



DECIPHER

Holistic decision-making for climate & environment

Financing Resilience: Investments in Climate Action, Flood Risk Reduction and Biodiversity Conservation

Macroeconomic analysis of EU investment needs under alternative
climate pathways

Authors: Zoi Vrontisi, Stelios Tsiaras, Chris Thoung, Jamie Pirie, Rutger Broer,
Ugne Keliauskaite



1.1 Motivation

While European governments are preparing their nationally determined contributions (NDCs) in advance of COP30¹, climate change continues, with increasing but unequally distributed impacts across Europe and the world. Emerging risks are manifold, associated with different types of hazards across sectors. Severe flooding² and sustained biodiversity loss³ are key drivers of these climate physical risks, with the first being identified as one of the major climate cost drivers (EUCRA(2024)) and the second being at the forefront of new research including in the financial sector (ECB (2024)).

The quantity and form of investments in climate change mitigation, adaptation, and biodiversity conservation are thus critical to both national and global policymaking. Policy debates concern, among others, the relative benefits of mitigation efforts and whether/how such investments (or otherwise) might also affect economic performance. Divergent views and evidence/data gaps complicate consensus building on the design and implementation of effective climate policies.

In response to these challenges, this policy brief presents an integrated macroeconomic analysis of climate change impacts and associated investment needs, focusing on climate change mitigation, flood adaptation, and biodiversity conservation. The analysis, drawing on work under the Horizon Europe DECIPHER project, shows that, for the EU, adapting in a timely manner can mitigate macroeconomic costs from future climate damages. This finding is robust across methodological approaches and for alternative financing schemes of adaptation measures. Results also show that biodiversity conservation costs are affordable, indicating that species loss due to climate change can be minimized with negligible macroeconomic implications.

Using two widely applied large-scale macroeconomic models, E3ME and GEM-E3, both of which were augmented under DECIPHER, we estimate in a consistent scenario framework the costs, economic and distributional implications of:

¹ <https://www.consilium.europa.eu/en/press/press-releases/2025/09/18/paris-agreement-eu-submits-statement-of-intent-to-the-unfccc-on-the-post-2030-ndc/>

² Copernicus Climate Change Service (C3S) and World Meteorological Organization (WMO), 2025: European State of the Climate 2024, climate.copernicus.eu/ESOTC/2024, doi.org/10.24381/14j9-s541

³ EEA (2025) Biodiversity: state of habitats and species. European Environment Agency. Accessible at: <https://www.eea.europa.eu/en/topics/in-depth/biodiversity?activeTab=07e50b68-8bf2-4641-ba6b-edalafd544be>



- Flood damages and the potential compensating role of adaptation measures
- Conservation expenditures to protect against climate-induced biodiversity loss
- Climate action and associated investments

We perform the analysis by comparing flood damages, associated adaptation pathways (low versus optimal) and biodiversity conservation measures in two climate scenarios:⁴

- Current Policies (corresponding to an RCP 6 temperature trajectory)
- A Net Zero scenario with NDCs and Long-Term Strategies (LTS) (corresponding to an RCP 2.6 temperature trajectory)

This gives rise to four scenarios over two overarching dimensions: low/high mitigation and low/optimal adaptation. The comparator (reference/baseline) in each case is the mitigation scenario before any consideration of flood damages or adaptation.

The present policy brief focuses on the EU and its Member States. For the complete global assessment, including other major economies beyond the EU27, see the reference study – DECIPHER Deliverable D6.3: Applications of the unified decision-making framework.

⁴ We compare two contrasting representative concentration pathways (RCPs), which are adopted by the IPCC and used for climate and economic projections. RCPs describe different plausible future scenarios of human behaviour and GHG emissions, resulting in a specific radiative forcing and global warming. In this assessment, we refer to RCP 2.6 (high reduction of GHG) and RCP 6 (low reduction of GHG). RCP 2.6 includes GHG peak emissions in the 2020s and a decline to near-zero levels. RCP 6 includes the GHG peak in 2080 and 3–4 degrees of global warming compared to pre-industrial levels.



1.2 Integrated risk assessment framework

The analysis uses two models, analysing four scenarios defined over a range of inputs.

- E3ME-FTT is a global macro-econometric model that applies economic (national) accounting identities and empirically estimated behavioural equations to model interactions between the economy, energy system and environment. E3ME incorporates a bottom-up approach to modelling power generation technologies and uses an input-output framework to model the supply-chain effects of changes in industrial output and expenditure.
- GEM-E3 is a large-scale hybrid computable general equilibrium (CGE) model used to assess the links between the economy, energy system, and environment. The model has a detailed sectoral and regional granularity and represents economic agents and their interactions with a sophistication that goes beyond standard CGEs. It simulates how households, firms, governments, and foreign trade interact, considering energy use, technological progress, labour market and environmental policies. Particular focus is placed on the representation of the energy system where specialized bottom-up modules of the power generation; buildings and transport sectors have been developed.

While the models offer similar regional and sectoral granularity and report common key indicators, their representation of and assumptions about the economy and how agents take decisions differs. It is for this reason that the two models, a macroeconomic and a CGE one, have been widely used in tandem for policy impact assessment (e.g. European Commission 2022 and 2024), allowing for robust insights that emerge from the two different representations of the economy, and a sensitivity of results to assumed differences.

With respect to the current analysis, a crucial difference is in the treatment of adaptation measures. In E3ME, adaptation costs are considered as investments that increase the productive capacity of the economy and can be financed over and above existing outlays, provided the return on investment is justified. In contrast, in GEM-E3, such costs are considered as non-productive investments financed through an increase in general taxation, generating demand but not adding to the productive capacity of the economy.



Direct costs and damages for selected climate impacts

The analysis integrates multiple dimensions of climate-related costs and investments, utilizing the methodological advancements of the DECIPHER project. The macroeconomic models have incorporated a damage and adaptation function for floods, derived from the DIVA model and a biodiversity indicator and conservation function, derived from the LC-IMPACT model (as described in detail in DECIPHER Deliverable D3.4). Below we present the inputs that form the core of the macroeconomic modelling exercise.

1. Flood Damages and Adaptation Costs (this considers costs for building dikes, conditional on the level of adaptation effort)

We consider two cases of adaptation: low adaptation (constant flood protection standard in the DIVA model) and an optimal adaptation scenario (optimal protection in the DIVA model). In the low adaptation scenario, coastal planners pursue a business-as-usual protection strategy in which protection levels are kept constant. Dikes grow with sea-level rise in this scenario but may not be optimal (some countries could be over- or under-protected). In the optimal adaptation scenario coastal planners in this scenario are at their most proactive, employing cost-benefit analysis to assess optimal protection levels. Overall coastal impacts, the sum of residual damages and adaptation cost, are minimized with respect to coastal protection.

Optimal adaptation investments are designed to minimize flood-related damages through optimal allocation which requires an early adaptation investment up to 2035. EU Member States have small levels of cumulative adaptation costs against sea level rise, compared to the global cumulative sum of USD 650 billion by 2050 for flood adaptation.

In the low adaptation case, cumulative damages and adaptation costs per Member State represent less than 0.25% of cumulative GDP over 2025–2050 with the exception of the Netherlands, for which the damage is in the region of 1% by the same metrics (as in the left-hand part of see Figure 1 and Figure 2). This is the case whether mitigation efforts are in line with current policies (RCP 6) or more concerted climate action (RCP 2.6), owing to broadly similar temperature trajectories over the period to 2050. Beyond 2050 the adaptation pathway of the two climatic scenarios deviates considerably, see (IPCC (2022) among others). Optimal adaptation involves more investment (thus incurring additional costs) but also reduces flood damage (reducing damage costs). The optimal adaptation case shows combined investment costs and damages to be much lower than in the low adaptation case; again, irrespective of the level of mitigation (as in the right-hand part of see Figure 1 and Figure 2). This shows clear cost advantages of optimal adaptation which is frontloaded on the short-run for the 2025–2050 period.

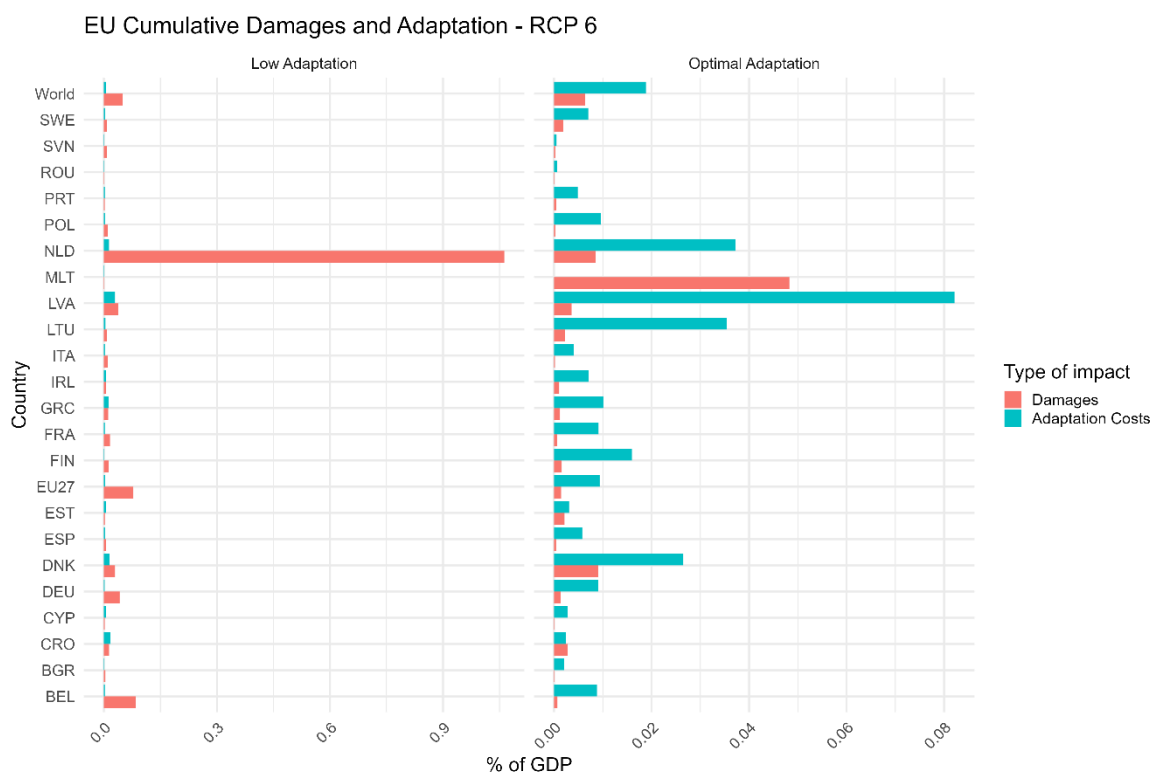


Figure 1 EU Cumulative Damages and Adaptation costs – RCP 6. Cumulative damages and associated adaptation costs are attributed to the Current Policies mitigation action scenario, from 2025 to 2050, presented as a percentage of cumulative GDP of the reference scenario.

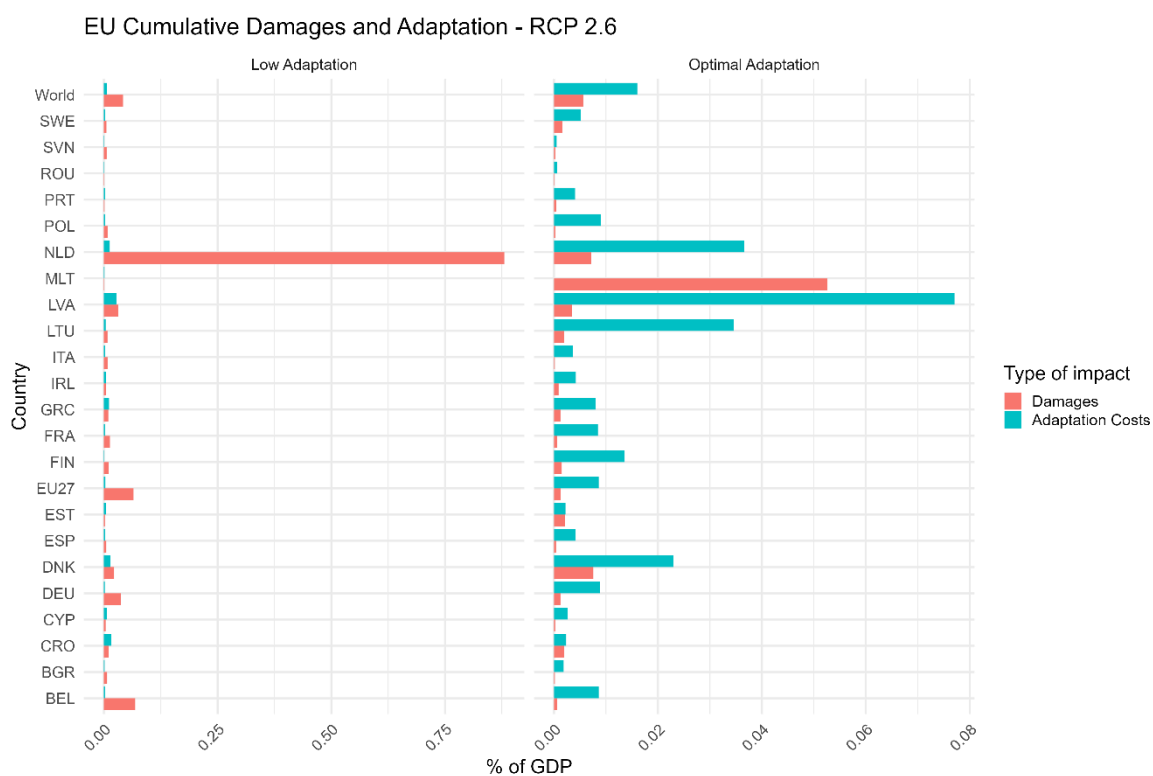


Figure 2 EU Cumulative Damages and Adaptation costs – RCP 2.6. Cumulative damages and associated adaptation costs attributed to the NDC/LTS mitigation action scenario, from 2025 to 2050, presented as a percentage of cumulative GDP of the reference scenario



It should be noted that flood damages are expected to materialize more substantially after 2050, when the two climate scenarios (RCPs) diverge significantly in terms of temperature increase and associated impacts. In the long run there will be a substantial difference between the damages of RCP 2.6 and RCP 6.

2. Biodiversity Conservation Costs in the EU

The cumulative costs required for biodiversity conservation in the EU over 2025–2050 are shown in Figure 3 and Figure 4. These are estimates of conservation costs necessary to avoid species extinction. The costs for the EU as a whole are significantly lower than total global costs of some 36 billion USD. This reflects the relatively lower biodiversity vulnerability and conservation needs in the EU compared to other parts of the world. Specifically, EU costs are about 8% of total global biodiversity conservation costs. Estimates for both climatic scenarios are of a similar magnitude as temperature changes up to 2050 are similar.

EU biodiversity conservation costs represent just 0.002% of cumulative GDP, similar to the global average of 0.001%, indicating that nature conservation is affordable under both climatic scenarios.

Given the relatively modest budgets involved, biodiversity initiatives could offer cost-effective and complementary benefits when implemented alongside flood adaptation measures. Such investments should therefore be viewed as part of an integrated package aimed at enhancing overall resilience.

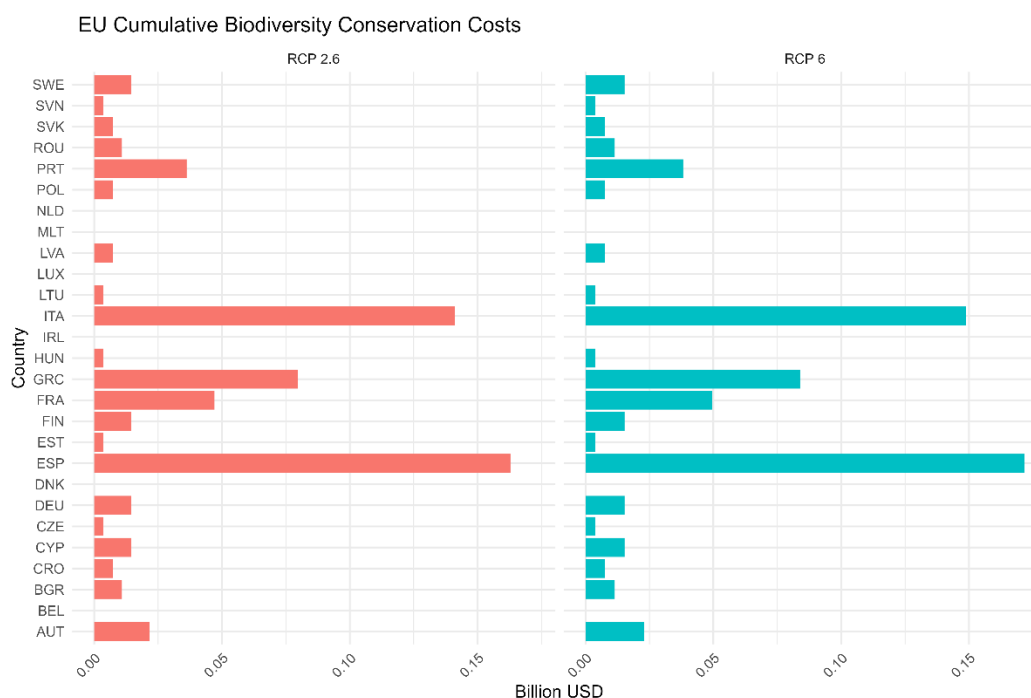


Figure 3 Cumulative Biodiversity Conservation Costs, 2025 to 2050

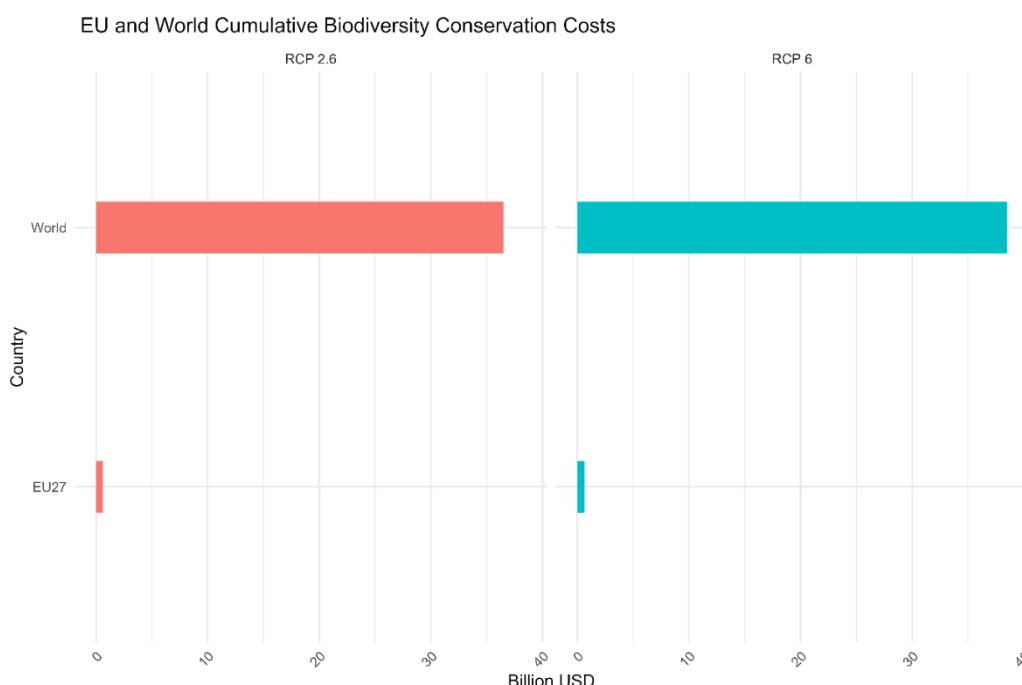


Figure 4 Cumulative Biodiversity Conservation Costs for the EU and the World total, 2025 to 2050

1.3 Macroeconomic implications

Here we focus on assessing the GDP impacts under two different mitigation pathways considering flood damages with associated adaptation options, and biodiversity conservation costs. To do this, we present four scenarios⁵ that use as reference the respective original mitigation scenarios (Current Policies and NDC/LTS) i.e. without any flood damages or adaptation considered.

⁵ An extended presentation of results, including further scenarios and regional scope, is provided in the DECIPHER D6.3 deliverable. In this deliverable, nine different scenarios are assessed: Current policies (baseline), current policies with low adaptation, current policies with high adaptation, current policies with high adaptation and biodiversity conservation costs, NDC/LTS, NDC/LTS with low adaptation, NDC/LTS with high adaptation, NDC/LTS with high adaptation and biodiversity conservation costs and finally an integrated scenario of NDC/LTS with high adaptation and also financial risks from the CLIMACRED model.

Current Policy Scenarios (RCP 6)

The outcomes of the high and low adaptation scenarios under Current Policies are presented in Figure 5, for both E3ME and GEM-E3. These scenarios are evaluated against a mitigation-only scenario which does not consider flood damages and adaptation measures.

Low Adaptation. In the low-adaptation scenario, both models project a decline in GDP. With adaptation flood protection investments kept at low levels, the economy is exposed to damages of 0.08% of GDP at the EU level resulting in overall macroeconomic implications of 0.07% reduction of GDP. Low adaptation results in increased damages, including capital destruction, which in turn exacerbates the negative macroeconomic impacts.

Optimal Adaptation. In the optimal adaptation scenario, damages are reduced to their lowest levels due to the more ambitious adaptation pathway. Optimal adaptation is designed with investment frontloaded to the short term, to 2030. After 2030, adaptation levels are much lower. In the short run, the two models exhibit diverging output responses. This divergence arises from their differing assumptions about whether adaptation investments are treated as productive (E3ME) or non-productive (GEM-E3). In the longer run, however, GDP in both models stabilises, to +/- 0.01% of baseline.

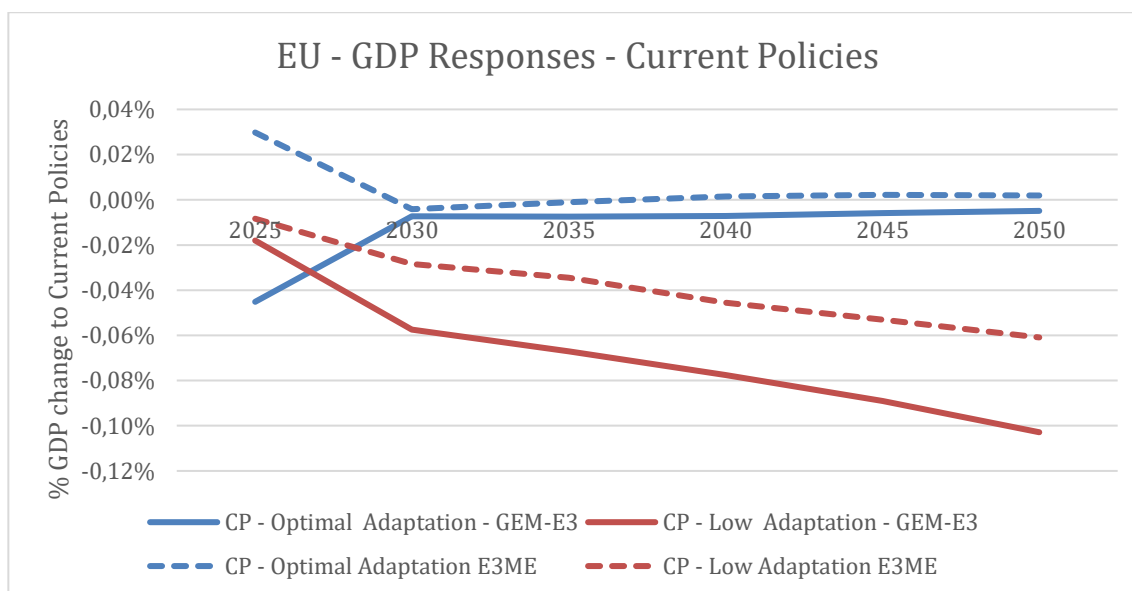


Figure 5 EU Current Policies – Optimal and Low Adaptation

Going to a more granular level, we observe heterogeneous responses among EU countries under the low adaptation scenario with high damages, see Figure 6. The Netherlands stands out as by far the most affected country, experiencing a cumulative GDP reduction of about 1%, while Belgium follows with a much smaller impact of less than 0.1%. This indicates that the negative aggregate results for the EU are largely driven by the Netherlands' response. Overall, the ranking of impacts aligns



well with the inputs used in the general equilibrium model, with only a few exceptions. In particular, Denmark exhibits a slight positive GDP effect, reflecting a rise in exports after 2040 due to competitiveness gains relative to the other countries.

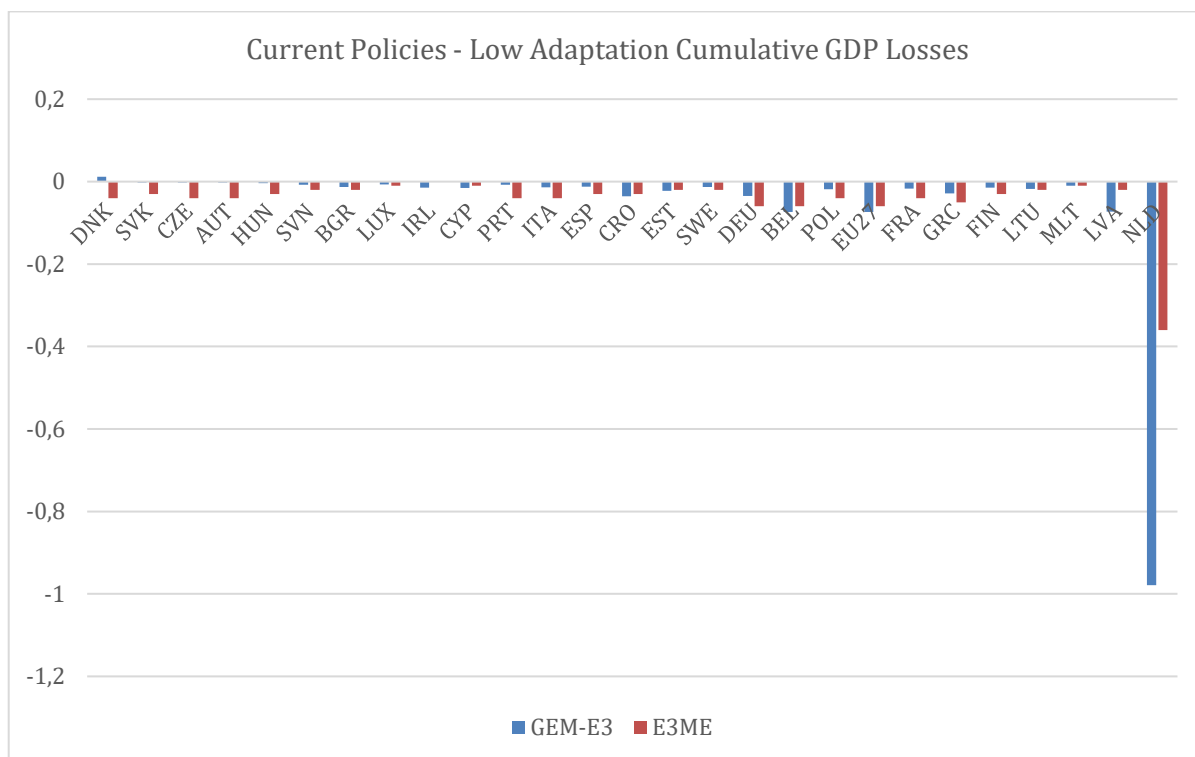


Figure 6 EU countries Current Policies – Low adaptation cumulative GDP losses, GEM-E3 results

Lastly, while the policy brief does not include a detailed sectoral analysis, the construction sector stands out with a notable difference between the low and optimal adaptation scenarios. Under low adaptation, construction activity declines slightly by approximately 0.01% compared to the baseline. In contrast, under the optimal adaptation scenario, it increases by around 0.2%. This divergence reflects changing sectoral demand across scenarios. Other sectors generally follow a trajectory that closely mirrors overall GDP trends.

NDC/LTS Scenarios (RCP 2.6)

A similar pattern emerges when examining the optimal and low adaptation scenarios under the NDC/LTS climate pathway of the Net Zero scenario (see Figure 7 7), with the outcomes continuing to highlight the contrast between low adaptation—leading to higher flood damages *and* economic losses—and optimal adaptation, which substantially mitigates damages and preserves economic growth.

It is important to note that although the analysis is conducted under a lower-emissions pathway (RCP 2.6) compared to the current policies scenario (RCP 6), the resulting damages under both adaptation intensity assumptions are not substantially different. This is due to the relatively short time horizon of the study: both



RCPs project similar global mean temperature increases up to 2050, with substantial divergence occurring only in the post-2050 period. This is much less likely to be the case beyond 2050, as higher temperatures increase both the frequency and severity of natural disasters.

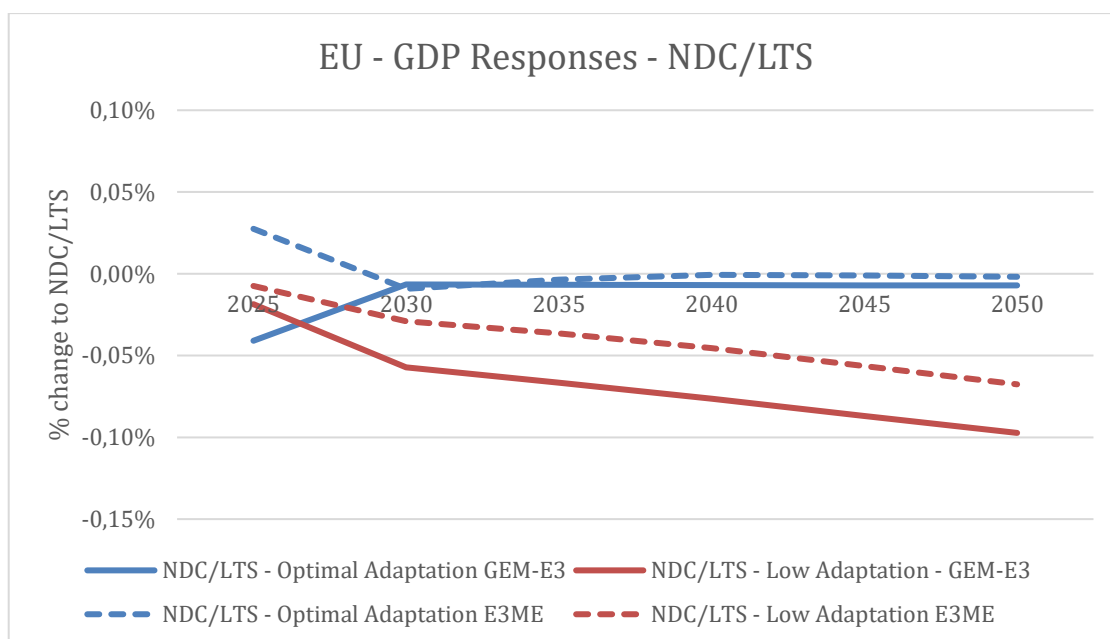


Figure 7 7 EU NDC/LTS – Optimal and Low Adaptation

Optimal adaptation investments are relatively modest in scale, yet they can nearly eliminate the damages from future flood events. Their macroeconomic effects, however, depend strongly on how they are modelled: if they are considered as non-productive investments, as in GEM-E3, they require additional resources in the economy, creating additional demand but also a tension for goods and services to the detriment of other more productive uses of these resources. On the contrary, if assumed as additional investments that activate idle resources, as in E3ME, the effect can be positive.

This key finding is robust across mitigation scenarios, holding under both current policies and the NDC/LTS pathways. Biodiversity conservation costs also require only limited funding, making them comparatively less resource intensive. Overall, high levels of adaptation generate the least economic distortions in the long run.

Similar to the Current Policies scenario, we present the heterogeneous cumulative GDP responses of EU member states under the low adaptation scenario of the NDC/LTS pathway in Figure 8. The Netherlands experiences the largest losses, while most other economies display comparable responses. Once again, Denmark records small positive gains, reflecting improved competitiveness.

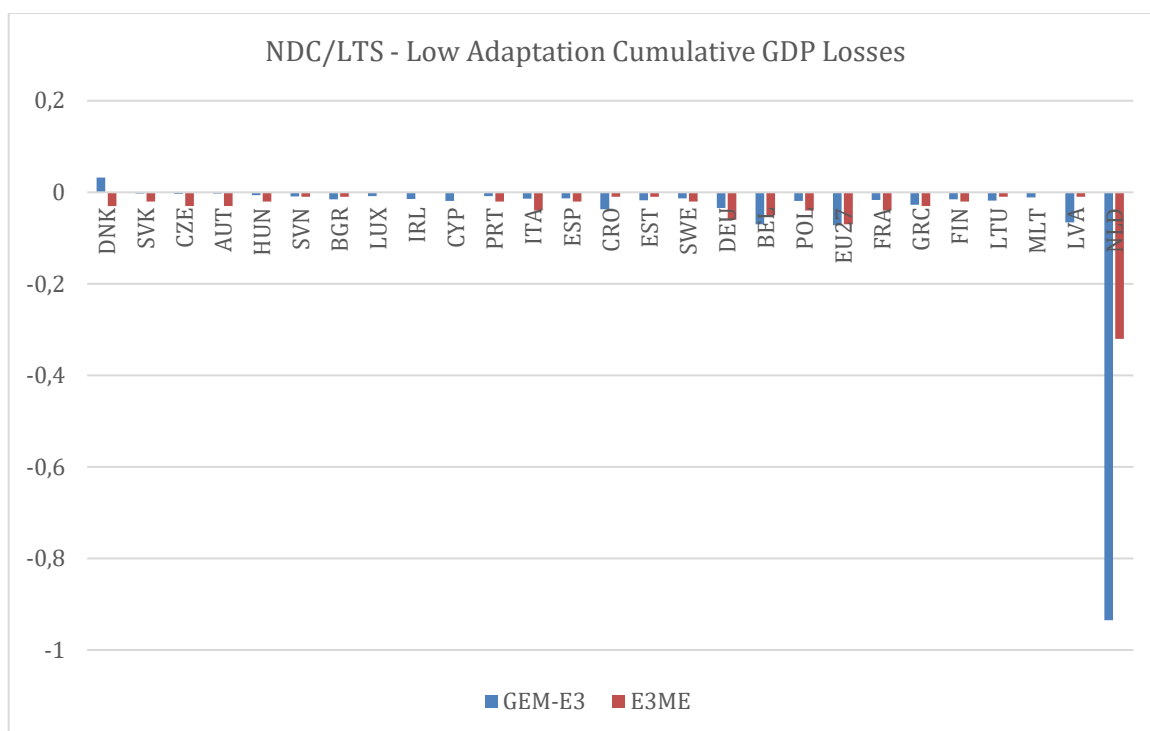


Figure 8 EU countries NDC/LTS – Low adaptation cumulative GDP losses, GEM-E3 results

Key Takeaways

- **Early, substantial flood adaptation** requires upfront investments but pays off in the long run by preserving GDP growth. This is the case even in a low-emissions world.
- **Biodiversity conservation costs** are comparatively small and affordable.
- **Flood damages are modestly amplified on a global scale when considering all direct, indirect and induced economic effects by a factor of 1.17.** For the EU level the impact is moderated by a factor of 0.94, showing a gain in competitiveness for the EU region, given the comparable lower magnitude of the damages.
- **Construction sector shows substantial difference between low and optimal adaptation**, as demand for those sectors change for each scenario. Construction while decreasing at the low adaptation at about 0.01%, on the optimal adaptation scenario it increases at about 0.2% compared to the baseline. The rest of the sectors follow similarly to the GDP trajectory.
- **EU MS level results show asymmetric responses** with Netherlands having the highest cumulative GDP losses of about 1% compared to the baseline levels and the rest of the economies averaging at a 0.1% loss of output.
- **Although adaptation costs are financed under budget neutrality and increased indirect taxes**, the overall tax revenues are reduced by 0.05% compared to the baseline, in the high adaptation scenarios due to the economic losses.



1.4 Policy implications

As countries update their NDCs, policymakers should consider the following recommendations:

Early action on flood adaptation is needed to protect future GDP growth

EU institutions and national governments should prioritize early financing for flood-protection infrastructure and nature-based solutions. Acting before 2050 is critical because *inaction* reduces GDP in the long run, especially compared to the case of no adaptation measures.

The impact of flood damages on EU economies is highly heterogeneous, differing substantially across member states. Potential subsidies should take this variation into account.

Sectoral impacts show only small variations. Construction is a notable exception, benefiting from early adaptation measures.

Extend flood adaptation studies beyond 2050

Expected damages caused by flooding are expected to increase, and at a much higher pace, after 2050. As such, 2050 is partially sufficient as a time horizon to examine the merits of adaptation measures and modelling studies should be extended accordingly. A proposed terminal year is at least 2070.

Protect biodiversity as part of climate action

Stable funding for biodiversity conservation is essential to maintain ecosystem services, including natural flood control. Given the relatively small budgets required, there is potential for biodiversity efforts to be cost-effective and synergistic when considered alongside flood adaptation. Investments should, accordingly, be considered as a broader package to strengthen overall resilience.

Strengthen coordination and data sharing for responsive adaptation policies

A dedicated EU platform to track effectiveness of adaptation measures and disseminate best practices could help Member States calibrate their policies and update cost-benefit analyses as climate impacts evolve. In the face of current uncertainty, this will support a responsive approach to developing and deploying solutions over time.

Embed adaptation in EU and national climate strategies

Strengthen the integration of flood-risk reduction within the European Green Deal, the EU Adaptation Strategy and upcoming NDC updates by ensuring dedicated, predictable multi-year financing and clear national implementation plans.



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