions, national and sub-national budgets, and private sources.

Within each source attempts were made to isolate the expenditure tagged as climate-relevant. Since in most cases climate finance is not broken down in adaptation or mitigation finance, evidence-based ratios were applied to distinguish adaptation from mitigation expenditure. This yields an indicative adaptation "slice" for every funding stream. Also, since most sources lines do not specify the end-use sector, the study allocated their adaptation share to transport, energy and agriculture using weighting factors derived from prior programming experience and sectoral investment patterns.

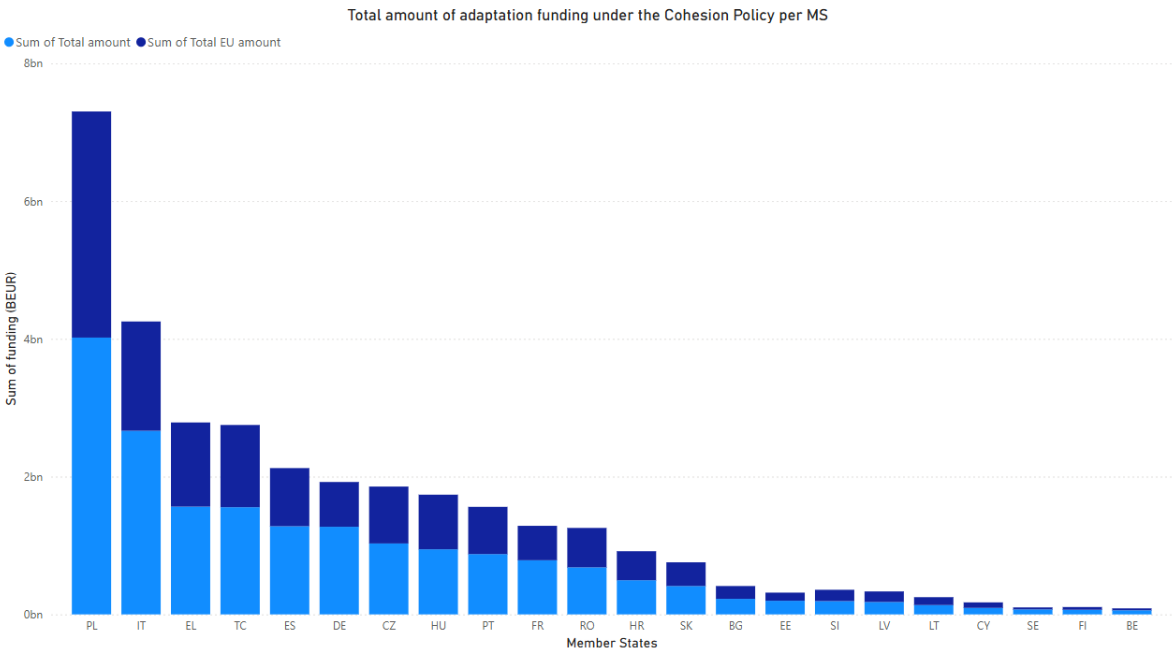
This structured procedure delivers a defensible, order-of-magnitude view of the resources currently reaching adaptation in the three focus sectors. While still constrained by the limitations of today's reporting architecture, the resulting estimates are sufficiently robust for the purposes of this study.

2.5.2 EU level

At the EU level, climate adaptation is mainstreamed into major funding programs rather than handled by a single dedicated fund. The EU's Multiannual Financial Framework (MFF) 2021–2027 requires at least 25% of the EU budget to be climate-related spending. This includes both mitigation and adaptation.

Within the MFF, the Cohesion policy represents approximately 1/3 of the total budget[11]. The budget for the Cohesion policy 2021-2027 gives an overview of EU adaptation funding at a macro-scale, focusing on the Policy Objective number 2 "Greener Europe" and for the sub-policy objective "costs of adaptation". According to it, the total amount for adaptation funding is EUR 14 billion for EU funding, and EUR 19 billion for total funding. The difference between the EU amount and the total amount comes from the co-financing principle of EU funding, as total funding includes both EU direct funding and contributions from the EU budget, and national co-financing. The following Figure 2.13 presents EU and total amounts of funding for climate change adaptation per Member State (2021-2027).

Figure 2.13 - EU amounts and total amounts of funding for climate change adaptation per Member State (Cohesion Policy 2021-27)



Even if these costs are not detailed per sector in the original source, they allow to give an estimate of public funding of costs of adaptation at EU-scale. However, they also only reflect a part of public funding, without considering private funding and additional public funding on national and EU level. Aggregated adaptation funding, both public and private, are therefore likely to be higher.

[11] As the total budget for the Cohesion Policy 2021-2027 is EUR 392B, and the total MFF budget is EUR 1.1 trillion (https://ec.europa.eu/regional_policy/funding/available-budget_en?utm)

Indeed, if policy Objective 2 is funded by two major EU sources: the European Regional Development Fund and the Cohesion Fund[12], other key instruments that support climate adaptation include:[13]

- Connecting Europe Facility (CEF): CEF is an EU program (2021–2027 budget €33.7 billion for transport) aimed at strategic transport infrastructure. While CEF primarily targets mitigation (e.g. greening transport) and connectivity, it also requires climate-proofing of projects. New technical guidance on climate-proofing for 2021–2027 was adopted to ensure CEF-funded projects (and other EU infrastructure investments) address future climate risks. In short, CEF funding decisions increasingly prioritise resilience (though specific adaptation spending is not separately itemised in CEF budgets).
- Recovery and Resilience Facility (RRF): The EU's €723 billion COVID-19 recovery fund (2021–2026) also mainstreams climate action. Member States' national Recovery and Resilience Plans must devote at least 37% to adaptation measures for transport climate-related investments. Precise EU-wide figures for adaptation in RRF are not centrally tracked.
- LIFE Programme: The LIFE Climate sub-programme provides grants for climate action projects, including adaptation pilots. Under LIFE, adaptation projects (e.g. for transport nature-based solutions to protect roads from landslides or research on heat-resilient pavements, for energy climate resilient energy systems, or for agriculture, climate-resilient farming techniques as well as land management) can receive EU co-financing. However, LIFE's scale is modest (the entire Climate Mitigation & Adaptation budget for 2021–2027 is under €1 billion), so its contribution to transport, energy and agriculture adaptation funding is relatively small.
- Horizon Europe and the Adaptation Mission: The EU's research and innovation funding (Horizon Europe, €95 billion) allocates 35% of its budget to climate objectives. Notably, the EU Mission on Adaptation to Climate Change (launched 2021) is channelling research funds into regional resilience initiatives; some of its calls cover resilient infrastructure and transportation systems. These investments build knowledge and pilot projects rather than large-scale infrastructure, but lay groundwork for future adaptation across sectors, including transport, energy and infrastructure. The mission launches a new call for proposal every year, and the indicative budget for the current one, published in May 2025, is €114 million.
- European Investment Bank (EIB): As the EU's lending arm, the EIB has become a pivotal source of climate adaptation finance. The EIB classifies climate adaptation as part of its climate action portfolio and has set a goal to increase adaptation lending to 15% of its climate finance by 2025[14]. In 2022, the EIB increased its finance for adaptation by over 40% from the previous year. In 2024, EIB financing for climate change adaptation reached EUR 4.6 billion or 11% of its total climate action, amounting to EUR 42.7 billion. Transport (including aviation and waterway transports) represented 29% of these 42.7 billion, or EUR 12.4 billion, energy represented 15.8% or EUR 6.7 billion and agriculture 1.1% or EUR 0.5 billion. Assuming that their shares can be transposed to adaptation funding, their shares would be the following: EUR 1.36 billion for transport, EUR 0.74 for energy, and EUR 0.05 billion for agriculture[15].
- The Common Agricultural Policy (CAP), especially focused on rural development (Pillar II): This instrument supports climate-resilient agriculture and rural infrastructure, especially through

[12] Cohesion Policy Funds consist mainly in the European Regional Development Fund and Cohesion Fund. They finance infrastructure investments with requirements to address climate risks. For example, the Cohesion Fund explicitly supports environment and Trans-European Transport Networks (TEN-T) projects, and recent TEN-T regulations mandate that new transport infrastructure be designed for climate resilience. In practice, this means EU co-funded road, rail, port, and inland waterway projects must assess vulnerabilities (e.g. flood or heat risk) and incorporate adaptation measures.

[13] Partly based on https://climate-adapt.eea.europa.eu/en/eu-adaptation-policy/funding

[14] See: https://www.e3g.org/bank-metrics/standalone-climate-strategy-and-integration-of-climate-in-overarching-strategy-eib

[15] See: European Investment Bank Financial Report 2024

resilience-building practices, and investments in infrastructure to prevent erosion, manage floods or enhance water retention.

Based on the above, the boxes below provide an estimate for EU funding used for adaptation in the transport, energy, and agriculture sectors.

Box 2.5 Estimate for EU spending on adaptation in the transport, energy and agriculture sectors

EU Budget Overview (MFF and RRF 2021–2027)

Together, the MFF and RRF represent an EU funding package of €1.8–2.0 trillion over 2021–2027

Climate-Related Share of EU Funding

The EU has a policy of "climate mainstreaming" which earmarks a significant share of its budget for climate action. For 2021–2027, at least 30% of the combined MFF and NextGenerationEU is set to be spent on climate objectives. Notably, the RRF has an even higher climate target: each national recovery plan must devote 37% of its funding to climate-related investments. These climate expenditures cover both climate change mitigation and adaptation – the target is holistic and does not distinguish how much goes to each.

Applying the 30% climate share to the budgets yields a very large climate funding envelope for 2021–2027. For the MFF, 30% of €1.074 trillion is roughly €322 billion potentially available for climate action over seven years. For the RRF, 30% of €672.5 billion is about €202 billion (and up to €248 billion if 37% is achieved). In total, on the order of €524–570 billion of EU funding in 2021–2027 is climate-related spending (mitigation + adaptation). This results in approximately €75–82 billion per year across the EU dedicated to climate measures.

Adaptation Funding

Because the EU's climate target encompasses both mitigation and adaptation, we must estimate the adaptation portion. The fund examples listed above suggest adaptation is a smaller share of climate spending. Here we assume 20% of climate-related spending is directed to adaptation, with the remaining 80% to mitigation.

Under this assumption, the EU's total adaptation-focused funding in 2021–2027 would be on the order of €105–114 billion (i.e. 20% of 524–570 billion). That equates to roughly €15–16 billion per year EU-wide for climate change adaptation initiatives.

Transport Funding

Within the adaptation funding, we further assume the transport sector receives 15%. Transport traditionally commands a high share of EU infrastructure investments – for example, about a quarter of EU cohesion policy funds have gone to transport infrastructure in some regions[16]. In addition, EIB climate finance data show that transport represents around 29% of total climate action funding (see above), suggesting a similarly strong weight in adaptation allocations. Using 15% as an approximate allocation reflects the transport sector's significant weight in infrastructure funding, while maintaining a conservative approach to not overestimate numbers.

This yields an estimated €16–17 billion over 2021–2027 dedicated to climate adaptation in the transport sector. Spread evenly, that is on the order of €2–2.5 billion per year.

Energy Funding

Within the adaptation funding, we can assume that energy will receive 10%. EIB climate finance data indicate that energy accounts for about 16% of total climate action funding (see above), and while the sector is clearly exposed to climate risks, EU investments have historically emphasised mitigation over adaptation (e.g. grid

[16] See: https://www.transportenvironment.org/articles/building-back-better-ukraines-transport-infrastructure

modernisation under the Connecting Europe Facility is primarily mitigation-focused, with climate-proofing as an add-on). Compared to transport's higher 15% share, this lower allocation reflects energy's smaller role in adaptation-specific spending.

This yields an estimated €10.5-11.4 billion over 2021-2027 dedicated to climate adaptation in the energy sector. Spread evenly, that is on the order of €1.5-1.6 billion per year.

Agriculture Funding

Within the adaptation funding, we assume the agriculture sector receives 35%. Although agriculture represents only about 1% of EIB climate action funding (see above), it is the most directly climate-sensitive sector and already absorbs large EU resilience support through the Common Agricultural Policy and the EAFRD, which specifically finance climate adaptation in farming and rural areas.

This yields an estimated €37-40 billion over 2021-2027 dedicated to climate adaptation in the agriculture sector. Spread evenly, that is on the order of €5.3-5.7 billion per year.

Estimated Annual Funding and Uncertainty

Using the above assumptions and approximations, a conservative estimate for current annual EU funding for transport-related climate change adaptation is around of €2–2.5 billion per year (low-single-digit billions annually). For context, this is the portion of EU funds each year (out of the MFF and RRF) that might be supporting adaptation projects in transport – such as climate-proofing roads, rail, ports, and other infrastructure against floods, heat, storms, and other climate impacts. It is the same for energy and agriculture, with estimated €1.5-1.6 billion per year and €5.3-5.7 billion per year.

Our calculation is an analytical approximation using reasonable assumptions, not an official EU figure. It illustrates an order-of-magnitude based on the best available information. The actual spending on transport, energy, and agriculture adaptation within EU funds could differ, and to obtain a precise figure would require granular analysis of project-level data which is not readily aggregated in EU budget reports.

2.5.3 National Government Funding and Initiatives

According to a 2023 European Environment Agency assessment, EU funds currently play a major role in financing adaptation action for most Member States, with only a few countries having standalone national adaptation funds[17]. In practice, this means many countries rely on European sources (like Cohesion funding or RRF grants) to support climate-proofing of roads, railways, ports, and airports, rather than using exclusively domestic budgets.

Some countries have reported own funds for adaptation[18] such as the Delta Programme in the Netherlands[19] (annual budget of about €1.3–1.4 billion for flood protection, water management, and related climate adaptation measures) but no aggregated summary exists for this spending. Also, reporting under the NECPs does not provide more detailed insights since data on adaptation spending is very variable and incomplete.

Therefore, no reasonable estimate can be made on how much of the adaptation spending is for adaptation in the transport, energy or agriculture sectors as compared to other sectors.

Due to those uncertainties, currently, no numbers of national spending are integrated in the calculations.

[17] [https://www.eea.europa.eu/en/newsroom/news/heatwaves-droughts-other-extreme]

[18] [Idem]

[19] See https://english.deltaprogramma.nl/news/news/2021/09/21/delta-programme-commissioner-additional-funds-and-action-needed-for-adaptation-to-climate-change

2.5.4 Subnational and City Investments

Cities and regional authorities are on the front lines of adaptation, often funding measures like heat-resistant road surfaces, improved stormwater drainage to prevent urban flash floods, or tree planting along transport corridors for cooling. A recent assessment, based on CDP reporting, found that European subnational governments invested about €8.3 billion in adaptation in 2022, across all sectors.[20] Other usable monetary values could not be identified.[21]

Box 2.6 Estimate for Subnational and City spending on adaptation in the transport, energy and agriculture sectors

Using the same assumption as for EU funds, namely that approx. 15% of all adaptation related funding goes into the transport sector, it is assumed that €1.3 billion per year (15% of €8.3 billion) of subnational adaptation spending supports transport adaptation. For the energy sector, if 10% of all adaptation related funding goes into it, it is assumed that €0.83 billion per year of subnational spending will support adaptation. For agriculture, its amounts to €3 billion per year.

2.5.5 Private sector spending

Private sector investment in climate adaptation – including in the transport sector – remains very limited compared to public funding. Globally, tracking by Climate Policy Initiative finds that only about 1.5% of climate adaptation finance comes from private sources[22]. The vast majority is provided by governments or public financial institutions. We thus assume this number can be used for the transport and energy sectors. For agriculture, forestry and other land use, public sources supply approximately 87% of adaptation finance, which leaves 13% for private funding[23]. Adaptation projects (such as strengthening public infrastructure) often do not generate direct profits, have often a low profit potential, high risk and poorly defined revenue models, which dampens private financing incentives.

Box 2.7 Estimate for private spending on adaptation in the transport, energy and agriculture sectors

Combining the EU-level estimate of approximately €2–2.5 billion per year with the subnational government estimate of around €1.3 billion per year yields a total public annual spending on transport adaptation in the EU of approximately €3.3–3.8 billion per year. Applying an additional 1.5% contribution from the private sector (a typical global share of private adaptation finance) increases this total by approximately €0.05 billion – 0.06 billion annually.

For the energy sector, applying the same reasoning, we have a total public annual spending on energy adaptation of €2.33-2.43 billion per year (€1.5-1.6 billion with the additional €0.83 billion for subnational spending). Applying the same additional 1.5% increases this total by approximately €0.03-0.04 billion annually.

And finally for the agriculture sector, applying the same reasoning, we have a total public annual spending on agriculture adaptation of €8.3-8.7 billion per year (€5.3-5.7 billion with the additional €3 billion for subnational spending). Following the assumption mentioned above, that for agriculture, private sources represent approximatively 13%, we have additional private spending of €1-1.1 billion annually.

[20] See slide 12 on https://www.pathways2resilience.eu/images/lauch-event/Pathways2Resilience-services_compressed.pdf Data is from self-disclosed actions in CDP's 2022 Cities questionnaire. Converted to € based on exchange rates in October 2023

[21] E.g. from reporting under the Covenant of Majors; or the governance regulation.

[22] [https://www.climatepolicyinitiative.org/publication/tracking-and-mobilising-private-sector-climate-adaptation-finance/tracking-and-mobilising-private-sector-climate-adaptation-finance/]

[23] Global landscape of climate finance 2024 - weADAPT

2.5.6 Summary

Based on the above, a conservative estimate of total annual funding for climate change adaptation in the EU is about €3.35–3.85 billion per year for the transport sector, €2.36-2.47 billion per year for the energy sector, and €9.3-9.8 billion per year for the agriculture sector.

The table below summarises the high-level estimates of **current annual adaptation funding** for the transport, energy, and agriculture sectors, broken down by key funding sources. All values are approximate **ranges in € billion per year**, as reported or derived in the chapter.

Table 2.2 Summary of estimates for current annual funding for adaptation (in billion€)

Sector	EU-Level Funds	Sub-national Budgets	Private Finance	Total (All Sources)
Transport	2–2.5	1.3	0.05–0.06	**3.35–3.85**
Energy	1.5–1.6	0.83	0.03–0.04	**2.36–2.47**
Agriculture	5.3–5.7	3.0	1.0–1.1	**9.3–9.8**
Total	**8.8–9.8**	**5.1**	**1.1**	**15.0–16.1**

All values are indicative and rounded, reflecting the conservative assumptions used in the study and the lack of precise tracking in official budgets.

3. FINDINGS

3.1 Transport

3.1.1 Data Coverage and Extrapolation Needs

Out of the 27 EU Member States, only 7 countries had national studies quantifying transport adaptation finance needs. These included Austria, Estonia, Finland, France, Italy, Romania, and Sweden (identified via the Eionet survey).

The remaining 20 Member States had no dedicated transport adaptation cost study, so their needs were estimated by extrapolation. The project derived average unit costs from the available studies and extrapolated to all other countries using a proxy (national transport sector GVA) to ensure no Member State or sector was left out.

3.1.2 Adaptation Cost Categories and Data Availability

The project classifies adaptation-related costs into five categories: Anticipation costs, Reaction costs, Maladaptation costs, Socio-economic impacts, and "Other/Unclear" costs. The availability of national data varied by category:

- Anticipation costs (proactive adaptation investments): Only 2 countries (France and Sweden) provided data in this category. These are forward-looking expenditures to improve climate resilience (e.g. upgrading infrastructure ahead of climate impacts).
- Reaction costs (post-disaster response and repair): 6 countries (including Austria, Estonia, France, Italy, Romania, Sweden) had data on reactive expenditures triggered by climate events. These are the costs to repair or retrofit infrastructure after damage occurs (often overlapping with "cost of inaction" if adaptation was insufficient).
- Maladaptation costs (resources spent on measures that are ineffective or counterproductive): 0 countries reported quantitative data explicitly under this category. No national study provided a clear "maladaptation cost" figure – if any such costs existed, they were not distinguished in the data.
- Socio-economic impacts (indirect macro-economic losses due to climate impacts): 4 countries (Austria, Finland, France, Sweden) reported such costs. These reflect broader economic damages (e.g. GDP loss, welfare impacts) from climate-related transport disruptions.

As can be seen, most national studies focused on either anticipatory investment needs or reactive damage costs, and a few included macro-level impact estimates. No single study covered all cost categories, and maintenance costs were sometimes noted separately within anticipation estimates. This patchwork means certain cost types (especially maladaptation or intangible costs) remain unquantified, underscoring data gaps.

3.1.3 EU-Level quantitative findings for energy

The Table below presents the findings of the calculations at EU level.

Table 3.1 Overview of findings at EU level (all numbers in MEUR)

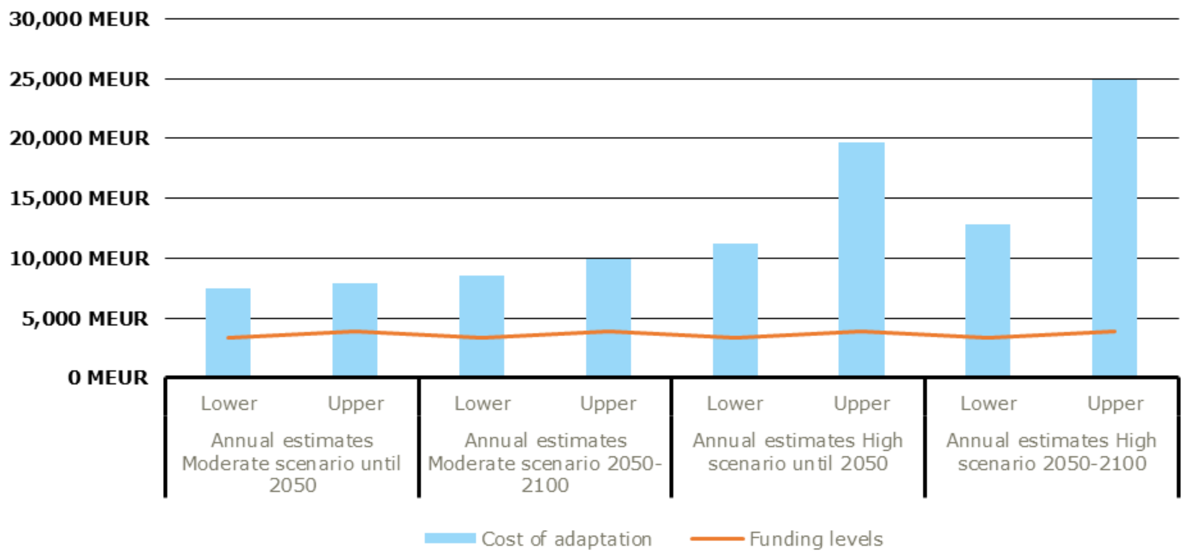
Type	Annual estimates Moderate scenario until 2050		Annual estimates Moderate scenario 2050-2100		Annual estimates High scenario until 2050		Annual estimates High scenario 2050-2100	
	Lower	*Upper*	*Lower*	*Upper*	*Lower*	*Upper*	*Lower*	*Upper*
Cost of inaction	1,639	1,639	2,497	2,497	1,950	1,950	3,886	3,886
Cost of adaptation	7,513	7,870	8,568	9,963	11,269	19,675	12,851	24,907
Funding levels	3,350	3,850	3,350	3,850	3,350	3,850	3,350	3,850
Gap cost of inaction/cost of adaptation	-5,874	-6,231	-6,070	-7,466	-9,319	-17,725	-8,965	-21,021
Funding gap	4,163	4,020	5,218	6,113	7,919	15,825	9,501	21,057

3.1.4 EU-Level Adaptation Funding Gap by Scenario and Horizon

Findings

At the EU aggregate level, current adaptation funding falls far short of estimated needs, creating a significant funding gap. The results are visualised in the Figure below.

Figure 3.1 Comparison of climate finance needs and current funding levels across different scenarios developed in the study



The gap widens under more severe climate scenarios and over longer time horizons:

- Near-term (until 2050), Moderate scenario: Annual adaptation needs for transport are about €7.5 billion, against roughly €3.3–3.8 billion in current funding. This leaves an annual funding gap of €4.1–4.2 billion in the moderate scenario. In other words, current budgets cover only about half of the needed adaptation investments through 2050.
- Long-term (2050–2100), Moderate scenario: Adaptation finance needs rise in the second half of the century (€8.6–10.0 billion/yr by 2100), while funding is assumed constant. The gap grows to €5.2–6.1 billion per year by 2100 under moderate warming.

- High-emissions scenario: The shortfall is even more stark. Through 2050, transport adaptation needs under a high climate change scenario are €11.3–19.7 bn per year, yielding a funding gap of roughly €7.9–15.8 bn annually. By end-century (2100) in a high scenario, required adaptation spending increases to €12.9–24.9 bn/year, making the annual funding gap as high as €9.5–21.0 billion if current funding levels remain unchanged. In the worst case, the funding available would cover only about 15% of the investment needed – an enormous shortfall.

These gaps illustrate a serious mismatch between adaptation needs and resources. This suggests that Europe must mobilise substantially more funding for climate adaptation in transport, especially under high warming trajectories. Closing the gap could involve increasing national budgets for resilience, leveraging EU funds (e.g. Cohesion Fund, Connecting Europe Facility) toward adaptation, and encouraging private sector investment. Notably, EU funds already play a *major role* in financing adaptation for many countries (few have dedicated national adaptation funds), so aligning EU budget instruments with the scale of needs is critical. A positive message is that early, moderate action (keeping warming to well below 3°C) contains the funding gap to more manageable levels – reinforcing the importance of global mitigation alongside adaptation planning.

Methodological context

The adaptation cost estimates were derived via a bottom-up approach (compiling national studies and extrapolating) while funding estimates came from top-down budget analyses. The two are not perfectly aligned: adaptation "needs" may include investments by both public and private actors, whereas current funding data mostly captures public expenditures (often under-reported or fragmented across ministries). This means the actual gap might be somewhat overstated if private adaptation spending is occurring but untracked – or understated if there are hidden costs not accounted for. Nonetheless, the trend is robust: under any scenario, a significant scaling-up of adaptation finance is needed to meet estimated needs. Policymakers should treat the funding gap as a call to action, prioritising adaptation in transport investment plans, improving tracking of adaptation spending, and considering new financing mechanisms (e.g. resilience bonds, climate-adjusted infrastructure tariffs) to bridge the gap.

3.1.5 Cost of Adaptation vs. Cost of Inaction in Transport

When comparing the results of the bottom-up calculations in the study for the costs of adaptation with the costs of inaction (which are derived from top-down modelling studies), it may appear that for the transport sector, the estimated cost of adaptation exceeds the cost of inaction (damage costs) – the opposite of the expected relationship. Typically, we expect that investing in adaptation should cost less than the damages it prevents. However, as explained further below, such comparison would be too simplistic and may lead to misleading conclusions.

In the current analysis the adaptation finance needs for EU transport (€7.5 billion/yr in moderate scenario to 2050) are several times higher than the inaction costs (€1.6 billion/yr in climate damages) over the same period. Even by 2100 under a high scenario, annual inaction losses (€3.9 bn) remain well below adaptation finance needs (which reach €12.9–24.9 bn). In other words, the transport numbers suggest spending more on adaptation than the direct losses one would suffer by doing nothing, which seems counter-intuitive.

The primary reason for this paradox is likely data and scope limitations on the "cost of inaction" side. The inaction cost figures are drawn from existing models that capture only a portion of climate damages. The transport inaction costs are based on the COACCH study, which only assessed river flood damage to road infrastructure (omitting rail, urban transport, and other hazards like heat and storms). This narrow focus likely understates total transport-related costs of inaction.

Additionally, many indirect and systemic impacts of climate disruptions (supply-chain delays, wider economic losses) are not fully in those damage estimates. In contrast, the adaptation cost estimates were more comprehensive – many studies took a broad view of needed upgrades (often covering multiple hazards and including safety margins). This asymmetry means the two values are not truly comparable in their current form.

Another factor is methodological: economic models for damages can underestimate inaction costs. Computable General Equilibrium (CGE) models, for instance, assume economies smoothly adjust to shocks, often ignoring extreme event disruptions and non-market losses. Such models systematically underestimate the economic damages from inaction by assuming high flexibility and omitting hard-to-monetise impacts. On the other hand, engineering-based adaptation assessments lay out actual investment costs for hardening infrastructure, which are easier to quantify fully. This leads to a bias where recorded adaptation finance needs appear higher than modelled damages, simply because the damage models left a lot out.

Implications: We should be careful not to conclude that adaptation is "not worth it" for transport. Instead, the findings point to information gaps – the cost of inaction is likely far higher than current figures indicate. In fact, if one were to account for all relevant hazards (floods, heatwaves buckling rails, storms hitting ports, etc.) and the knock-on economic disruptions, the damages avoided by adaptation would presumably greatly exceed adaptation finance needs.

The current mismatch underscores the need for improved modelling of transport climate impacts. It also suggests a timing issue: many transport adaptation measures are large up-front investments (e.g. elevating roads, reinforcing bridges) whose benefits play out over decades. Benefits (avoided losses) are not as immediately visible as costs, and some adaptation investments have co-benefits (or address risk aversion) that are not captured by narrow damage estimates.

3.1.6 Additional Analytical Insights

Beyond the core findings above, several other insights emerge from the transport dataset and analysis:

- There are considerable uncertainties in the estimates, reflected in the "lower" vs "upper" bounds for adaptation finance needs in the calculations. These ranges stem from factors like different adaptation scenarios (e.g. incremental vs transformational measures) and other assumptions. For transport, the upper-bound costs assume a more ambitious adaptation pathway (or higher unit costs), which in some cases nearly double the lower-bound. This range underlines that actual needs could be higher if, for example, more stringent design standards or faster climate deterioration necessitate costlier interventions.
- The bottom-up approach used (aggregating national studies) yields a more granular sectoral picture than top-down models, but it also introduced issues of consistency. Each national study had its own scope – some counted only capital investments, others included maintenance, some looked at 2030 or 2050, others to 2100. The project applied calibration factors to harmonise time horizons and scenarios, but some differences remain embedded. For example, one country's study might assume all new roads are climate-proofed (spreading costs over time), while another might cost a one-off climate retrofit program. Such differences complicate cross-country comparisons. The analysis team performed sensitivity checks and noted that enlarging the database with more studies would improve robustness. In short, the data here should be seen as **indicative estimates** – sufficient to flag orders of magnitude and gaps, but not precise budgets.

3.1.7 Key Findings and Policy Messages

- Only a handful of Member States have quantified transport adaptation finance needs; most are relying on rough extrapolations. This highlights the need for further research at national and local levels. The EU could encourage standardised methodologies for costing adaptation to improve the knowledge base across all countries. Better data will enable more efficient allocation of resources to where adaptation is most cost-effective.
- The transport sector will require billions of euros per year in adaptation investments, even under moderate climate scenarios. By mid-century, on the order of €7–8 billion/yr is needed EU-wide for transport resilience, and under high warming this could rise to €12–25 billion/yr by 2100. These numbers put into perspective the scale of the challenge – comparable to or exceeding current annual infrastructure maintenance budgets in many countries.
- There is a clear adaptation funding gap in the transport sector on the order of several billion euros per year. Without ramping up finance, many necessary measures (e.g. bridge reinforcements, drainage upgrades, new dikes or culverts) will remain unfunded, leading to greater vulnerabilities. Policymakers should consider dedicated adaptation funding streams for transport (at EU and national levels) and integrate climate resilience criteria into all transport infrastructure investments. Bridging this gap is urgent to avoid much higher costs from future damages.
- The analysis reinforces that achieving global climate mitigation goals will substantially ease adaptation burdens. In a 2°C-compatible scenario, transport adaptation finance needs are much lower than in a 3–4°C world. Policy message: every bit of emissions reduction that limits warming also buys down the long-term adaptation bill. Thus, adaptation and mitigation go hand in hand – an argument for strong climate action on both fronts.
- Improve Cost-Benefit Assessment: The counter-intuitive finding of adaptation finance needs exceeding inaction costs should prompt a revaluation of how we assess benefits of adaptation. We need to capture a fuller picture of avoided damages and indirect benefits. Developing more comprehensive "cost of inaction" models for transport (including multi-hazard risks and economy-wide impacts) is essential. In the meantime, decision-makers should rely on expert judgement and scenario analysis to ensure that critical adaptation measures are not ignored just because of imperfect damage data. Proactive adaptation should be pursued when the potential consequences of not adapting (even if hard to quantify) are catastrophic or irreversible.

3.2 Energy

3.2.1 Data Coverage and Extrapolation Needs

Data on climate adaptation finance needs in the energy sector is sparse across EU Member States. Our inventory of existing research showed that 8 out of 27 EU countries (Austria, Belgium, Croatia, Estonia, France, Italy, Romania, and Spain) had national studies at the time of preparing this report or estimates specifically quantifying energy-sector adaptation finance needs. All other Member States lacked such studies, necessitating extrapolation of adaptation cost figures from the countries with data. In practice, the project derived unit costs from the few countries with data and projected them onto the remaining countries to fill the gaps. This approach is a stopgap measure, highlighting the need for more comprehensive national assessments. Overall, the limited coverage means conclusions must be drawn with caution, as they rest on a small base of country-specific studies.

3.2.2 Adaptation Cost Categories and Data Availability

The available national studies for energy sector adaptation cover a subset of possible cost categories, focusing mainly on anticipatory measures and reactive costs, with no cases of explicitly identified maladaptation finance needs. Specifically, among the countries with data, five provided estimates of anticipation costs (proactive adaptation investments, e.g. upgrading infrastructure for future climate conditions) and three reported reaction costs (expenses for reactive or corrective actions, e.g. repairs after climate-related damage). Four countries (Austria, France, Italy, Spain) included a category for socio-economic impacts – effectively estimates of climate-related economic losses in the energy sector if adaptation is insufficient. The presence of such data in some adaptation studies indicates an effort to quantify broader consequences (like GDP loss or welfare impacts from energy shortfalls).

3.2.3 EU-Level quantitative findings for Energy

The Table below presents the findings of the calculations at EU level.

Table 3.2 Overview of findings at EU level (all numbers in MEUR)

Type	Annual estimates Moderate scenario until 2050		Annual estimates Moderate scenario 2050-2100		Annual estimates High scenario until 2050		Annual estimates High scenario 2050-2100	
	Lower	*Upper*	*Lower*	*Upper*	*Lower*	*Upper*	*Lower*	*Upper*
Cost of inaction	-873	-873	4,348	4,348	-1,000	-1,000	4,107	4,107
Cost of adaptation	39,116	39,838	43,316	50,995	58,673	99,594	64,974	127,486
Funding levels	2,360	2,470	2,360	2,470	2,360	2,470	2,360	2,470
Gap cost of inaction/cost of adaptation	-39,989	-40,711	-38,968	-46,647	-59,674	-100,594	-60,867	-123,379
Funding gap	36,756	37,368	40,956	48,525	56,313	97,124	62,614	125,016

Several key findings emerge from these EU-level estimates. First, the cost of inaction in the energy sector is relatively low compared to other sectors, and even *negative* in the near term (2025–2050) under both scenarios. A negative inaction cost means a net economic *benefit* from near-term climate change in this sector – primarily due to reduced winter heating needs outweighing increased cooling demand up to mid-century, yielding net energy savings. By the late 21st century, however, the cost of inaction becomes positive, as intensifying warming drives large cooling demand increases and other damages (in the moderate scenario, €4.3 billion/year by 2050–2100; in the high scenario, a similar €4.1 billion/year despite greater warming, reflecting some adaptation in the modelling of inaction or saturation of demand changes).

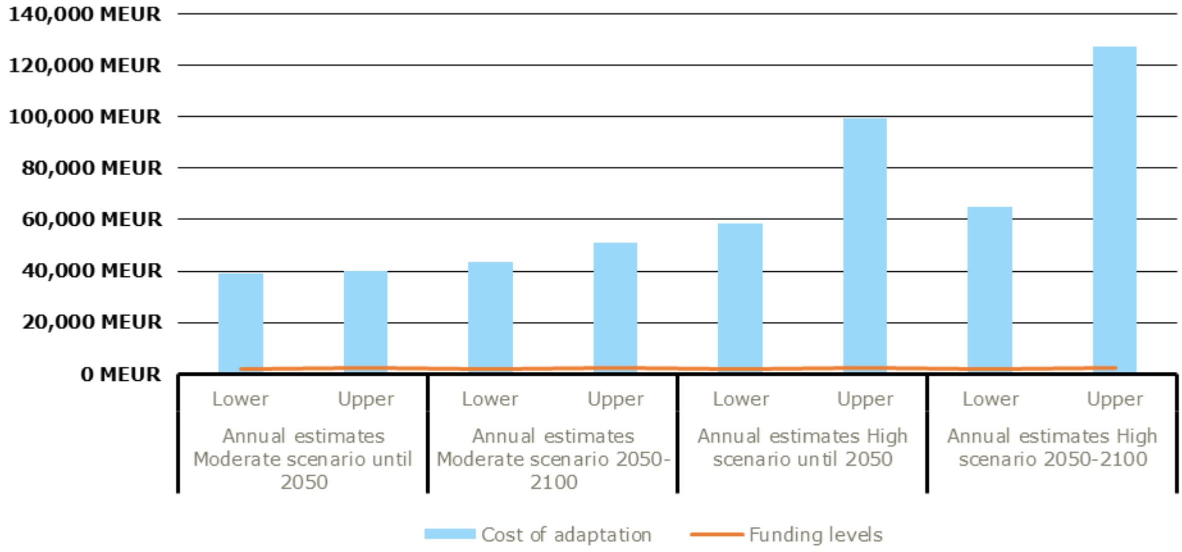
These inaction cost estimates are notably *partial*: they mostly reflect operational cost impacts (changes in energy demand and supply costs due to temperature changes), and do not fully include extreme-event-related damages (like storm damage to grids or drought impacts on hydropower). In contrast, the values for the cost of adaptation, which have been derived bottom-up in this study and have a much wider coverage as explained further below, are substantial and grow over time, reaching double-digit billions per year. Under a moderate climate pathway, adaptation in energy is estimated at roughly €9.7 billion/year by mid-century, rising to €10.7–12.7 billion/year in the latter half of the century. The high warming scenario drives much higher adaptation needs: about €14.6–24.3 billion/year by 2050, and a striking €16.1–31.7 billion/year by 2100. These ranges reflect uncertainty (different sources and assumptions yield lower vs. upper-bound estimates). Even the lower-bound figures in the high scenario are about 50% higher than the moderate scenario, illustrating the sensitivity of adaptation finance needs to the climate trajectory – a reminder that stringent mitigation (staying on a lower warming path) could significantly reduce long-term adaptation expenditures in energy.

Current **adaptation funding for the energy sector** (based on reported public spending) is only on the order of **€2.4 billion per year**. Importantly, this figure is assumed constant across scenarios and time – it represents today's spending level, which has not yet ramped up for future needs.

3.2.4 EU-Level Adaptation Funding Gap by Scenario and Horizon

Across all scenarios, a significant adaptation funding gap is evident for the EU energy sector, with the gap escalating under more severe climate scenarios and over longer time horizons. The results are summarised in the figure below.

Figure 3.2 Comparison of climate finance needs and current funding levels across different scenarios developed in the study



Under the moderate scenario, the gap (unmet annual investment need) is already on the order of €7–10 billion per year (growing from mid-century to late-century). This suggests that even if global warming is kept moderate, Europe must mobilise roughly 3–4 times more funding than currently allocated to adequately protect its energy systems by mid-century, and 4–5 times more by 2100. Under the high-emissions scenario, the shortfall is dramatically larger: on the low end about €12 billion/year in the near term, and in a worst case up to €29 billion/year by century's end, implying an order-of-magnitude increase over current spending. In other words, under high warming the energy adaptation gap could roughly equal today's entire annual EU climate adaptation budget many times over. This widening gap with higher warming reflects the compounding effect of more intense climate impacts requiring costlier measures, whereas current funding remains relatively flat.

From a policy perspective, these numbers carry a clear message: current adaptation financing for the energy sector is nowhere near the scale needed to manage future climate risks. Even in the best-case climate scenario, the EU would need to at least triple or quadruple energy adaptation investments to meet projected needs; in high-impact scenarios, an order-of-magnitude increase in funding may be necessary. Bridging this gap will likely require mobilising new resources – including increased national budget allocations, leveraging EU-level funds, and private sector contributions (since much energy infrastructure is privately owned). The magnitude of the gap also underlines the importance of integrating adaptation into energy policy and planning. For instance, National Energy and Climate Plans (NECPs) and long-term strategies should explicitly account for climate resilience investments, ensuring that adaptation is not an afterthought but a core component of energy transition funding.

Notably, the gap analysis here is based on *bottom-up estimated needs versus current spending* (a "bottom-up vs. top-down" comparison): the adaptation cost estimates were derived from identified measures at sector level, whereas the funding figures come from aggregated national budget data (which may not be fully comparable). This mismatch in methodology (discussed below) means the gap could be even larger than stated if current spending is misaligned or under-reported.

3.2.5 Cost of Adaptation vs. Cost of Inaction in Energy

Based on the numbers derived in the study, a simplistic conclusion might be that the cost of adaptation exceeds the cost of inaction. For example, in a moderate scenario to 2050, we estimated spending roughly €9.7 billion/year on adaptation to avoid about €0.9 billion/year in damages. At face value, this suggests a poor return on investment – whereas typically studies find that adaptation finance needs are lower than the losses they prevent (e.g. EU-wide studies like PESETA project hundreds of billions in inaction damages versus tens of billions in adaptation finance needsecologic.eu). This is contrary to the intuitive expectation, and also academic consensus, that usually investing in adaptation averts larger damages down the line.

However, for this it is important to keep in mind how the numbers in the study very derived and that simply comparing them is challenging, and several methodological and scope-related factors help explain this paradox:

- **Partial Coverage of Inaction Costs:** The energy-sector *cost of inaction* used here is likely an underestimate of true potential damages, because it covers a limited set of impacts. The inaction costs were derived from modelled changes in energy demand and supply (heating and cooling needs under warming, etc.), and possibly some direct impacts on production. However, critical impact channels are missing. For instance, extreme weather events (storms, floods, wildfires) can cause massive damage to energy infrastructure – downing power lines, disrupting fuel supply chains, damaging power plants – leading to economic losses far beyond the energy sector itself. These sorts of low-probability but high-impact events are generally not captured fully in the models that produce inaction cost estimates for energy. Additionally, indirect and systemic effects (e.g. cascading failures, long-term investment deterrence due to unreliable energy) are not reflected. If the inaction cost calculations had included a broader spectrum of risks (for example, large-scale blackouts caused by climate extremes, or the macroeconomic drag of chronic energy supply disruptions), the cost of inaction would certainly be much higher, closing the gap with adaptation finance needs.
- **Scope of Adaptation finance needs**: On the flip side, the *cost of adaptation* compiled in this study is relatively comprehensive in that it attempts to include many measures to climate-proof the energy sector. These include capital-intensive investments (upgrading grid infrastructure, reinforcing power plants, diversifying energy sources for resilience, etc.) that can be very costly. Importantly, many adaptation measures in energy are upfront investments that yield benefits over decades (e.g. building a more resilient transmission network has a high initial cost but prevents numerous outages far into the future). Our analysis counts those upfront costs fully, whereas the modelled inaction damages accrue gradually over time and, as noted, omit certain extremes. This mismatch in timing and scope can make adaptation look "oversized." Moreover, some national studies may have taken an ambitious adaptation approach – essentially estimating the cost to climate-proof nearly the entire energy system to a high safety margin.

Such an approach would naturally result in a very high adaptation bill, potentially overshooting the statistically expected damages (because it's guarding against worst-case scenarios or low-probability tail risks). In essence, the adaptation finance needs reflect a *policy choice* of a high level of protection, whereas the inaction costs reflect an *average expected damage*. The comparison is not apples-to-apples: one is akin to paying an insurance premium for peace of mind, the other is the expected payout.

Considering these factors, it becomes apparent that the exceedance of adaptation cost over inaction cost does *not* indicate that adapting is inefficient. Rather, it highlights a likely underestimation of inaction impacts and possibly an overestimation or over-specification of adaptation needs under certain assumptions. This result calls for a nuanced interpretation: it suggests that, with the current state of knowledge, many energy adaptation investments cannot be justified on avoided direct damage alone – but that could be because we haven't quantified those damages properly. For example, a catastrophic blackout affecting multiple countries for days (as might occur from an extreme event) is not in the "cost of inaction" model, but energy planners know it is a risk worth averting with robust infrastructure.

In policy terms, this finding should prompt further analysis rather than discourage adaptation. It underlines the importance of improving models to capture the full *benefits of adaptation* (including avoided rare disasters and indirect benefits). It also suggests a need to prioritise adaptation actions – focusing on no-regret measures and those with clear co-benefits, given finite resources. If certain very high-cost measures only pay off under extremely adverse but unlikely climate outcomes, it may be prudent to sequence or conditionalize them (e.g. implement adaptively as climate signals emerge). In sum, the current methodological gap between adaptation and inaction costs for energy is a caution that we must refine our understanding of risk and strategy in this sector, rather than a literal recommendation to do nothing. Indeed, as the next section notes, numerous uncertainties remain, and the real-world balance of costs could shift with better data.

3.2.6 Additional Analytical Insights

Uncertainty is high in both the adaptation and inaction cost estimates for the energy sector, and this affects interpretation. One major source of uncertainty is the climate scenario and hazard scope. Our analysis uses two emissions scenarios (moderate and high), but within each, there are underlying assumptions about which climate variables impact energy. Small differences in assumptions about, say, frequency of extreme storms or the severity of heatwaves can lead to large swings in projected damages and required adaptation. The widening range for late-century high scenario adaptation finance needs (€16–32 billion) reflects compounding uncertainties in climate projections, socio-economic developments (energy demand growth, technology changes), and adaptation effectiveness. Socio-economic scenarios (population, economic growth, energy mix) are particularly influential for energy: a more electrified, digital economy might be more vulnerable to power disruptions (raising inaction costs and adaptation needs) than a diversified, energy-efficient one. Yet our extrapolations may not fully account for how future energy system changes could mitigate or exacerbate climate impacts.

Another insight is the role of ancillary benefits and co-costs. Adaptation measures in energy often yield co-benefits (or co-costs) outside strictly avoiding climate damages – for example, reinforcing the grid could reduce routine outage losses and improve efficiency, or investing in distributed renewables could cut emissions and fuel import costs. These benefits are not captured in the "cost of inaction" (which only tallies climate damage avoided), meaning the true benefit-cost ratio of adaptation may be more favourable than our narrow comparison suggests. Conversely, some measures might have negative side-effects (e.g. environmental impacts of hard infrastructure) that are not monetised here. Integrating such factors is complex but necessary for a full picture.

Data quality and consistency issues also introduce uncertainty. As noted, we had to extrapolate data for 19 countries, some of which may have very different vulnerability profiles than the proxy data assumed. The extrapolation was based on simplified metrics, which cannot capture all the nuances of local climate impacts or adaptive capacity. This could lead to over- or under-estimation for certain regions. For instance, a small country with unique energy infrastructure challenges (say, an island state) might require more adaptation investment per unit of avoided damage than implied by another country's data. Additionally, the national studies we relied on vary in methodology – some might include only public sector costs, others include private costs; some annualise capital expenditures, others report cumulative totals. We attempted to harmonise these to annual needs, but some inconsistencies likely remain.

Furthermore, individual data points from certain studies have a key influence on the results. For example, the French estimates for the energy sector are notably high relative to other countries, based on two studies: one assessing adaptation-related investments for the electricity sector, and another estimating current annual losses from drought impacts. Both report particularly large values, especially in comparison to other sectors in France (e.g. transport), and to energy sector values reported for other countries. These high values may reflect the granularity and ambition of the underlying studies - for instance, accounting for large-scale grid reinforcement or extensive drought-induced hydropower losses - but they also illustrate how methodological depth, hazard scope, or sectoral coverage in national assessments can shape comparative outcomes in our extrapolated dataset.

Overall, these additional insights point to a need for cautious interpretation. While the numbers give a sense of scale, one should not take the precise values as the absolute truth. There is a range of plausible outcomes around each estimate. What seems like a marginal benefit adaptation measure under one set of assumptions could become vital under another (and vice versa).

Importantly, the fact that the high-end adaptation cost estimates are so much greater than the low-end ones by 2100 signals that policy choices now (on mitigation and adaptation pathways) heavily influence long-term costs. If the EU and the world manage to limit emissions (approaching the moderate scenario), the adaptation challenges for energy, while still significant, remain more manageable. If we drift toward the high scenario, not only do adaptation needs explode, but so do the uncertainties – suggesting a risk of facing unmanageable situations. This reinforces the synergy between mitigation and adaptation: aggressive mitigation can be seen as a way to reduce uncertainty and the upper bound of potential adaptation finance needs for sectors like energy.

3.2.7 Findings and Policy Messages

In summary, the analysis for the energy sector reveals several key points: data gaps are a major hindrance, current adaptation efforts are under-funded, and the benefit-cost balance of adaptation is difficult to assess with present methods. Only a handful of countries have quantified their energy adaptation needs, forcing us to use extrapolations for the rest – this is a clear call for improving data collection and sharing. The EU and Member States should invest in detailed sectoral analyses (possibly building on the methodologies of those 8 pioneer countries) to get better resolution on where and how much adaptation is needed in energy systems. Such analyses should strive to cover all relevant cost categories, including those neglected so far (e.g. maladaptation risks, cross-sectoral impacts), to avoid the current situation of hidden costs.

The adaptation funding gap identified – on the order of billions per year even in moderate scenarios – highlights a pressing policy issue. The European Green Deal and associated funds need to explicitly incorporate adaptation finance targets for critical sectors like energy. Mainstreaming adaptation into energy investments (for example, making climate resilience a criterion for energy infrastructure funding, whether EU or national) is a practical step. The upcoming rounds of National Adaptation

Plans and climate strategy revisions should quantify sector-specific gaps and propose financing strategies to close them. Engaging the private sector is also crucial: energy companies and utilities will benefit from resilient infrastructure, so regulatory frameworks (like climate disclosure and stress testing) can encourage them to invest in adaptation alongside public efforts.

The finding that adaptation finance needs can exceed inaction costs in current models should be taken as a call to refine methodologies, not to downplay adaptation. It suggests that more comprehensive cost–benefit analysis is needed. Policymakers should demand improved modelling that captures extreme events and system-wide failures for the energy sector – areas where today's estimates fall short.

3.3 Agriculture

3.3.1 Data Coverage and Extrapolation Needs

Out of the 27 EU Member States, only 3 countries had national studies quantifying adaptation finance needs in the agriculture sector. These countries – Austria, France, and Sweden – provided detailed estimates via their national analyses. The remaining 24 Member States had no dedicated agriculture adaptation cost studies, so their needs were estimated by extrapolation. To fill these gaps, the project derived average unit costs from the available three studies and extrapolated those to all other countries using a suitable proxy, ensuring no Member State was left out.

This heavy reliance on extrapolation underscores a significant data gap. With only 3 Member States supplying primary data, the results for agriculture carry high uncertainty. The few national studies may not capture the diverse farming systems and climate vulnerabilities across Europe, meaning extrapolated figures for other countries should be interpreted with caution. Improving data coverage – through more national studies or EU-wide sectoral assessments – would greatly enhance the robustness of future estimates.

3.3.2 Adaptation Cost Categories and Data Availability

The project categorises adaptation-related costs into five groups: anticipation costs, reaction costs, maladaptation costs, socio-economic impacts, and "other/unclear" costs. For agriculture, the availability of data was limited to essentially one category (anticipatory investments).

All three countries (Austria, France, Sweden) provided data on anticipation costs. Thus, all three national studies focused on forward-looking measures to improve climate resilience in agriculture – for example, investments in upgrading drainage and irrigation infrastructure or adjusting farm management practices. These are costs incurred *before* climate impacts fully manifest, aiming to reduce future damage (e.g. installing efficient irrigation systems ahead of worsening droughts).

Notably, no other cost types were covered in any study.

3.3.3 EU-Level quantitative findings for agriculture

The table below summarises EU-wide annual cost estimates for the agriculture sector under two climate scenarios (moderate and high emissions) and the two time horizons used in the calculations (short-term through 2050, and long-term 2050–2100). All figures are in million euros per year (MEUR), presented as lower–upper estimate ranges based on the underlying data and assumptions.

Table 3.3 Overview of findings at EU level (all numbers in MEUR)

Type	Annual estimates Moderate scenario until 2050		Annual estimates Moderate scenario 2050-2100		Annual estimates High scenario until 2050		Annual estimates High scenario 2050-2100	
	Lower	*Upper*	*Lower*	*Upper*	*Lower*	*Upper*	*Lower*	*Upper*
Cost of inaction	8,704	8,704	29,934	29,934	6,812	6,812	27,914	27,914
Cost of adaptation	6,950	7,523	6,950	9,028	11,189	17,375	11,189	20,850
Funding levels	9,300	9,800	9,300	9,800	9,300	9,800	9,300	9,800
Gap cost of inaction/cost of adaptation	1,753	1,181	22,984	20,907	-4,377	-10,563	16,725	7,064
Funding gap	-2,350	-2,277	-2,350	-772	1,889	7,575	1,889	11,050

Cost of inaction refers to the projected damage or economic loss to agriculture if no further adaptation is undertaken. Notably, for near-term years the modelled inaction cost can be negative in the moderate scenario (resulting in a negative cost of inaction for some countries in the underlying data, here aggregated), meaning a net benefit due to climate change (e.g. reduced cold stress, CO_2 fertilisation improving yields) – indeed we see a smaller inaction cost in the high scenario to 2050 (only €6.8 bn, lower than the moderate’s €8.7 bn). By the late century, however, inaction costs turn sharply positive in both scenarios, reflecting significant climate damages to agriculture (on the order of €28–30 billion per year by 2100). These figures are partial – they derive from economic models focusing on crop yield changes and market adjustments. They do not include all possible impacts (for instance, losses from extreme droughts or floods, or impacts on livestock and farm infrastructure are largely omitted). Additionally, some positive effects (like longer growing seasons in the north) counterbalance negatives in the near term, explaining the relatively modest or even beneficial inaction costs initially.

Cost of adaptation represents the estimated annual investment needed to implement adaptation measures in agriculture. Under a moderate climate scenario, this is about €7.0–7.5 billion per year in the short term, remaining in a similar range (€7.0–9.0 bn) in the second half of the century. Under a high-emissions scenario, required adaptation finance needs are significantly higher – roughly €11.2–17.4 billion/yr through 2050, and potentially up to €20.9 billion/yr by 2100 in the upper-bound estimate. These ranges reflect uncertainties in how much adaptation is pursued (incremental vs. transformational) and the unit costs of measures. Importantly, all three national studies on which these figures are based focused on “incremental” adaptation (improving existing agricultural practices and infrastructure) and did not include radical transformative measures. The three national studies for costs of adaptation in agriculture approach their estimates rather differently. For example, in the French study, costs of 1.5 billion EUR/year for the next 10 years only cover technical solutions, and do not consider fundamental changes to the agricultural system or practices. It should also be noted that the analysis was carried out on only part of France's agricultural land (86%) and does not take animal production into account. There are probably other possible adaptation scenarios (especially if we look beyond 10 years) with quite different cost structures and less capital-intensive responses. In Sweden, the costs are even more specific, only covering investment in increased subsurface drainage and the maintenance of ditches. Such narrowly focused costing needs to be treated with particular caution when used for extrapolation, particularly when other countries may require different adaptation approaches in the agriculture sector. This means the upper end of the range still reflects relatively conventional adaptation approaches. A truly transformational adaptation (e.g. relocating major agricultural regions, wholesale shifts to new crops or farming systems) could push costs even higher, but such measures were outside the scope of the source studies.

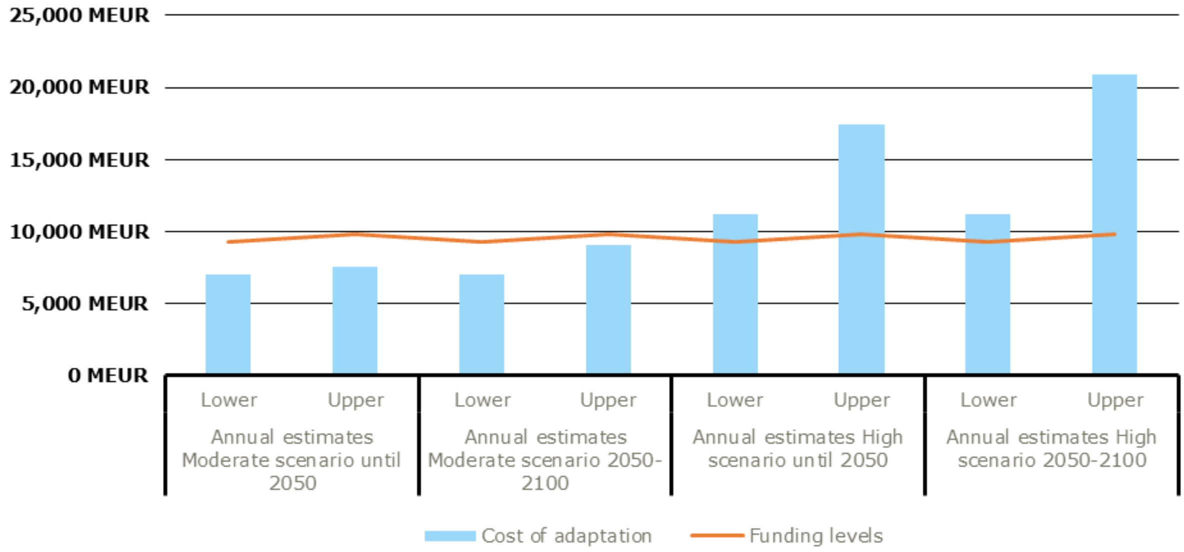
Funding levels indicate the current annual funding directed toward climate adaptation in EU agriculture. Based on budget analyses (primarily the climate-relevant portion of the Common Agricultural Policy and national co-financing), this is estimated around €9.3–9.8 billion per year for the EU-27 (in current spending) – a figure which we assume remains constant across scenarios and time horizons for comparison purposes. In practice, this encompasses various streams: investments in climate-resilient rural development (e.g. through CAP Pillar II programs that support irrigation, soil conservation, water management), national funding for agricultural innovation and extension services, and some private on-farm investments incentivised by subsidies or insurance. It's worth noting that this funding estimate has uncertainty and may include activities with mixed mitigation/adaptation benefits. But in broad terms, current spending on agricultural adaptation is on the order of €9–10 billion annually EU-wide (mostly public funds via CAP) as a status quo baseline.

3.3.4 EU-Level Adaptation Funding Gap by Scenario and Horizon

Findings

At the EU aggregate level, the agriculture sector's adaptation funding situation differs by scenario. The results are summarised in the Figure below.

Figure 3.3 Comparison of climate finance needs and current funding levels across different scenarios developed in the study



Under moderate climate change (2°C), current funding appears *just sufficient* to meet the estimated needs overall – essentially a zero or slightly positive surplus of funds in the near term. However, this result should be interpreted cautiously (see below). By contrast, under a high-emissions scenario (3–4°C), current adaptation funding falls short of requirements, creating a notable funding gap that widens over time:

- Near-term (until 2050), Moderate scenario: Annual adaptation needs for EU agriculture are about €7.0–7.5 billion, roughly matching the €9.3–9.8 billion/year currently directed to agricultural adaptation and resilience (largely through CAP). This implies no significant funding shortfall in aggregate – in fact, taking midpoint values, current spending might slightly exceed minimum estimated needs. In other words, at the EU level, there is *no immediate funding gap* for agriculture adaptation in a 2°C scenario; existing funds could cover the necessary investments. However, this aggregate view conceals distributional issues: some countries or sub-sectors might still be underfunded while others have more than enough. It also reflects the relatively low adaptation cost estimate (which, recall, omits some risks). Thus, the absence of a gap should not breed complacency – it may be a temporary or illusory balance (more on this in the methodological context below).

- Long-term (2050–2100), Moderate scenario: Adaptation finance needs stay in the €7–9 billion range by late century, and if funding remains around €9.5 billion, the gap remains roughly zero to a slight surplus (€0.8–2.3 bn/yr). Essentially, even as climate impacts grow, the moderate scenario does not drastically increase agriculture adaptation needs beyond current funding levels, thanks in part to CO_2 fertilisation and adaptation in models keeping net damages manageable. This suggests that stabilising global warming (e.g. via Paris Agreement targets) keeps agricultural adaptation challenges financially manageable at the macro level – an important policy insight. The sector could integrate necessary measures within existing funding envelopes, assuming they are efficiently allocated.
- Near-term (until 2050), High-emissions scenario: The shortfall becomes evident. With annual needs of €11–17 billion and current funding €9.5 billion, the funding gap is on the order of €2–8 billion per year in the coming decades. In a plausible mid-case (say €14 bn needed vs €9.5 bn available), Europe would be underinvesting by about €4–5 billion annually in climate-proofing its agriculture through mid-century. This means many required measures – irrigation projects, research into heat-resistant crops, farm infrastructure upgrades – might remain unfunded or underfunded, leaving agriculture more vulnerable to intensifying droughts, heatwaves, pests, and floods. The gap in the high scenario is especially concerning because it hits in the near term: unlike some sectors where big costs come later, agriculture might feel strains by the 2030s–2040s if warming accelerates.
- Long-term (2050–2100), High-emissions scenario: By end-century, required adaptation spending could reach €16–21 billion/yr (mid to upper estimate). If current funding were flat, that yields an annual gap up to €11 billion in the worst case. Even the lower-bound need (€11.2 bn) would exceed current funding, implying a gap of €1.9 bn/yr at minimum. In percentage terms, the funding available might cover only about 50–85% of the investment need, leaving a significant portion of necessary measures unfunded. Such a gap indicates that without increased financing, the agricultural sector would face escalating climate damages or productivity losses that could have been avoided. For perspective, an €11 bn/year shortfall is enormous – roughly equivalent to half of the entire current CAP Pillar II budget for rural development in the EU. Bridging that would likely require both reallocating existing agricultural funds and injecting new resources (potentially from national budgets or EU climate funds) on a massive scale.

These scenario outcomes highlight a critical point: the adequacy of adaptation funding for agriculture is highly scenario-dependent. If global mitigation succeeds in keeping climate change moderate, Europe's existing agricultural support structures might suffice to handle adaptation (though targeted improvements would be needed). But if the world follows a high warming path, the current funding paradigm falls far short, and the EU would need to mobilise substantially more adaptation finance for agriculture.

The moderate-scenario "no gap" should not be taken to mean that all is well. Rather, it likely indicates that current spending is counting towards adaptation needs that are underestimated. As discussed below, the bottom-up adaptation cost estimates omit some reactive and systemic measures, and the top-down funding figure might include expenditures that are not purely for adaptation. There is also a strong distributional dimension – even if EU-wide sums align, some regions (e.g. Southern Europe) will require much more than others (Northern regions might even see short-term gains). Policymakers should thus focus on redirecting and targeting funds efficiently: ensuring that the substantial monies in CAP and national programs actually flow to the farmers and areas with the greatest climate risks. In a moderate scenario, better targeting and planning could potentially cover the needs without huge budget increases, but this demands proactive governance.

In the high scenario, the widening gap sends an unequivocal message: significantly more investment in climate adaptation for agriculture will be needed. This could involve increasing the climate earmark within the CAP, establishing dedicated national funds for agricultural resilience, or leveraging instruments like the European Recovery and Resilience Facility for climate adaptation in rural areas. Private sector involvement (e.g. via insurance schemes, public-private partnerships for water infrastructure) will also be crucial to close the gap. The earlier the ramp-up begins, the more we can avoid compounding climate damages. It's also worth noting that global mitigation efforts strongly influence this outcome: keeping warming low is effectively a form of "cost avoidance," sparing the EU from having to find an extra €5–10+ billion every year for agricultural adaptation by late century.

Methodological context

It is important to highlight that the funding gap analysis comes from comparing two very different sources – bottom-up estimated needs vs. top-down budget data. The adaptation cost figures represent an aggregation of identified measures (including what farmers and governments *should* invest in), whereas the current funding numbers mostly capture public expenditures (and even those are not always transparently labelled as adaptation). In agriculture, many adaptation actions are taken by private actors (farmers), sometimes with public subsidies. So, if farmers are already investing in, say, drip irrigation or new technologies without explicit "adaptation funding" labels, the real gap might be smaller than budget numbers suggest. Conversely, the current funding might include spending that is only tangentially related to adaptation or is not used effectively for resilience, which means the *practical* gap in protective action could be larger than the raw numbers imply.

3.3.5 Cost of Adaptation vs. Cost of Inaction in Agriculture

For agriculture, the comparison between adaptation finance needs and inaction costs should be interpreted with particular caution. The results indicate adaptation costs that are in some instances higher than the estimated costs of inaction – a counter-intuitive outcome that mainly reflects the limited evidence base and methodological differences rather than a true cost–benefit relationship. The current analysis shows instances where adaptation finance needs for EU agriculture are higher than the modelled inaction costs, particularly in the near term under a high-emissions scenario. For example, through 2050 in the high scenario, annual adaptation needs (€11–17 bn) are substantially above the annual inaction losses (€6.8 bn). This may suggest that spending more on adaptive measures than the direct losses one would suffer by doing nothing in that period – seemingly counter-intuitive as explained below, a too simplistic and misleading conclusion.

However, only a handful of national studies were available, differing widely in scope and assumptions, and the EU-level estimates therefore rely heavily on extrapolation. The figures should thus be seen as indicative orders of magnitude, not as precise forecasts, and should not be used to draw firm conclusions.

Against this background, two important aspects merit particular attention:

- The inaction cost figures are drawn from a top-down economic model (Ramboll, 2024) focusing on changes in crop yields and production value. This model actually shows *net benefits* in some countries and timeframes – for instance, higher CO_2 concentrations and milder winters can increase crop yields in parts of Europe, leading to *negative* damage estimates (i.e. climate change initially boosts agriculture in those areas). Indeed, the data indicated that countries like

Belgium, Hungary, the Netherlands, and Spain might see "negative costs" of inaction (net gains) in agriculture early on. This greatly understates the harmful side of inaction, because it ignores or downplays many factors: extreme weather events (droughts, floods, heatwaves) that can cause catastrophic crop failures, wildfires destroying farmland, new pest and disease outbreaks under warming, soil degradation, and so on. Those impacts tend to be episodic and were not fully captured in a model averaging yield changes over time. Also, the model did *not* include livestock farming at all, nor some high-value but climate-sensitive sectors like horticulture. In essence, the "cost of inaction" here is incomplete and even optimistic in the near term – it might suggest that doing nothing has little cost or even a benefit, which is misleading. If one were to account for the full spectrum of climate risks to agriculture (including extreme year losses, livestock impacts, and long-term soil and ecosystem damage), the inaction costs would be much higher, and likely far exceed adaptation finance needs. The current narrow focus (crop yields, gradual changes) is biasing the comparison.

- On the flip side, the adaptation cost estimates, while incomplete in categories, are relatively comprehensive in terms of measures considered. They effectively imagine an aggressive implementation of many adaptation options – e.g. upgrading all drainage systems, expanding irrigation wherever needed, changing farming practices across the board to climate-smart techniques. These are largely *up-front investments*, incurred early to safeguard future production. For example, building a new reservoir or modernising an irrigation network is costly now, even if the benefit (avoided drought losses) accrues over decades. The adaptation studies likely took a "desired level of protection" approach – estimating costs to climate-proof a large portion of the sector, rather than only the minimum needed to offset the modelled damages. As a result, the adaptation cost number can be higher because it's aiming for a robust resilience that avoids not just the average damages but also prepares for worst-case scenarios. Meanwhile, the inaction cost number (as noted) is an average expected loss *not counting worst-cases*. It's not an apples-to-apples comparison: it's like comparing the cost of insurance vs. the expected payout. Often insurance (adaptation) will look expensive relative to average losses if those average losses don't reflect rare disasters. In agriculture, this is evident – the adaptation spending includes building resilience against things like a 1-in-50 year drought, whereas the inaction model might be smoothing that out or ignoring it.

The primary takeaway is that the current comparison between adaptation and inaction costs for agriculture is not truly reflective of the real trade-off. The fact that adaptation finance needs appear higher in some cases does not mean adaptation is a bad investment or "not worth it." Instead, it flags that our understanding of inaction costs is insufficient. Key impact channels are missing in the damage estimates (especially extreme events and non-crop factors), and thus the benefits of adaptation are undervalued. As noted in the draft report: "the estimation presents an increase of crop yields (benefit) due to CO_2-fertilisation, challenging the discussion of cost of adaptation vs cost of inaction… the top-down models do not account for extreme events and associated losses".

In reality, if we properly accounted for droughts that wipe out harvests, livestock losses in heatwaves, or pest outbreaks in a warmer climate, the cost of inaction would likely far surpass adaptation finance needs in agriculture. For example, consider that the €27.9 bn/year inaction cost for late-century high scenario mainly reflects yield declines; if one major heatwave in 2080 causes a Europe-wide crop failure, the damage in that single year could be hundreds of billions (as seen in smaller scale events already). Adaptation (like heat/drought resistant crops, water storage, insurance schemes) would mitigate such a catastrophe.

3.3.6 Additional Analytical Insights

Beyond the core findings above, several other insights emerge from the agriculture data and analysis:

- High uncertainty and wide ranges: There are considerable uncertainties in the estimates, reflected in the "lower" vs "upper" bounds for adaptation finance needs. In the agriculture sector, these ranges are significant – for example, under a high scenario to 2100, the lower-bound adaptation need (€11.2 bn) is almost half of the upper-bound (€20.9 bn). This large spread stems from different assumptions about how adaptation is implemented (incremental improvements versus more transformational, costly measures) and the efficiency of those measures. It underlines that actual needs could be substantially higher if worst-case climate impacts materialise or if more extensive measures (like large-scale irrigation projects, new infrastructure, or relocation of production zones) become necessary. On the other hand, if climate impacts are milder or if adaptation can be integrated into regular farm investments at low marginal cost, the lower end might be sufficient. Policymakers thus face a wide "planning range" – it would be prudent to prepare for the higher end, given the risks, while working to keep costs nearer the lower end through innovation and efficient implementation.
- Sparse data and extrapolation reliability: The agriculture adaptation estimates rest on a very limited empirical foundation – just three national studies. Each of these studies had its own scope and methodology. The project applied calibration factors to standardise these to common scenarios, but inherent differences remain. With only three data points feeding a model for 27 countries, the extrapolation introduces significant uncertainty. Countries without studies were assigned costs based on proxies (like share of EU agricultural value or land) which cannot capture local nuances.

4. Key Findings and Policy Messages

- Only a handful of Member States (3 out of 27) have quantified their agriculture adaptation finance needs, meaning the majority of EU countries are currently relying on rough extrapolations. This is a clear call to improve the knowledge base. The EU should encourage and support Member States in conducting detailed adaptation cost assessments for agriculture.
- Even under a moderate scenario, Europe needs on the order of **€7–9 billion annually** to adapt its agriculture by mid-century, and more if high-impact climate scenarios unfold. Under 3–4°C of global warming, that figure could reach **€11–21 billion per year by 2100**. These sums are comparable to, or even exceed, some current agricultural support expenditures. Climate adaptation is not a peripheral issue for agriculture – it will demand a scale of resources similar to existing major budget lines. Policymakers should integrate climate resilience as a core objective of the Common Agricultural Policy. Future CAP reforms (and national agricultural strategies) must explicitly factor in these investment needs; otherwise, there is a risk of severe agricultural output losses and rural livelihood impacts from climate change.
- At present, roughly **€9–10 billion/year** is spent on adaptation-related agricultural measures (through CAP greening, rural development, etc.), which is roughly enough to cover estimated needs if warming is kept to around 2°C. However, in a high-emissions world, **there could be a funding gap up to €11 billion/year by late century** where needed investments outstrip current budgets. The EU and Member States should **plan for scaling up adaptation finance** for agriculture in line with climate scenario trajectories. is likely cheaper and more effective than disaster relief after the fact.

4.1 Cross-sector comparison

- Even under a moderate pathway, required energy-sector adaptation spending (€ 40 bn yr^{-1}) is five-to-six times larger than that for transport or agriculture, reflecting the capital-intensive nature of generation and grids and the broad hazard set they face. Funding today covers barely 6 % of that need, leaving by far the largest absolute gap.
- Transport shows a persistent mid-sized gap. Current outlays finance roughly half of the € 7-8 bn yr^{-1} that would be needed through mid-century; the gap widens sharply in a high-warming world. Moreover, recorded adaptation finance needs already exceed the (narrowly defined) damages modelled for inaction, hinting that transport-related climate losses are under-represented in impact studies.
- Agriculture is (for now) the outlier. Thanks to CAP and rural-development streams, present funding slightly exceeds estimated near-term needs under a moderate scenario. But two caveats apply: (i) estimates rely on only three national studies and heavy extrapolation, and (ii) in a high-emission scenario the sector flips back into deficit, with a € 1.9–7.6 bn yr^{-1} shortfall by 2050.
- Adaptation vs. inaction dynamics differ sharply.
  - Transport & Energy: adaptation finance needs are far higher than the partial damage estimates now available, largely because the latter omit cascading failures and many hazards.
  - Agriculture: the opposite holds in the medium term - avoided damages exceed the cost of preventive measures, indicating strong economic rationale for timely action

4.2 Challenges associated with comparing costs of adaptation to costs of inaction

Methodological challenges

In general it should be pointed out that comparing adaptation finance needs to "inaction" costs entails several challenges.

Firstly, in the context of this study, the two are estimated by very different methods and cover different things.

Models that estimate the inaction costs typically use one of a few approaches – each with built-in assumptions that bias the results low. For example, an enumerative approach simply adds up separately estimated sectoral impacts (such as lower crop yields or heat-related mortality) to get total damage. While transparent, this method ignores economy-wide feedbacks. It omits price changes and cross-sector effects, and it cannot determine the value of hard-to-measure losses (like loss of biodiversity or social disruption). In practice, that means many important consequences of climate change never appear in these sums.

Similarly, computable general equilibrium (CGE) models – which simulate the whole economy – tend to understate damages. These models assume resources (labour, capital, materials) can shift from one use to another at virtually no cost, with wages and prices adjusting instantly to clear markets. In effect, they assume perfectly flexible, full-employment In reality, large floods, droughts or heatwaves often create bottlenecks, unemployment and expensive transitions that CGE models don't capture. Because CGE models smooth over these frictions, they too give damage estimates that are likely too low compared to what would actually happen in an economy hit by severe climate events. A third line of evidence uses econometric (statistical) models based on historical weather-economy data. These regressions typically link past year-to-year temperature changes to GDP or productivity changes, then extrapolate forward. This implicitly assumes that how society coped in the short run will scale into the future. Econometric models also struggle to capture nonlinear thresholds (say, crop failure after a certain heat limit). In short, by relying on past correlations, they risk missing accelerating damages under future warming. In fact, recent critiques of the literature emphasise that all these economic methods (enumerative, CGE, econometric, etc.) share a common flaw: they tend to seriously underestimate climate damages

By contrast, our adaptation-cost estimates come from explicit engineering and investment plans (for example, building seawalls or upgrading infrastructure). Those costs are concrete, one-off expenditures. This mismatch – "well-defined spending" versus "partial modelled damages" – means direct comparison is not valid. Adaptation finance needs are often comprehensive (covering entire projects), whereas modelled inaction costs are partial and conditional on assumptions (some sectors, some effects). In many cases the adaptation budget exceeds the model's damage estimate, simply because the model did not count all the losses that adaptation would prevent.

All this corroborates that simple cost comparisons miss key factors, so adaptation finance needs should not be judged against a narrow "cost of inaction" total.

Issues of justice and fairness when considering costs of adaptation vs costs of inaction

Questions of justice often arise when comparing the costs of adapting to climate change with the costs of doing nothing. Inaction effectively shifts burdens onto those who are often least responsible for emissions – for example poorer communities or future generations – which raises equity concerns. If adaptation investments are treated as optional, the resulting damages (crop failures, property loss, health impacts, etc.) will fall disproportionately on the most vulnerable. From an ethical standpoint, many would argue that it is unfair to impose these future losses on others simply to save money today. In this light, it is important to weigh not only the economic figures but also the distribution of impacts. Fairness suggests that societies should consider both who pays for adaptation and who suffers if we fail to adapt. Ultimately, the choice is not just between two cost totals, but between different risk-sharing arrangements. Policymakers often conclude that financing adaptation (especially for those with limited resources) is justified to prevent much greater harm from inaction.

5. POTENTIAL WAYS FORWARD BUILDING ON THE PROJECT

5.1 Filling the remaining gaps in the database

Despite substantial effort for identifying existing studies, many sectors still seem to lack comprehensive data on adaptation finance needs. This uneven coverage suggests that more national-level studies would be beneficial – they would not only help each country plan better but also enrich EU-wide overviews and comparisons.

The Excel-based calculation matrices delivered with this study have been designed as living tools: every cell that hosts an input value is clearly flagged, formulae are transparent, and summary tables and charts update automatically. The EEA can therefore treat the workbooks as a permanent repository for adaptation-cost evidence. As new national or sectoral studies emerge, analysts can input new data; the calibration routines and extrapolation blocks will refresh the EU totals instantly.

Looking ahead, future work could refine our approach further. For instance, extrapolations might be made more accurate by calibrating them according to each Member State's specific hazard exposure rather than assuming uniform vulnerability. These steps would help to close gaps in the data and improve the reliability of our cost estimates.

5.2 Advancing methodological guidance on the cost of adaptation

The project has demonstrated that the absence of a common costing framework remains a major barrier to credible EU-wide comparisons. Building on the project findings, the Agency could convene a technical working group to draft a practical handbook for Member States. Such guidance would harmonise cost categories (anticipatory, reactive, maladaptation, socio-economic spill-overs), recommend default calibration coefficients and discount rates, and set out minimum documentation standards so that studies can be plugged straight into the database. A companion spreadsheet template and simple QA checklist would lower the entry threshold for national teams, while annual webinars could keep the expert community aligned on emerging best practice.

5.3 Filling the evidence gap on current adaptation funding

Another large blind spot revealed by the study is the lack of reliable, granular data on how much is actually being spent on adaptation each year. EU budget lines, national grants, local authority projects and private investments are reported under different headings and with varying levels of detail, making aggregation difficult. The Agency is well placed to spearhead an Adaptation Finance Tracker that would bring these strands together. Such a resource would allow policymakers to monitor progress against estimated needs, spotlight funding gaps in particular sectors or regions, and provide the empirical basis for future EU budget debates.

6. CONCLUSIONS

This study delivers the first EU-wide, sector-specific comparison of the cost of adapting to climate change with the cost of doing nothing and with the resources currently spent. By combining bottom-up evidence from Member State studies with calibrated extrapolations, and by setting those figures against a top-down picture of public and private spending, it provides policy-relevant insights.

First, the numbers confirm the economic case for decisive, early action.

Even under a moderate-warming pathway, annual adaptation needs run to at least €50 billion across transport, energy and agriculture; in a high-emissions world they could easily double. Current flows of dedicated adaptation finance cover only a fraction of those sums - around one half in transport, one quarter in energy and, once the CAP is included, roughly the full amount in agriculture, but only if warming is held close to 2 °C. Under a 3–4 °C trajectory the aggregate gap widens to between €15 billion and €30 billion a year by mid-century, with transport alone facing up to €21 billion of unmet needs by 2100

Bridging that gap is more cost-effective than bearing the escalating damages that would otherwise materialise; the apparently low "cost of inaction" in some sectors stems from well-known under-estimation biases in current damage models, not from genuine resilience

Second, the exercise exposes critical knowledge and governance gaps that now demand attention.

Only a quarter of Member States have quantified transport or energy adaptation finance needs. Funding data are equally patchy and reported under divergent headings, obscuring who pays and who benefits. Without a common costing framework and an EU-level Adaptation Finance Tracker,

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Appendix 1. CALCULATION MATRIXES

See calculation matrixes in separate files.