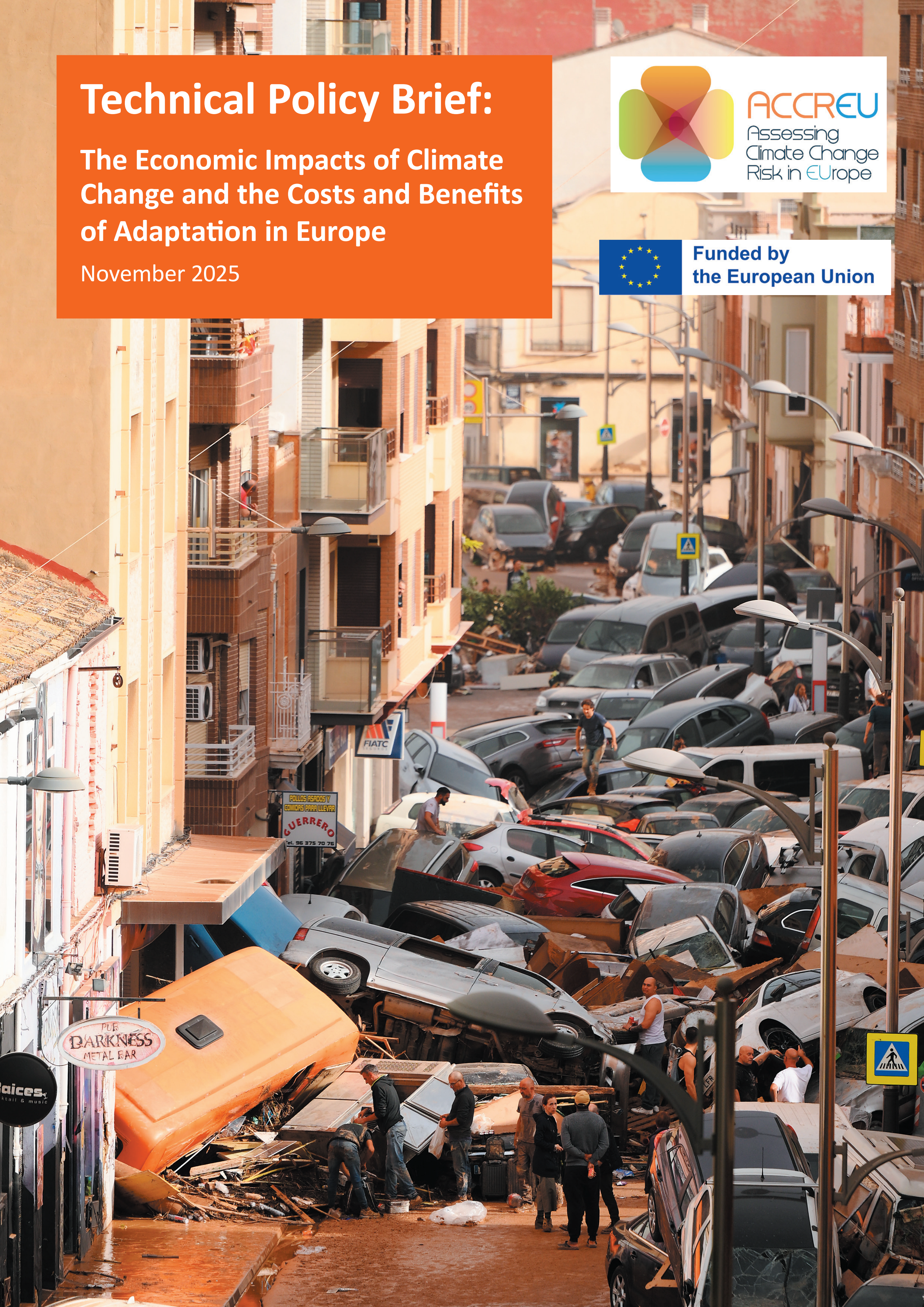
Technical Policy Brief:

The Economic Impacts of Climate Change and the Costs and Benefits of Adaptation in Europe

November 2025

ACCREU
Assessing Climate Change Risk in EUrope

Funded by the European Union



Summary

Climate change will have major economic costs in Europe, even if ambitious climate mitigation goals are met. These impacts can be reduced by adaptation, although this also has a cost.

ACCREU (Assessing Climate Change Risk in EUrope) is a Horizon Europe Research and Innovation funded project that is investigating these issues. This technical policy brief summarises the early sector results from the project, on the economic costs of climate change in Europe, and the costs and benefits of adaptation.

The project has looked at a number of the major risks facing Europe, covering a mix of hazards and sectors. These include the potential economic impacts, as well as the adaptation costs and benefits, for: sea-level rise; river flooding; agriculture and land-use; labour productivity; health; energy use; and an initial analysis of wildfires. It is stressed that this coverage is partial and does not represent the total costs of inaction, or the total adaptation costs.

Nonetheless, the results indicate that the economic costs of climate change in Europe will be significant, estimated at several hundred billions of Euros per year, for these impacts. It also shows that adaptation can have major economic benefits in reducing these impacts, at relatively low cost (estimated at tens of billions of Euros per year), though there will still be residual impacts after adaptation.

Finally, the analysis shows that these impacts – and adaptation costs – will not be distributed equally across Europe. There will be strong differences between country across Europe, but also strong differences within countries.

Introduction

ACCREU (Assessing Climate Change Risk in EUrope) is a project funded by the HORIZON Europe Research and Innovation Funding Programme. The objective of the project is to develop a fully integrated framework for climate change impacts, mitigation, adaptation and the prospects for social and economic sustainable development. This technical policy brief summarises the early sector impact results from the project on the economic costs of climate change in Europe.

The economics of climate change

Climate change will lead to economic costs. These are often known as the 'costs of inaction' and they provide key inputs to the policy debate on climate risks, mitigation, and loss and damage.

The ACCREU project is using a set of models to assess the economic costs of climate change, and extending these to also assess the costs and benefits of adaptation. At the European level, the project is running a large number of sector impact assessment models – shown in the bottom row of Figure 1 – for a set of consistent scenarios. The economic costs of climate change from these assessments capture the impacts on social welfare, i.e., the total costs to society, including both market and non-market impacts.

The analysis has covered a number of the major risks facing Europe, but it is stressed that this is a partial analysis. There are a large number of additional risks that are not covered here that will also be important, and the work has not looked at compounding and cascading risks, or major climate tipping points. For this reason, the sectoral numbers do not represent the full economic costs of climate in the EU, or the total adaptation costs.

The results from this analysis (work package 2 of the project) are the focus of this policy brief. These results will subsequently be fed into a cross-economy Computable General Equilibrium model (CGE) for European analysis, as well as into Integrated Assessment Models for subsequent global analysis.

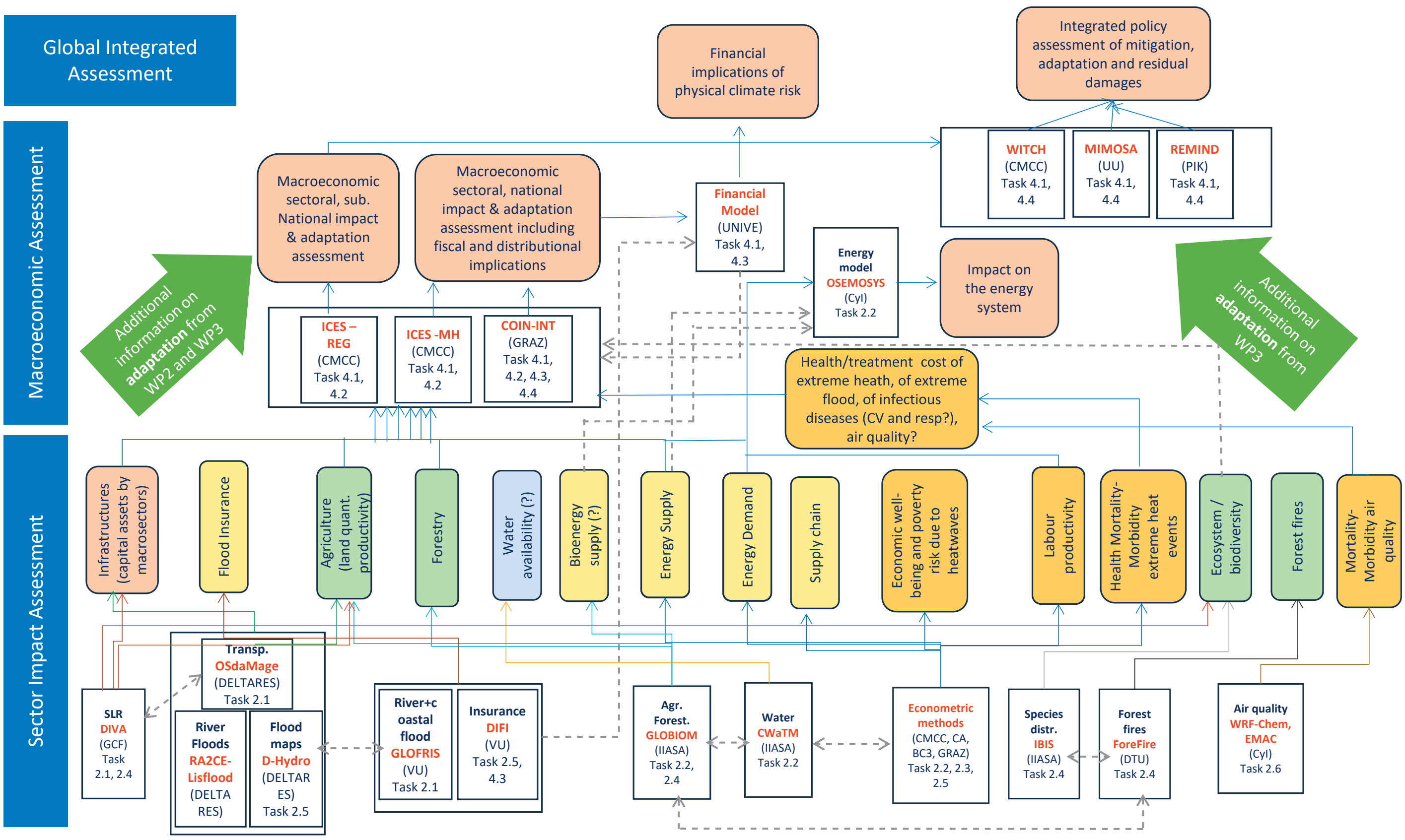


Figure 1. The ACCREU Modelling Framework

Scenarios

To assess future climate change in the ACCREU project, a consistent set of future scenarios have been used in all models, based on the **Representative Concentration Pathways (RCPs).**

The analysis framework for ACCREU includes three RCPs. A low warming scenario, RCP2.6, which is broadly consistent with 2°C of warming by 2100 globally (relative to pre-industrial levels) and RCP4.5, a moderate warming scenario, which is similar to current policies, and leads to approximately 3°C of warming by 2100.

It also includes RCP7.0, a high emission scenario that leads to approximately 4°C of warming by 2100. This provides a worst-case or stress test scenario, but one which is plausible due to the feedbacks in the climate system. The project has used the latest climate outputs from the sixth phase of the Coupled Model Intercomparison Project (CMIP6) to generate the climate information for these RCPs.

These RCPs are combined with the **Shared Socio-economic Pathways (SSPs)**. These provide a set of socio-economic data for alternative future pathways, with differing population, economic development, technology, policies, etc. There are five SSPs, each with a unique set of socio-economic data and assumptions.

In the ACCREU project, the results are modelled for one socio-economic scenario only, SSP2, the middle-of-the-road scenario.

The use of one SSP allows the direct comparison of results between different levels of warming, showing the incremental effect of the RCPs. It also allows multiple adaptation scenarios to be run, within the same analytical framework.

The models set out in the previous page have been run for the three RCP-SSP scenarios and the results are presented in this technical policy brief. For full details, see the Deliverables from Work Package 2 on the ACCREU web site https://www.accreu.eu/deliverables/. The results presented here are in current prices (Euros, 2023) for future time periods, without discounting. This makes it easy to undertake direct comparison, over time and between sectors. The results are reported as the combined impacts of future climate and socio-economic change together.

The modelling analysis in ACCREU also considers **Adaptation**. Adaptation delivers economic benefits because it reduces the costs of inaction, but it involves costs. However, adaptation rarely reduces climate impacts completely, and there are residual impacts after adaptation (see schematic in Figure 2 below).

This leads to a trade-off between the costs and benefits of adaptation and the residual impacts. It is possible to have more ambitious adaptation (reducing residual impacts) but this is likely to involve much higher costs.

To investigate this, ACCREU has identified three levels of adaptation for each of the models. This includes a central reference level, as well as low and high levels of adaptation.

The approach and results are described below for each sector in turn.

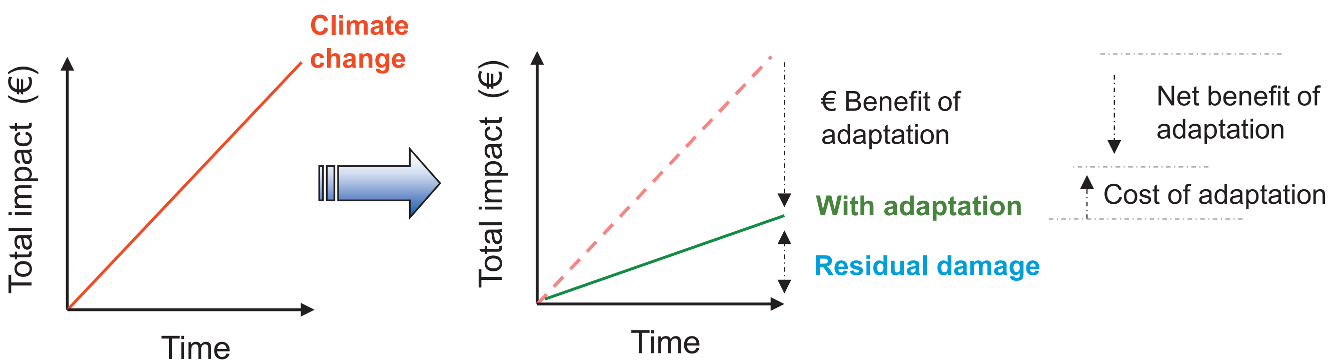


Figure 2. Schematic of the costs and benefits of adaptation

Coastal

Coastal zones contain high populations and significant economic activity, as well as providing important ecosystem services. Sea level rise and changes in storm surges will increase risks to these areas, which can lead to increased flooding, loss of land, coastal erosion, salt-water intrusion and ecosystem impacts. Adaptation to these risks includes strategies to protect, accommodate, retreat or advance, with the potential to use ecosystem-based adaptation, as well as engineered options.

Modelling approach

Methods for assessing coastal flood risks have been developed and widely applied, at multiple scales. These typically use models to assess the costs of coastal flooding (from sea level rise and storm surges), looking at events of different return periods. As coastal floods are probabilistic events, results are presented as expected annual damages (EAD). These models can also consider adaptation, and estimate the costs of protection and its economic benefits (in reducing risks). However, even with protection, some residual risk will remain.

ACCREU has used the global coastal integrated assessment model DIVA, to provide updated global and European estimates of the impacts of sea-level rise on coastal areas, and the costs and benefits of adaptation. The updated analysis includes higher spatial resolution, which leads to lower damages than previous analysis (such as the COACCH study), and novel adaptation options (including autonomous/reactive migration).

For adaptation, the analysis has considered three levels of adaptation:

– No adaptation. In this scenario, current protection (and dykes heights) are not upgraded and no new dykes are built. This is an unrealistic scenario. Reactive migration takes place when the floodplain falls within the 1-in-1 year flood return period.

– Constant flood protection. In this scenario, current flood protection standards are maintained, so existing dykes are upgraded to keep up with sea level rise, but no new dikes are built. Again, reactive migration is included.

– Economically optimal protection. In this scenario, dykes are upgraded and new dykes are built, but only when economically justified, i.e., when benefits exceed costs. This is based on a cost-benefit framework that minimises the total cost of adaptation, the protection costs and the residual damage. This also means that when costs outweigh benefits, no action is taken, potentially triggering migration.

ACCREU Results

The updated analysis shows that – without adaptation – sea-level rise will lead to very large costs in Europe (EU27). However, there are major differences in the damage costs borne by different Member States, with strong distributional patterns across Europe (See Figure 3). The greatest costs are projected to occur around the North Sea (Belgium, France, Netherlands, Germany and UK).

The expected annual damage costs are shown in Figure 4 for the various scenarios. Annual damage costs are approximately €40 billion/year by mid-century without adaptation (more detailed analysis for all scenarios are presented in Table A1 in the annex). The EAD increase by 2080 to almost €125 billion/year even in a RCP2.6 scenarios, and are much higher (€170 billion/year) for the RCP7.0 scenario.

With adaptation, these damages are significantly reduced (see Figure 4). Under the scenario where constant flood protection standards (to today) are maintained, additional costs are incurred, of approximately €3 to 4 billion/year across the period, but provide large annual economic benefits, as shown in Figure 5 for the mid-century (numbers for all periods and scenarios are presented in Table A1).

With the optimal protection adaptation strategy, more significant reductions in damage are delivered. EAD is reduced by two orders of magnitude compared to the no-adaptation scenario (as shown at the bottom of Figure 4), and residual damages are limited to €0.5 to 1.0 billion/year.

Adaptation costs are also low in this optimal scenario, at €2 to 3 billion/year, but this is because adaptation is targeted only to those areas where benefits outweigh costs: this means that many areas will no longer be protected. These areas are likely to be rural areas with lower population density.

Both adaptation scenarios deliver very high benefits, when compared to costs, as shown in Figure 5, but the ratio of benefits over costs is around 50% higher for the optimal scenario. However, in

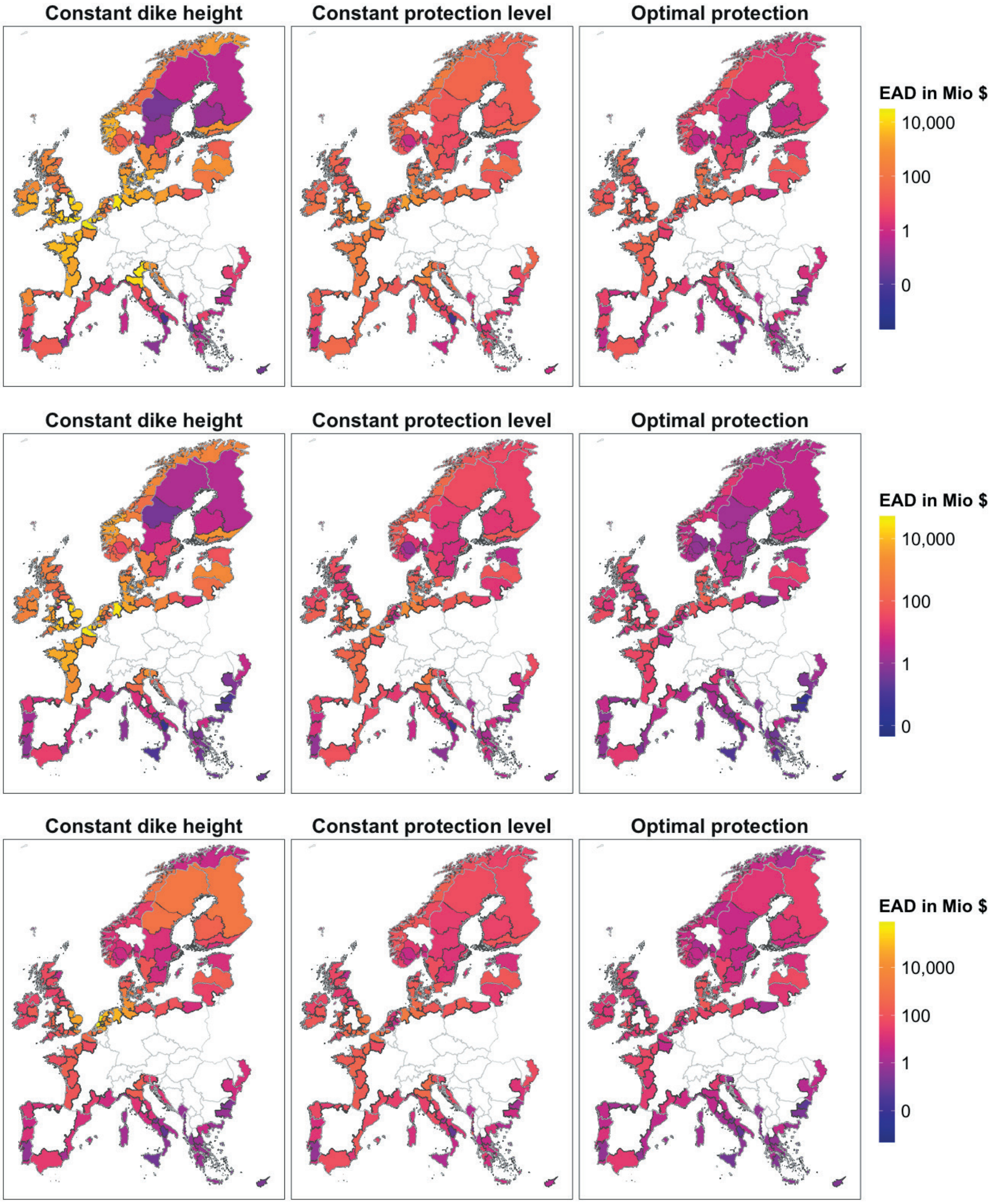


Figure 3. Expected annual damages in 2100 in Europe for different adaptation scenarios, for low (RCP2.6, Q50), medium (RCP4.5, Q50) and extreme (RCP7.0 Q95) SLR scenario.

Europe, the approach to setting coastal protection objectives vary, but they are often set on the basis of acceptable levels of risk, rather than the economically optimal level. This recognises that societal preferences on levels of risk determine protection strategies.

The project has also run a second global model, GLOFRIS, to compare these results. This also identifies high EAD for the EU27, at over €100 billion/year by mid-century. These are similar to DIVA and also have similar patterns of spatial risks. This model also finds similarly large reductions in residual damages with adaptation.

The results show that the EAD and adaptation costs vary significantly with the level of future climate change, but also with the objectives used for adaptation decisions. This also affects real-world adaptation planning and there is a need to recognize and work with uncertainty. This requires an iterative and flexible approach for adaptation planning (pathways), noting that this needs to be centred within integrated coastal-zone management policy frameworks.

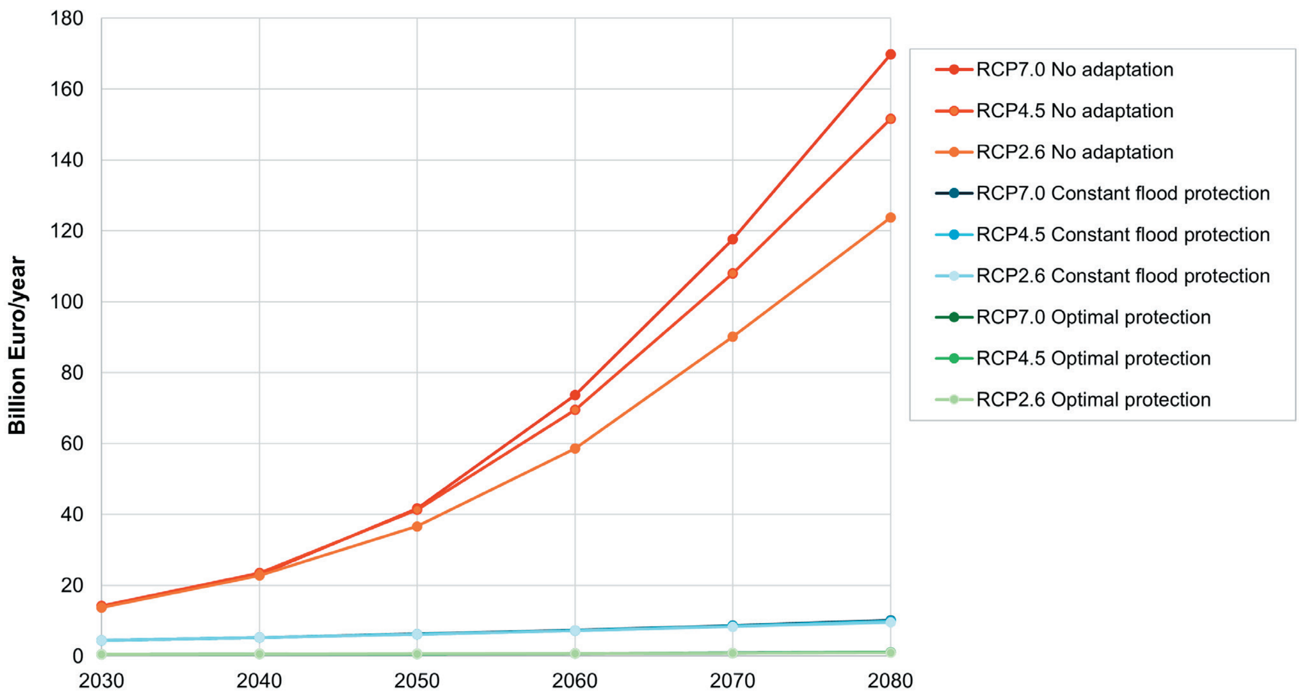


Figure 4. Coastal EAD, with no adaptation and alternative adaptation scenarios, in the EU27.

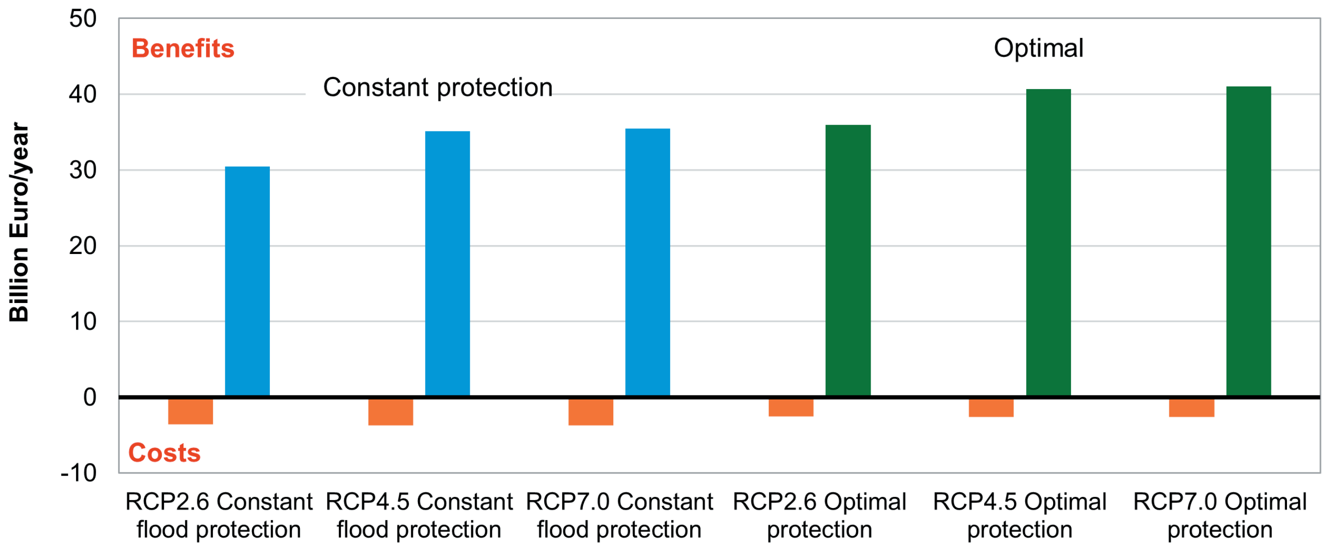


Figure 5. Annual cost and benefits of coastal adaptation (€Billion/year) in 2050 for different adaptation scenarios for the EU27.

Values are presented as additional costs and benefits relative to the baseline period, from the combination of climate and socio-economic change, and are presented as undiscounted values in future years in current prices (€2023). It is stressed that there is a wide range of uncertainty around these central estimates reflecting the underlying uncertainty in global temperatures, sea- level response, and ice sheet melt.

Finally these results reinforce the message that the most appropriate response to sea-level rise for coastal areas is a combination of mitigation to limit the long-term rise to a manageable level, and adaptation to deal with the inevitable residual damages. More detailed, local-scale assessments and adaptation plans are also required to assess and reduce risk to vulnerable areas.

River Floods

River floods are one of the most important weather-related loss events in Europe and have high economic impacts. In addition to affecting hydrological cycles, climate change has the potential to increase the magnitude and/or frequency of intense precipitation events that cause floods, although there will be differences in changes between regions. There are many types of adaptation options for addressing these flood risks, though the modelling literature mainly focuses on flood protection structures.

Modelling approach

Modelling of the costs of (river) floods, as well as the costs and benefits of flood protection, are well established in the literature. Most studies use hydrological models that assess flood hazard and exposure, then use probability-loss (depth) damage functions to capture the impacts of multiple probabilistic events. The resulting flood probability-impact function can be integrated to obtain expected annual damage (EAD). The estimation of EAD can be extended to consider adaptation (flood protection) and estimate the costs and benefits of adaptation (in reducing risks).

ACCREU has further developed the global river flood assessment model GLOFRIS, to provide updated global, European and subnational estimates of the direct impacts of river floods, as well as the costs and benefits of adaptation in reducing risks.

This has considered future climate and socio-economic change. As floods are probabilistic events, the results are presented as expected annual damage (EAD) costs (undiscounted). For adaptation, similar scenarios to the coastal flooding have been assessed:

- No adaptation scenario. Current flood protection is not upgraded, and no new structures are built.
- Constant flood protection scenario. Current flood protection standards are maintained, so existing protection is upgraded in line with locally increasing flood hazard conditions.
- Economically optimal protection scenario. Protection is upgraded and new protection is built, when economically justified based on cost-benefit analyses.

ACCREU results

With no adaptation, river floods lead to large economic costs in Europe. Annual damage costs from river floods rise to approximately €40 billion/year by mid-century and €80 billion/year by end-of-century (see Figure 7 over the page and Table A2 in the annex of this policy brief). These include strong distributional patterns of impacts across Europe, shown in Figure 6 below.

However, while EAD increases over time, there is relatively little difference between the RCPs (see Figure 7). When compared to coastal flood risk assessments, climate change impacts on river flood risks are more complex and show larger regional differences: under certain climatic conditions, flood risk may increase in certain areas, but decrease in others due to a dryer climate. This can be seen in Figure 6. This emphasizes the importance to consider local conditions when designing adaptation measures.

With adaptation, these damage estimates are significantly reduced, leading to large adaptation benefits. Under the scenario where constant flood protection standards are maintained, EAD drops significantly, as shown in Figure 7. Addi-

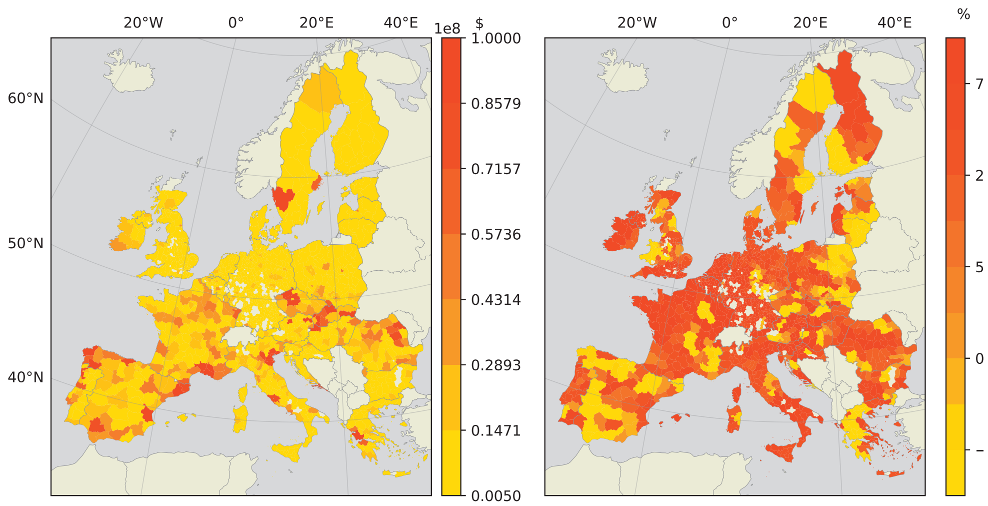


Figure 6. Left Baseline expected flood damage (EAD) in 2010. Right. % increase in flood EAD with climate change (RCP4.5)

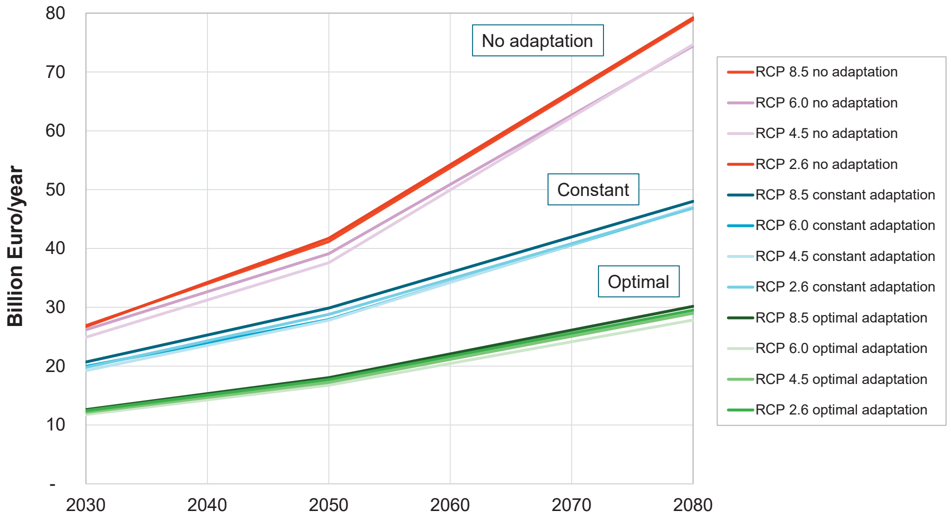


Figure 7. Expected Annual Damage for River Floods for different RCPs and Adaptation Scenarios (EU27).

tional costs are incurred to deliver this benefit, of approximately €3 billion/year across the period, but the overall economic benefits far outweigh these costs (see Figure 8 and Table A2 in the annex). However, residual damages are still high at approximately €30 billion/year in the 2050s and just under €50 billion/year in 2080s

With the optimal protection strategy, more significant reductions in damages are delivered. This leads to the lowest residual damage, at approximately €12 billion/year in the 2050s and €17 billion/year in 2080s (see Figure 7). However, this does require higher investment costs, of approximately €12 billion/year across the scenarios (see Figure 8 and Table A2). When comparing the two adaptation scenarios, the constant protection scenarios has lower costs and lower benefits, but higher residual damage. The optimal scenario has higher costs, higher benefits and lower residual benefits (see Figure 8 for the 2050s).

It is highlighted that the approach for adaptation in the model prioritises investment within the first 30 years (2020-2050), and thereafter, only maintenance costs arise. The results show that the EAD and adaptation costs vary significantly with future climate change, but also with the adaptation objectives. In practice, there is a need to recognize such uncertainty in decision-making. It is also stressed that the model and results here only assesses river floods – there will be additional impacts and adaptation to surface water floods.

The project has also run a second global model, LISFLOOD, to compare results. This has lower EAD for the EU27, estimated at €17 billion/year (2050s RCP4.5). This model also finds similarly large reductions in expected flood damages with adaptation, especially for flood protection structure and for retention areas: it finds lower benefits from relocation or flood-proofing.

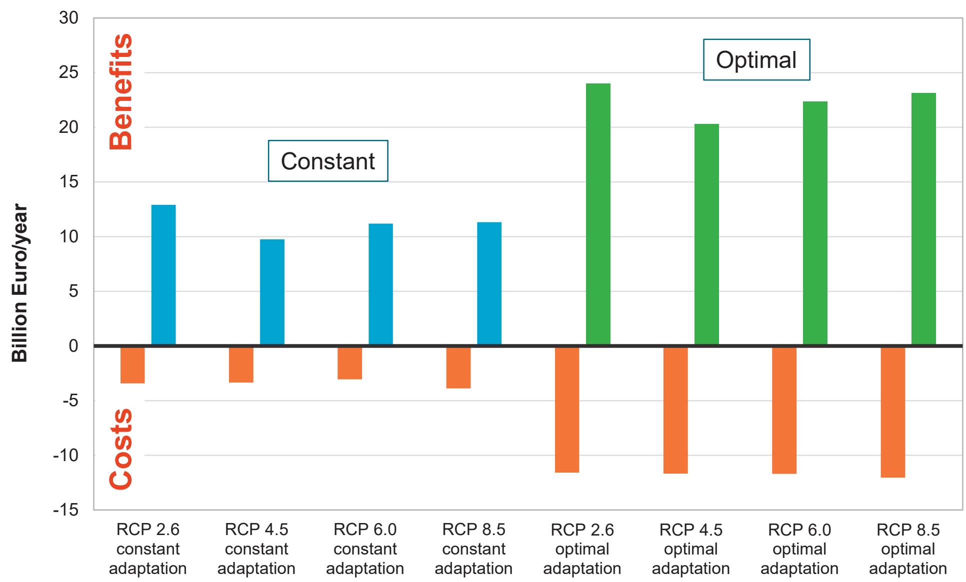


Figure 8. Annual Costs and Benefits of Constant versus Optimal Adaptation for River Floods in the EU27 in 2050.

Values are presented as additional costs relative to the baseline period, from the combination of climate and socio-economic change, and are presented as undiscounted values in future years in current prices (€2023). It is stressed that there is a wide range of uncertainty around these central estimates.

Agriculture and Land-Use

Climate change will have significant and uneven impacts on Europe's agriculture sector. It can reduce the productivity of land through changes in temperature, variable rainfall and more frequent extreme weather, but also create potential opportunities from yield benefits from CO_2 fertilisation or longer growing seasons. These effects will directly influence relative profitability, market prices, trade flows, and land-use decisions, with economic, social and environmental consequences.

Modelling approach

Agriculture, forestry, and water resources are closely interconnected through competition for land, resource constraints, productivity feedbacks, and market interactions. In ACCREU an integrated modelling framework is used to comprehensively assess climate change impacts, by combining detailed crop, forest, vegetation, hydrological, and livestock models, with an economic land use model (see Figure 9 below). The sectoral models estimate the climate-induced change in productivity and resource availability. These results are then integrated into an economic land-use model (GLOBIOM) to evaluate the full economic consequences of climate change.

This produces global, European and subnational estimates of climate change across multiple, interconnected sectors. The framework also considers the impact of mitigation policies that target emissions from these sectors. The results can be used to further assess the impacts of land use change on water, using a hydrological model, and biodiversity, with a species distribution model.

The framework can consider adaptation, and in GLOBIOM both autonomous and planned adaptation are represented. Producers *autonomously* adapt to changing climate and market conditions by adjusting their crop choices and management practices based on expected yields, market prices, and trade competitiveness.

The *planned* adaptation options include the increase of agricultural research and development to raise crop yields under future possible climate change. The ACCREU project also assessed the potential for irrigation as an additional adaptation measure to climate change, including its costs and benefits. For Europe, this assessed three alternative scenarios.

- Low adaptation: irrigation expansion is based on historical trends from 2000-2020 and limited to expansion of only 10% in future periods and there is limited support for agricultural R&D and upkeep and maintenance of existing irrigation infrastructure.
- Central (reference): irrigation is limited to 30% expansion in future periods and there is moderate support for improving efficiency of irrigation systems and support for agriculture R&D.
- High adaptation: high expansion is allowed and there is high support for irrigation efficiency improvements and upgrading existing systems and for agricultural R&D.

Note in all cases, irrigation expansion is conditional on water being available locally.

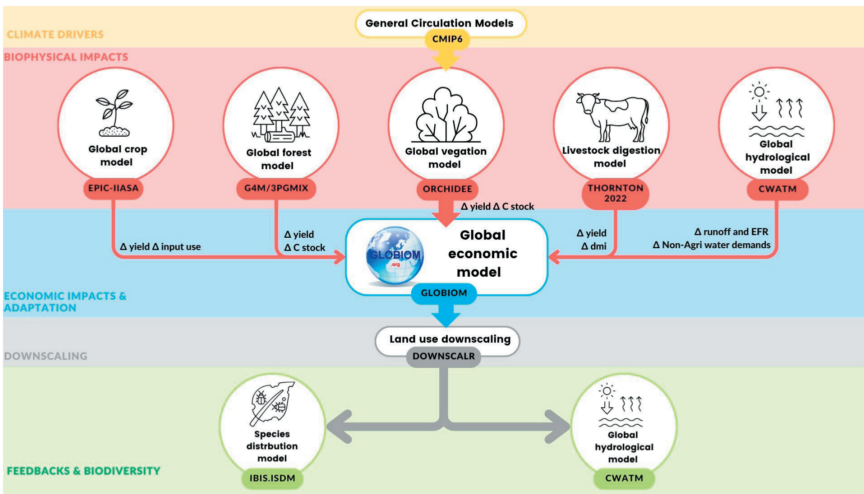


Figure 9. Schematic figure of the ACCREU impact assessment modelling framework.
Source: Palazzo, Arbelaez-Gaviria et al. in prep

ACCREU results

The effects of climate change on crop yields and irrigation water requirements for major European crops were first assessed with the global gridded crop model, EPIC-IIASA, using a CMIP6 multi-model ensemble.

The results show that climate change impacts vary for different crops and also with different regions across Europe, as shown for rainfed crops in Figure 10, left hand columns, below. For example, maize yields are projected to decline with climate change, with estimated EU level production losses of 10% to 13% by 2050 (compared to 2020 levels). These are dominated by impacts in Southern and Western Europe, where there are regional production losses of 15% and 19% respectively.

In contrast, for wheat, the impacts vary strongly with the different climate model projections, even

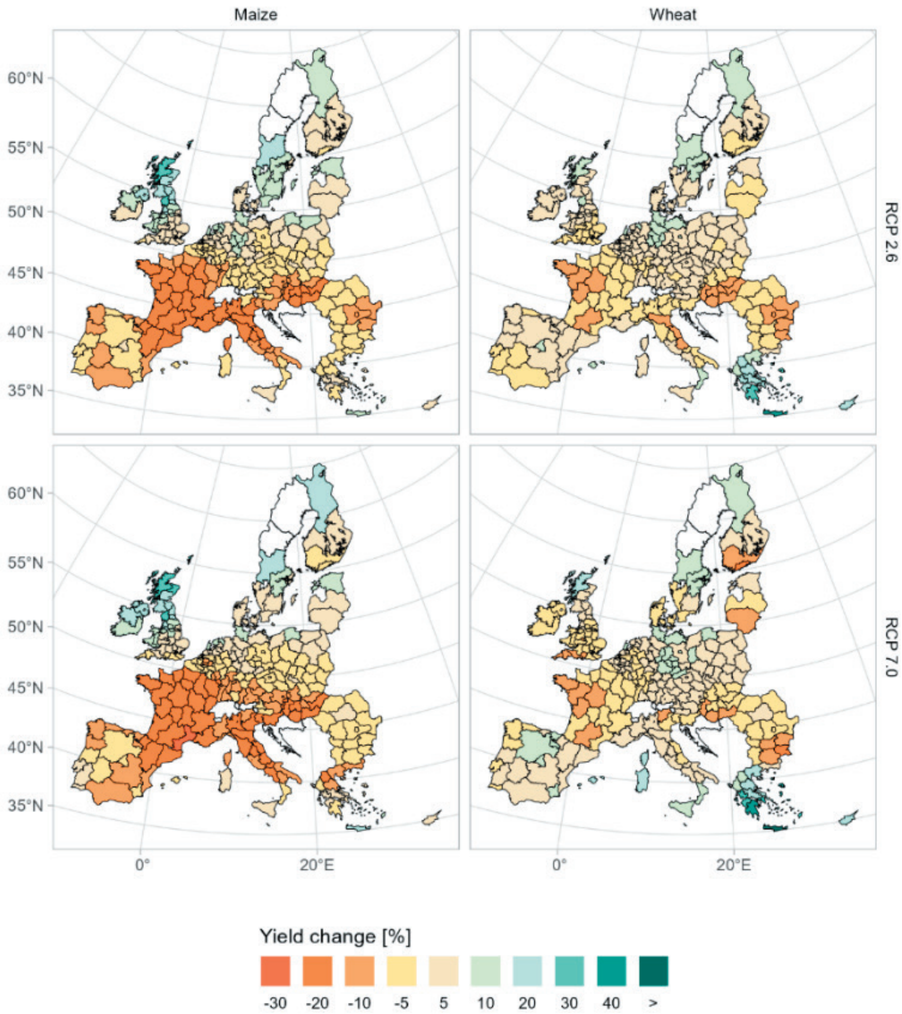


Figure 10. Projected mid-century (2035-2065) climate change impacts on rainfed crop yields in Europe by mid-century (GCM ensemble). Percentage change with respect to yields under current climate. Source: EPIC-IIASA ISIMIP3b

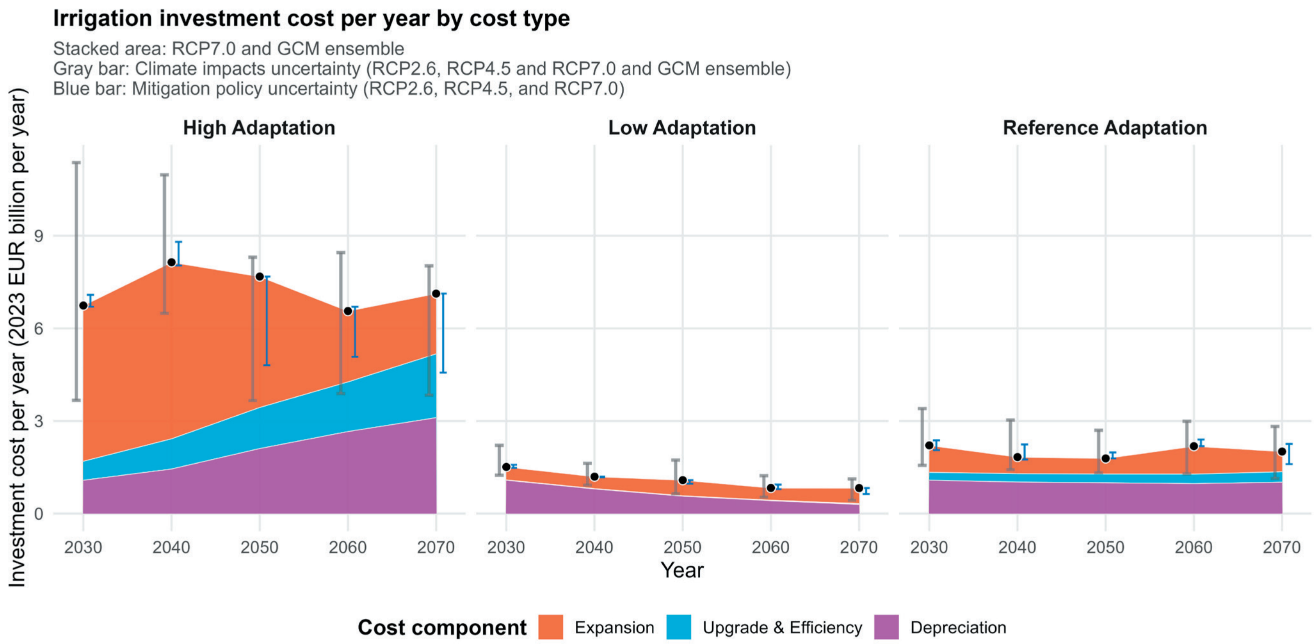


Figure 11. Adaptation costs for agriculture (irrigation) (Euro 2023 billion/year)
Source: Palazzo, Arbelaez-Gaviria et al. in prep

in terms of the direction of change (positive or negative, see Figure 10, right hand columns). On average, there are modest projected yield effects, with EU production losses varying between 2 to 3% by 2050, though these mask much larger changes in some regions. For example, in Northern Europe, production losses under the highest warming levels could reach 9%.

These results were then fed into the economic land use model, which simulates how the agriculture and forestry sector adjusts to changes in future productivity by reallocating land and resources to maximize producer revenues (i.e., the revenue received for the sale of goods by producers (market price times quantity sold)).

The analysis then assessed how potential productivity losses from climate impacts can be reduced by different adaptation options, and how the costs and economic benefits of this adaptation differ across different levels of warming for the three adaptation scenario.

The analysis finds that under the high adaptation scenario, which provides supportive subsidies for irrigation infrastructure and on-farm water storage, farmers greatly expand the irrigated area in response to climate change. This is found across all warming levels. The most significant expansion occurs in the period up to the year 2050, with an extra 150,000 ha of irrigated area per year (on average) across the EU.

This addresses the negative yield effects of climate change, though it does involve significant costs, as Figure 11 (and Table A3 in the annex). In contrast, the low and central adaptation scenarios show limited irrigated area expansion, and in some cases, even reductions in the irrigated area, leading to lower investment (adaptation) costs. This indicates that limited public policy support for irrigation may substantially constrain its potential for adaptation to climate change.

Livestock are also exposed to climate impacts, directly through temperature stress, and indirectly through changes in the yield of their feed sources including field crops and grassland.

The GLOBIOM model includes a detailed representation of the livestock sector and the different management systems including diet composition, feed requirements and greenhouse gas emissions.

The ACCREU analysis has assessed the impact of temperature stress on livestock feed intake and the resulting impacts on meat and milk yield as well as the effects on grassland productivity. Though the grassland yield effects in Europe are projected to be modest by mid-century, the global impacts, particularly negative yield effects in South America, may have significant impacts on the competitiveness of the European livestock sector.

Impacts on the Labour force

Higher temperatures and extreme heat have impacts on the labour force and on productivity. This can include reduced working time, affecting labour supply. It also can include reduced worker output, leading to lower labour productivity per hour worked. These effects will be negative for hotter countries, but potentially beneficial for some colder regions or countries. These impacts affect both outdoor and indoor work, though the latter is influenced by air conditioning.

Modelling approach

There are numerous studies of the economic costs of climate change on labour productivity. Some of these use impact functions that link the impacts of climate change (on temperature or wet bulb temperature) to labour productivity impacts. Others are based on econometric (statistical) analysis of historical data, which are then used to assess possible future impacts.

ACCREU has undertaken a new analysis using empirically estimated response-functions to look at the impacts on both the number of hours worked and on the productivity of workers during their working hours. These are combined in a compound metric of **effective labour** to assess the overall impact on the labour force.

The analysis has been undertaken for both high exposure outdoor work (e.g., agriculture), low exposure work that takes place inside or in shaded areas outdoors (e.g., manufacturing).

ACCREU results

The results of the impact of climate change on effective labour for Europe (EU27) are shown in Figure 12 below. These show the net percentage change from climate change on effective labour for the 2050s (RCP4.5). These aggregate the negative and positive effects of higher temperatures, but show a large net negative impact.

There is a strong distributional pattern to these impacts, and Southern Europe is projected to experience a decline of more than 20% in effective labour, while many northern European countries experience net gains.

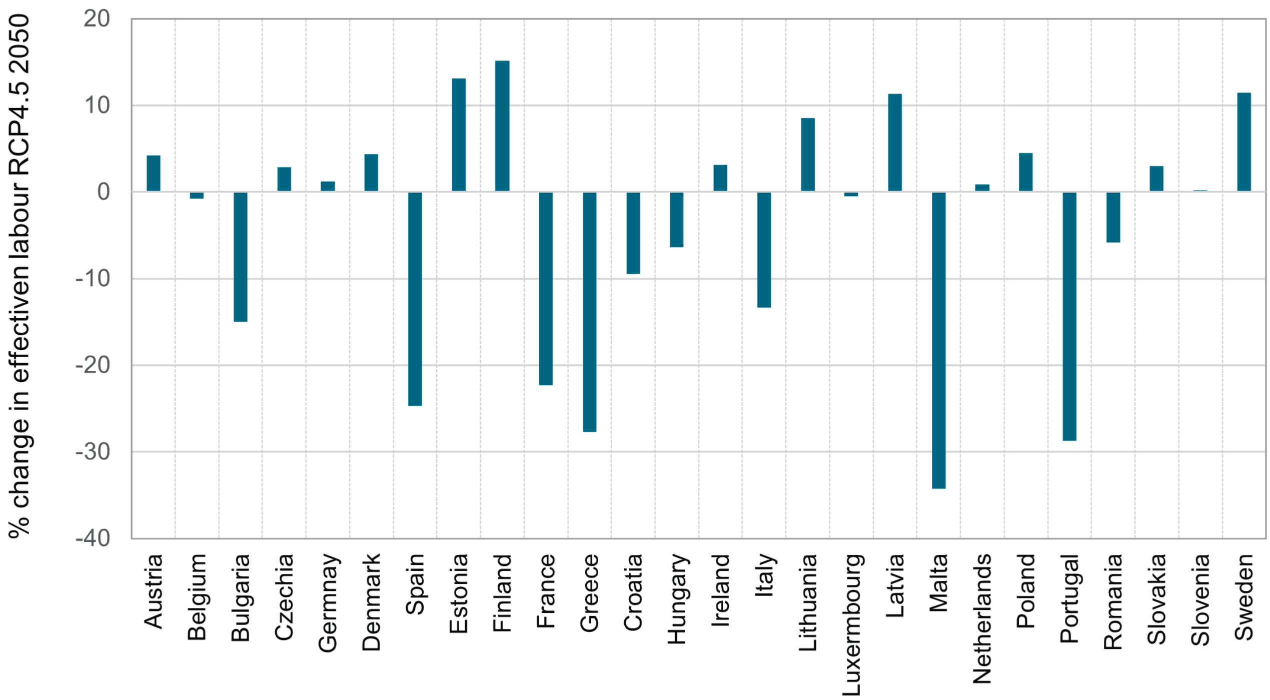


Figure 12. Percentage change in effective labour for low and high activity work from climate change across the EU by the 2050s (RCP4.5). Note figure shows the aggregate of positive and negative changes.

Note that positive and negative effects are summed in these values. It is stressed that even for countries that have net positive effects overall, there are still likely to be additional heat related impacts, which will require planned adaptation. It is stressed that there is a large range around these central values reflecting different scenarios and climate model outputs.

The project has estimated the economic costs of this lost productivity. This was calculated by looking at the net lost hours with climate change, and valuing these changes using the Gross Value Added divided by the labour force numbers, using sector specific data. This provides a measure of the societal loss of labour productivity (rather than just wage losses).

The analysis also differentiates between the impacts on high-exposure work that takes place mostly outdoors in the sun (such as agriculture or construction) and low-exposure or work that takes place mostly inside or outdoors in the shade (manufacturing and utilities).

This leads to high estimated costs for the EU27, with strong increases over time, especially with warmer scenarios, as shown in Figure 13 (values for all scenarios are shown in Table A4 in the annex). For example, by mid-century (2050s), annual economic costs estimated for low activity work (indoor) at approximately €150 to 200 billion/year for RCP2.6 to RCP7.0 respectively. These costs more than double by the 2070s. Again, it is stressed that there are multiple sources of uncertainty influencing the results.

There are a set of potential adaptation options to reduce these impacts, which include regulatory, behavioural, technical and other options. These can include heat alerts, work practice change, and moving labour activities to different times of the day, as well as air conditioning and other options for the indoor environment (for low exposure impacts).

The potential costs and benefits of adaptation for indoor labour impacts with air conditioning has been investigated in the ACCREU project. The benefits of cooling in reducing indoor (low activity) labour impacts are shown in Figure 13 below. This shows the economic costs in 2030 and 2050 with and without adaptation (full results are included in Table A4 in the annex). This indicates that air conditioning could have very large benefits in reducing indoor heat impacts. These benefits are estimated at 40 to 60 billion Euro/year by 2050, depending on the scenario.

It is stressed that there would be additional adaptation needed for the high exposure (outdoor) work, which as highlighted above, involves larger losses under climate change in Europe.

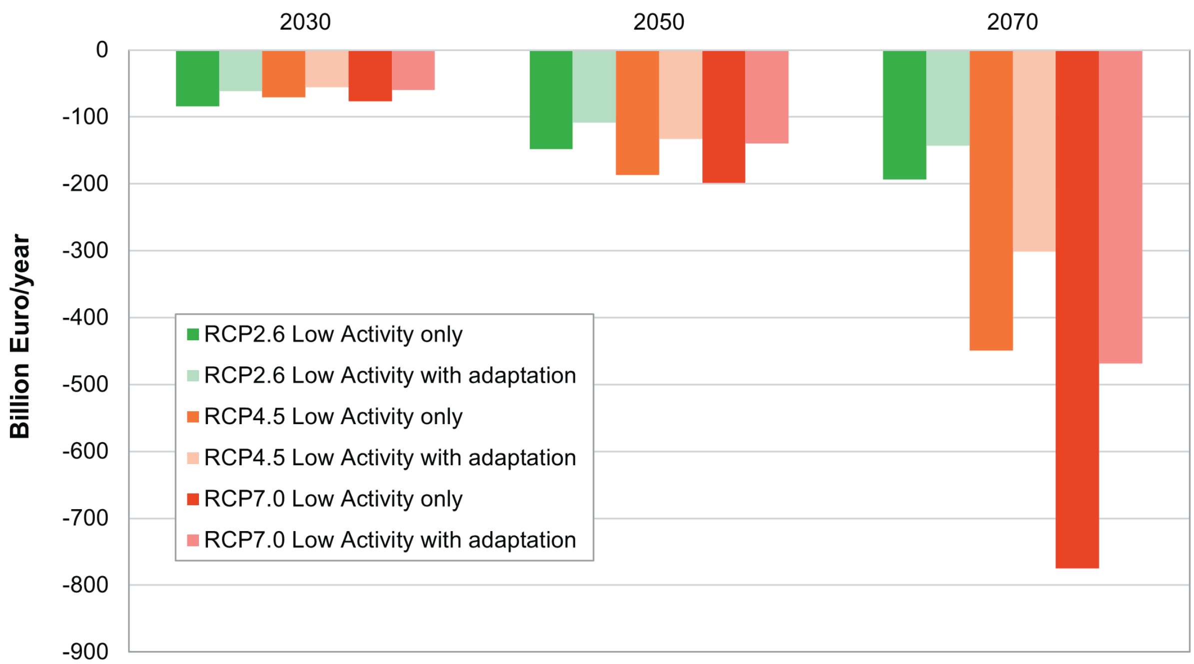


Figure 13. Economic costs of climate change on labour for the EU (Billion/year) for the 2030s and 2050s. The figure shows the total effects for low activity with and without adaptation.

Values are presented as the total cost for the combination of climate and socio-economic change. They are presented as the undiscounted values in future years in current prices (€2023). It is stressed that there is a wide range of uncertainty around these central estimates. Note that positive and negative effects are summed in these values: even for countries that have net positive effects overall, there can still be heat related impacts, which will require planned adaptation.

Health

Climate change is projected to impact on health, including with direct impacts, such as heat-related mortality, but also indirect impacts from changes in the range, seasonality and intensity of vector-borne, food-borne and waterborne disease transmission. There are also climate risks to health infrastructure, and the delivery and demand for health systems and services.

Modelling approach

For heat-related mortality, most studies use epidemiological studies to derive functions which link health impacts to relevant climate parameters. These are then used to assess the physical impacts of climate change. These impacts can be then valued by looking at the impacts on welfare, by assessing the combination of treatment costs, lost productivity and dis-utility. ACCREU has developed a new analysis of the impact of climate change on heat-related mortality and morbidity, and has also extended this analysis to adaptation.

ACCREU results

Recent heatwaves across Europe have led to large numbers of additional fatalities, with over 60,000 estimated deaths in 2022 and 48,000 in 2023. Climate change and warmer temperatures are projected to increase these impacts.

The ACCREU analysis has estimated the number of annual fatalities from heat in Europe with climate change, considering higher temperatures and heat waves. This projects strong increases, and by 2050, annual fatalities could rise to over 200,000 deaths per year. The highest relative increases in heat-related mortality are projected for the Czech Republic, Hungary, Romania, Bulgaria, Slovakia, Croatia and Spain (see Figure 14). The higher resolution used also indicates greater increases in the interior regions of countries compared to coastal areas.

The project has also estimated the economic costs of these impacts: this can be calculated using two alternative metrics: the Value of a Statistical Life (VSL) and the Value of a Life Year Lost (VOLY). For the main results here, the VOLY values are reported, noting that the fatalities predominantly occur in those aged 65 and over.

The values using the VOLY approach are shown in Table A5 in the Annex. The results indicate that climate change will have large economic (societal) impacts, for example, by the 2050s, these could be around >€100 billion/year billion/year.

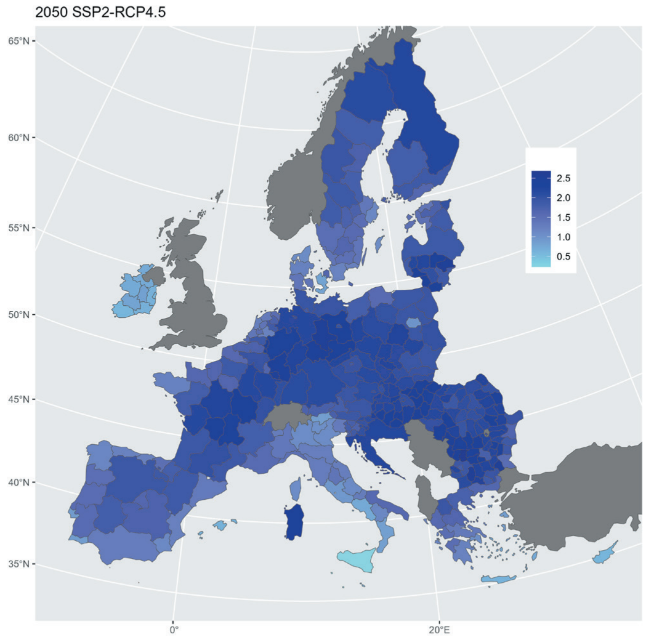


Figure 14. Number of heat-related deaths per 1000 inhabitants over 65 years in European regions by 2050 (RCP4.5).

The ACCREU project has also derived new estimates for heat-related morbidity, assessing the increased emergency visits, outpatient visits, and hospitalisations and valuing these. The results project that by the year 2050, the number of hospitalisations could rise to between 120,000 and 160,000 cases per year, depending on the RCP.

The study has also costed these total heat-related morbidity cases, estimating these could rise to aroundeconomic costs of €0.7 billion by the 2050. These are considerably lower than the mortality results, but still an important additional cost.

These heat-related health impacts can be reduced with adaptation. There is an important role for heat health early warning systems, and these are already in place across much of Europe. However, even with these warning systems in place, residual heat-related fatalities are projected to be large, and will grow over time.

The analysis has therefore looked at the energy demand forecasts from climate change in ACCREU (see energy section, later in this policy brief) and the projected increase in cooling demand and higher uptake of air conditioning. The reduction in indoor temperatures will have an important co-benefit in reducing down heat-related fatalities. These co-benefits are estimated to be around €50 billion/year by the 2050s (see Table A5). These benefits are high when compared to the additional costs of AC, presented in the energy section.

Energy

Climate change will affect future energy use, increasing summer cooling demand but reducing winter heating needs. These responses are often autonomous and can be considered as an impact or an adaptation.

For heat, adaptation can help to maintain desirable levels of temperatures in homes and businesses with mechanical cooling (air conditioning) or passive ventilation and measures. Urban temperatures can also be reduced with green infrastructure or urban planning. These options have strong interactions with health and labour (see other sections of this policy brief).

Climate change will also have effects on energy supply, notably on hydro-electric generation, as well as on wind, solar, biomass and thermal power (nuclear and fossil). It also has the potential to have impacts on electricity transmission infrastructure (assets and efficiency).

Modelling approach

There are several approaches for assessing the impact of climate change on energy demand, including technology models, econometric analysis and integrated assessment models. These can include the effects and linkages to mitigation policy.

ACCREU developed an econometric model to assess the impacts of climate change on total energy demand across fuels and sectors at the global level and for the EU. This assessed heating and cooling degree days, as well as weather fluctuations, for four sectors (residential, commercial, industrial, agriculture) and two energy carriers (electricity and fossil fuels).

For total energy supply, the project developed an empirically-based model that assessed the impacts on extreme weather conditions on power supply unavailability of thermal (nuclear, coal, gas, and oil) and renewable (hydro) power generation.

ACCREU results

The energy demand results are presented in Figure 15 and show that climate change will lead to large changes in Europe. These include the net of the decrease in winter heating as well as the increase in summer cooling. For electricity demand (all sectors), the net effects are low in Northern Europe, but there are large increases in Southern Europe, where increases in electricity demand could increase by 20% to 30% by 2050. For fossil fuel demand, there are reductions of around –15% to –25% in Northern European countries by 2050.

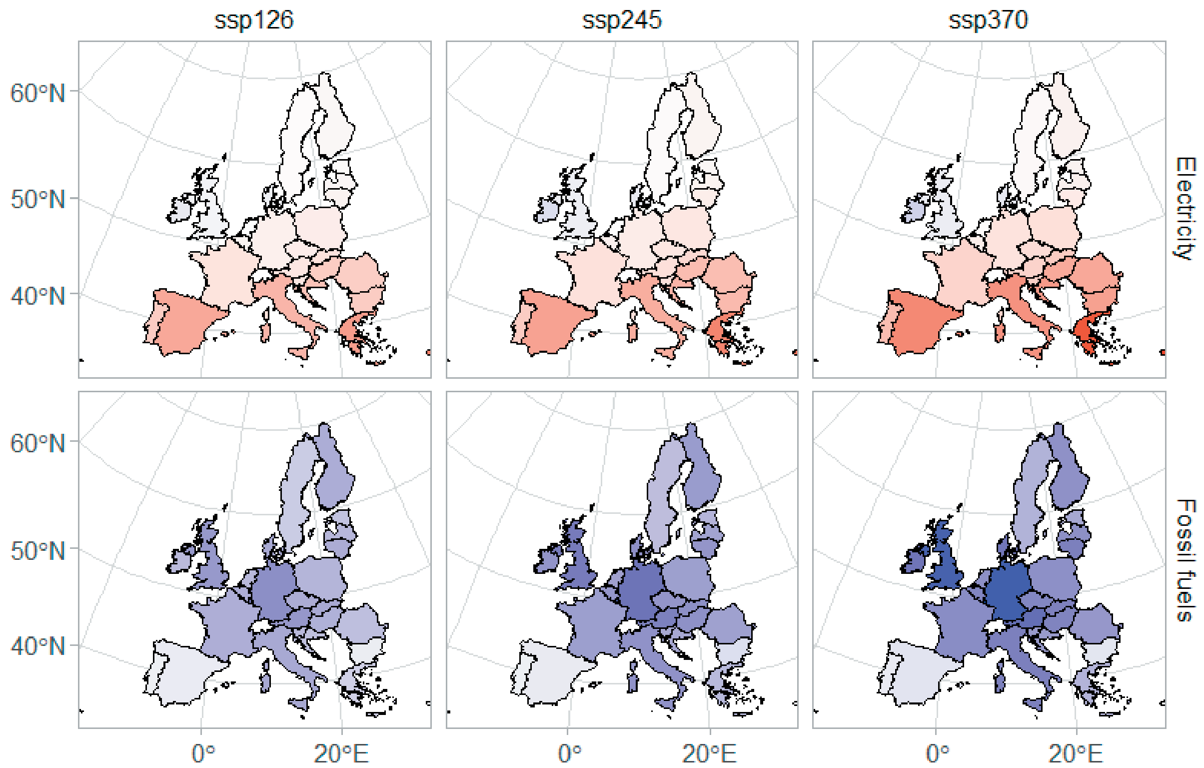


Figure 15. Country-level final energy demand change in percentage changes with respect to projected future final energy demand with no climate change for electricity (top panels) and fossil fuels (lower panels) for three warming scenarios.

The net effect of these effects changes over time in Europe, shown in Figure 16. In 2030, there are projected benefits overall as the reduction in fossil fuel costs are higher than electricity increases. In 2050 the two compensate for one another, however, in later years, cooling starts to dominate and increases overall costs.

The analysis has also focused down on the residential sector, looking at the potential rise in air conditioning (AC) to address rising summer heat in Europe. This has looked at three adaptation scenarios.

- Low adaptation. This assesses the impacts of warmer temperatures and associated higher electricity use for the current stock of AC only.
- Central adaptation. This builds on above but also looks at the influence of climate change in increasing the ownership of AC (new uptake) and resulting higher electricity use.
- High adaptation. This takes the central scenario, but also factors in the additional influence of higher income in increasing AC ownership levels, which further amplifies electricity use for cooling under higher future temperatures.

The analysis assessed the increase in annual electricity demand for cooling and the associated costs (using historic electricity prices) and also the additional costs of new AC stock/upgrades.

These results indicate additional costs of approximately €6 to 10 billion per year by 2050 for the EU27 (for central and high adaptation scenarios respectively, with the higher values for the RCP7.0 scenario). The results are shown in Figure 17 and provided in Table A6A in the annex at the end of this brief.

The Figure shows the breakdown by country: this finds that Italy and Spain will have the highest net increase. Note that for many countries, there are higher costs of acquisitions of new AC units in earlier years, and costs are lower later as retrofitting rather than new acquisitions, but in all cases annual electricity use for cooling rises over time. Income is a key factor in AC ownership. The values for the three scenarios for Europe are shown in Table A6A in the annex. These show that there are only small differences between the central and high scenarios, because European per capita incomes are already high. However, these income factors are important in other parts of the world, and leads to large additional increases in AC uptake in many developing countries.

The increase in residential cooling is an impact, but it has economic benefits by reducing the health risks of climate change. These benefits have been quantified and valued, see the earlier health section later in this policy brief (and Table A5). A comparison shows that the additional costs of residential cooling (Figure 17) are low when compared to the economic benefits that it delivers in terms of reduced health impacts.

The ACCREU project has also looked at the additional costs of cooling for commercial and industrial buildings under climate change. This only analyses the additional annual electricity costs – it does not include the capital costs of new AC units.

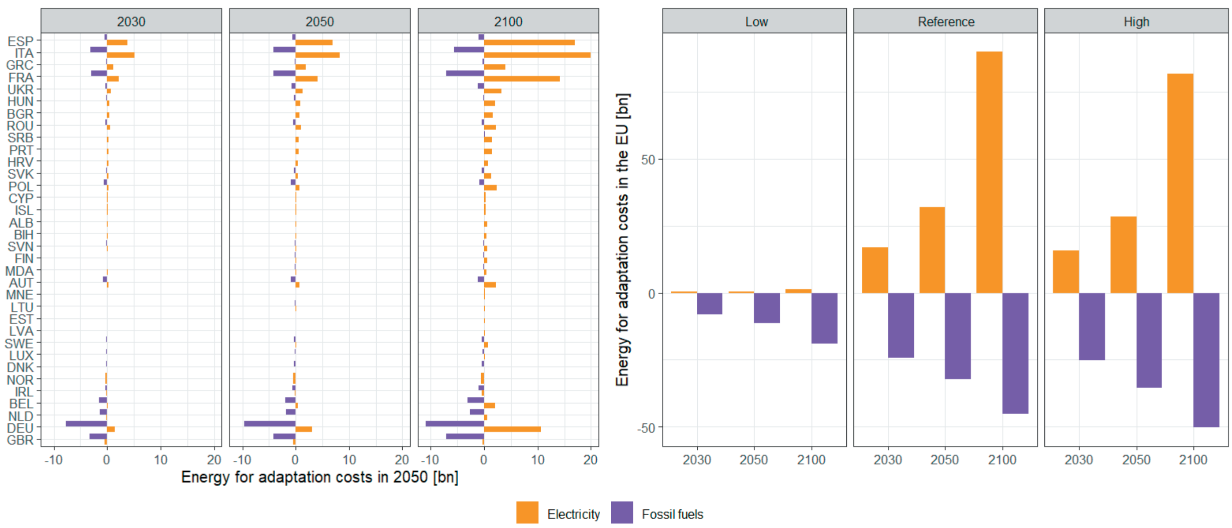


Figure 16. Projected costs for electricity and fossil fuel energy demand, by period and scenario for RCP 4.5 over time.

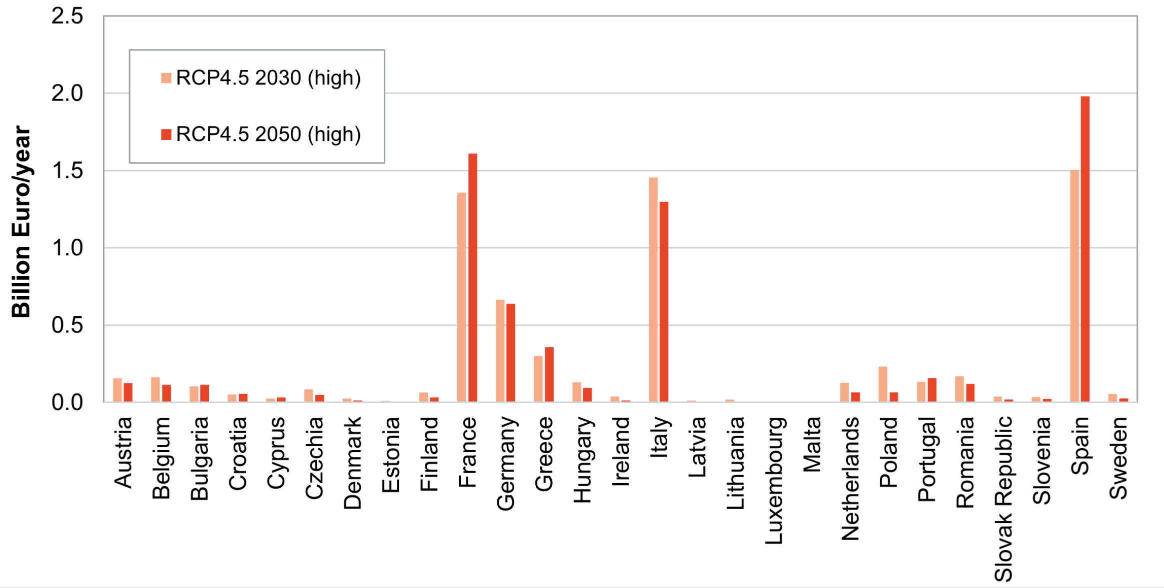


Figure 17. Additional costs of electricity from climate change (energy costs and AC investment costs) for residential properties (€Billion/year) in 2030 and 2050 (RCP4.5), high adaptation scenario.

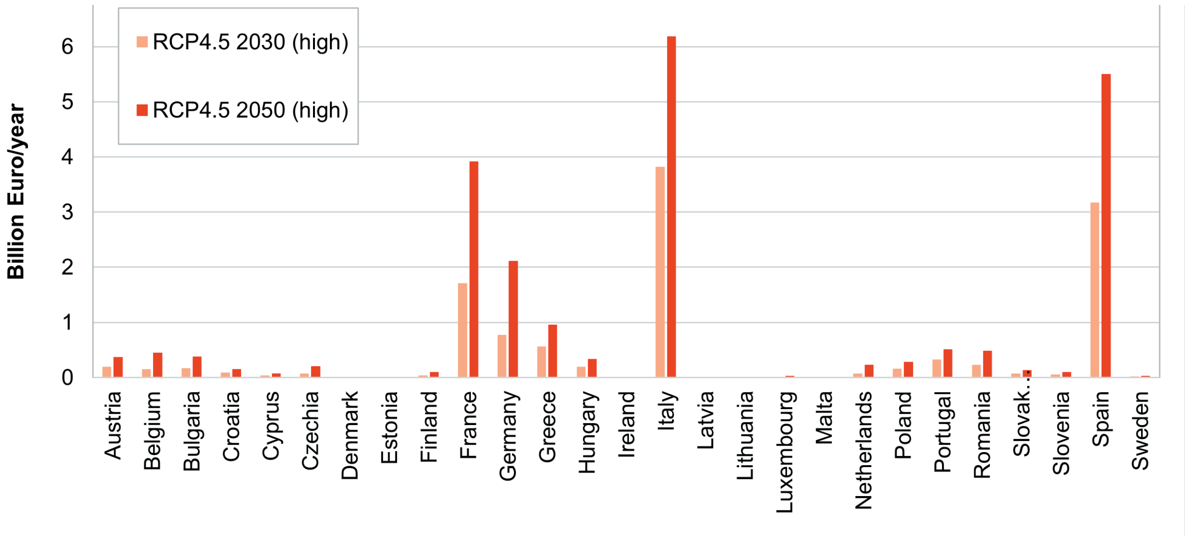


Figure 18. Additional annual costs of electricity for cooling for non-residential properties (€Billion/year) in 2030 and 2050 (RCP4.5), high adaptation scenario.

Values are presented as the total cost for the combination of climate and socio-economic change. They are presented as the undiscounted values in future years in current prices (€2023). It is stressed that there is a wide range of uncertainty around these central estimates. Electricity use values are based on historical prices.

These results are shown in Figure 18 and show the increase in electricity used for cooling with climate change (full results are in Table A6B). Again these project that there will be much higher cooling costs for Southern Europe, though some of the larger economies (Germany) also have significant costs. The results indicate additional costs of approximately €20 to 34 billion per year by 2050 for the EU27 (central and high scenarios respectively).

The increase in commercial and industrial cooling is an impact, but it has economic co-benefits by reducing the labour productivity impacts of climate change. These benefits have been quantified and valued, see the labour section earlier in this policy brief (and Table A4). This shows the adaptation benefits of cooling in reducing labour impacts are very large, estimated at €40 to 60 billion Euro/year by 2050 (see Table A4).

While the analysis here has focused on AC, it is stressed that alternative planned adaptation actions could be used. This includes passive measures, both in new buildings and retrofit , as well as green infrastructure, though these also involve costs.

Wildfires

Wildfires are uncontrolled vegetation fires. They can be ignited by natural sources, such as lightning, but most ignitions are related to human activities (e.g. agriculture, campfires, arson). Wildfires are exacerbated by the availability of combustible fuels and land-use management, but also by weather conditions. The main weather drivers include relative humidity, precipitation, wind, and temperature and compounding factors of low rainfall periods and drought (soil moisture).

Wildfire data are published by European Forest Fire Information System (EFFIS) and these show wildfire size and severity are generally increasing in Europe, along with an earlier start to the wildfire season. Recent years have also seen exceptional wildfires – for example in 2023 over 500,000 hectares of land was burned in the EU – as well as the emergence of uncontrollable 'megafires' that are almost impossible to bring under control by traditional firefighting. Wildfires have very large economic costs, from the direct loss and damage, but also from the release of carbon and air pollution and associated externalities.

Modelling approach

The ACCREU project has developed advanced and highly resolved wildfire risk projections for Europe. These were produced by combining the ForeFire fire spread model with a probabilistic fire ignition model, and regional climate model simulations, to create spatially explicit risk maps for three climate scenarios (RCP2.6, RCP4.5, RCP7.0) through to 2100. The ignition probabilities under different climate scenarios were obtained from a machine learning (ML) based fire probability model, which was trained using observed fire events from the EFFIS dataset and 23 predictors, including climate, land cover, topography, and human activity. This was used to generate daily fire risk maps, which were subsequently used to estimate ignition points and simulate fire spread. This novel methodology allowed the quantification of the average burned area per year, the direct fire impacts and the secondary ecological consequences.

ACCREU results

Figure 20 below shows the total annual burned area for each scenario from the fire spread simulations, as well as the cumulative impact in each of four 20-year periods (2021–2040, 2041–2060, 2061–2080, and 2081–2100), for the three different RPC scenarios.

Under RCP2.6, the burned areas show a slight increase towards the middle of the century followed by a slight decrease by the end of the century. This reflects the temperature trend of the RCP2.6 scenario itself. In contrast, under the RCP4.5 and especially the RCP7.0 scenarios, there are substantial increases projected in the burned area from wildfires over the century. Under RCP7.0, the average burned area is estimated to be almost double current levels, and there is 150,000 km^2 burned in the 20 year period at the end of the century.

These projections were fed into the GLOBIOM-G4M framework. This allows an analysis of the impacts on forest biomass losses and greenhouse gas (GHG) emissions.

The results find that climate change-driven wildfire impacts will be substantial but heterogeneous across Europe (noting they will also vary with management regimes). Southern European countries face the greatest projected biomass losses from wildfires, with approximately 90% of total losses concentrated in Spain, Italy, France, and Greece. Unmanaged forests, particularly those under protection or set aside for conservation purposes, are generally more susceptible to biomass losses following fire events due to their limited natural regeneration.

The analysis also projects that wildfire-related carbon dioxide (CO_2) emissions from European forests will increase under future climate change, reflecting both greater wildfire occurrence and higher biomass losses in vulnerable regions. Historical estimates suggest that between 2000 and 2016, the average annual CO_2 emissions from wildfires in Europe were approximately 7 Million tonnes (Mt) of CO_2 per year. The model results from ACCREU estimate that by 2050, these could increase to 11.9 Mt CO_2 per year under RCP2.6, 12.9 Mt CO_2 per year under RCP4.5, and 14.6 Mt CO_2 per year under RCP7.0. This underscores the increasing role of wildfires as a source of greenhouse gas emissions from Europe's forest sector.

Further work is now underway to assess the total economic costs of wildfires, as well as the costs and benefits of adaptation options.

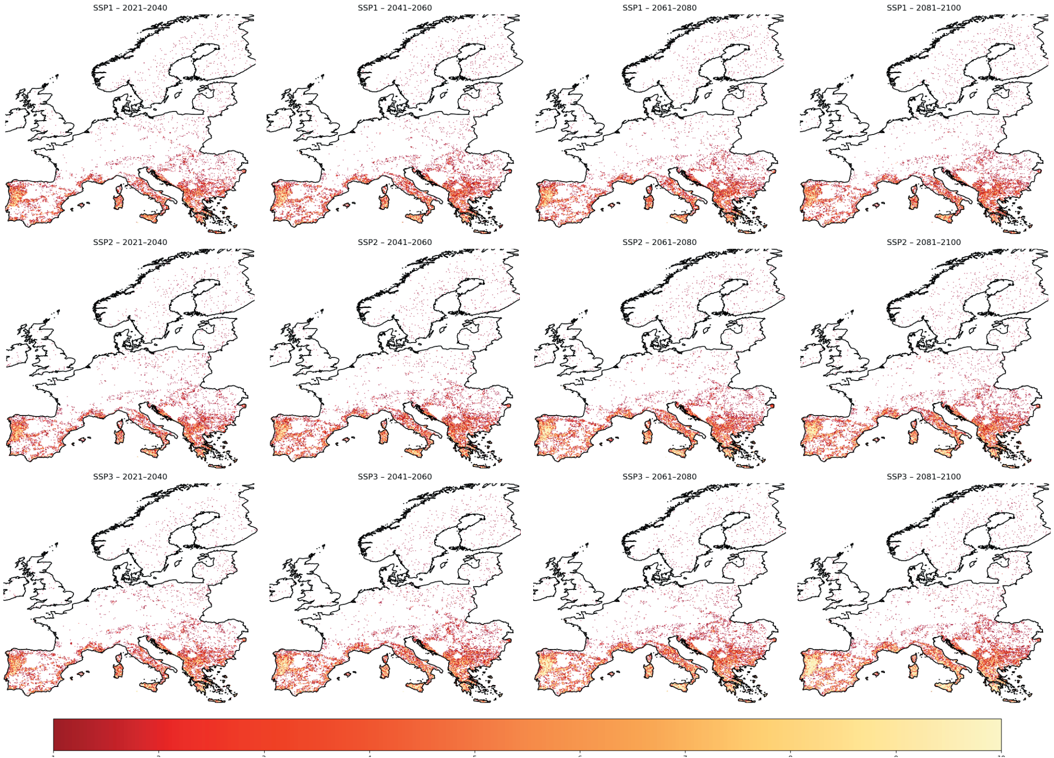


Figure 19. Location of ignited wildfires simulated by the probabilistic ignition model in each 20 year time slice, RCP 7.0.

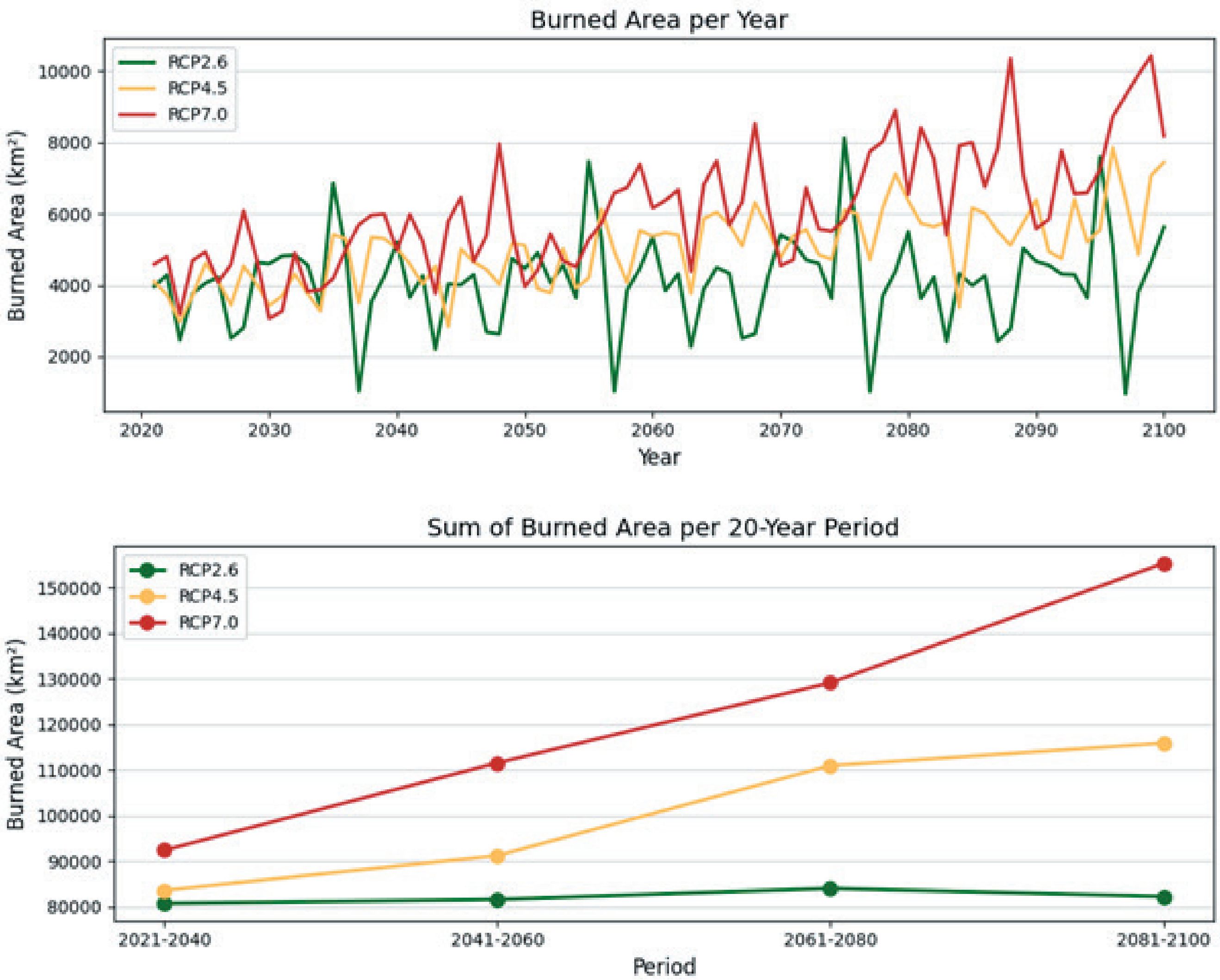


Figure 20. Annual (top) and cumulative per 20 year period (bottom) burned area from wildfires across Europe under three climate scenarios.

The cost of compound climate extremes to European households

The impacts of climate change on welfare, income and poverty are projected to have strong distributional patterns across Europe, affecting countries differently. Furthermore, when experiencing the same exposure to climatic events, households *within* countries may be affected differently, and higher relative impacts may be borne by low-income households.

The ACCREU project has investigated these issues for compound events, which arise when two or more hazards occur at the same time. It has assessed whether compound events result in an impact that is larger than if the hazards occurred separately, and whether these resulting impacts differ by household income level.

Modelling approach

The ACCREU project investigated how compound dry-and-hot events (CDHE) affect the economic wellbeing of European households using econometric analysis. This looked at the effects of heatwaves during severely dry months (droughts), which is important as CDHEs have been occurring more frequently and for longer durations due to climate change. The analysis quantified the current impacts and potential future risk of CDHEs by combining EU household survey data from EU Statistics on Income and Living Conditions (EU-SILC) at the subnational level (NUTS-1) with high-resolution temperature and drought data

ACCREU results

The results found statistically significant reductions in household income for every additional heat wave day and drought month. It also found that compound events, where heat wave days co-occurred with drought, had a higher impact on income (a 0.8 percentage points difference) than when heat wave days occurred during non-drought months. This provides empirical evidence for the additional impacts of compounding extremes. The impact of these events was found to be unequally distributed across European regions, due to differing frequency and magnitudes of heat waves and droughts, with some regions experiencing more frequent CDHE, leading to higher marginal income impacts. The countries of Spain, Italy and Hungary experienced the most extreme events over the period 2004-2022, and also bore the highest estimated income losses (see Figure 1).

The analysis also found large differences in income impacts for households ***within*** countries, even when households experienced the same exposure to heat waves and droughts. The largest relative impact occurred in those households with lowest incomes (Figure 2, left). These differences were large: the lowest-income household quintile experienced a 2.7 greater percentage point reduction in income than the highest-income households for the same events.

The analysis also looked at the implications of these income impacts on poverty, by assessing

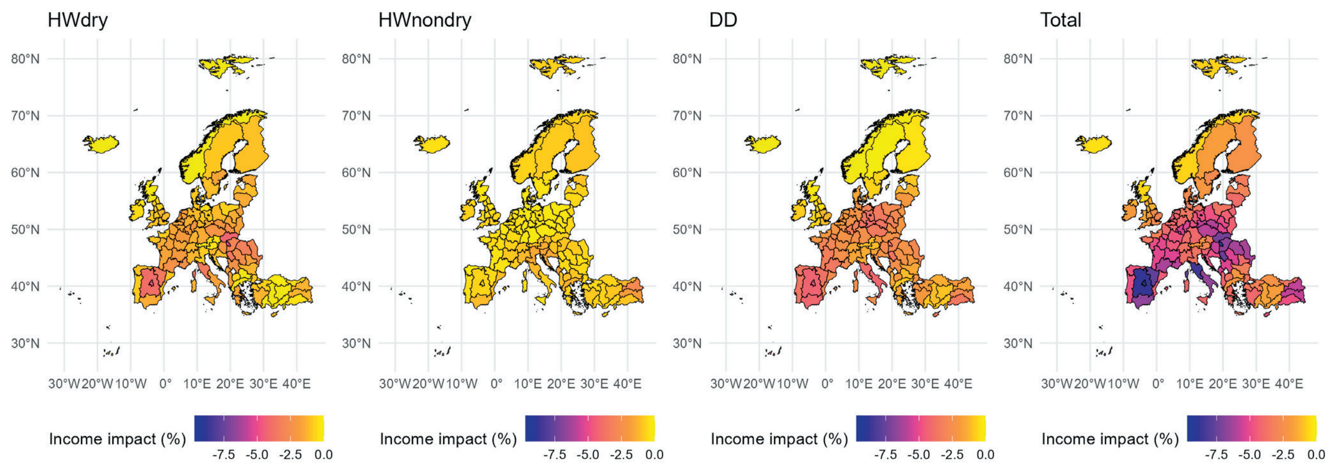


Figure 21. Average estimated historical impact of heatwave-dry (HWdry), heatwave-nondry (HWnondry) and droughts (DD) on household income from 2004-2022 by NUTS-1 region in percent difference from a counterfactual scenario (i.e., if no heatwaves, nor droughts happened during the same period). The income impacts are calculated by multiplying the marginal effect of a heatwave day or drought month to the average frequency of the hazards. The total income impact (Total) is a summation of the three impacts.

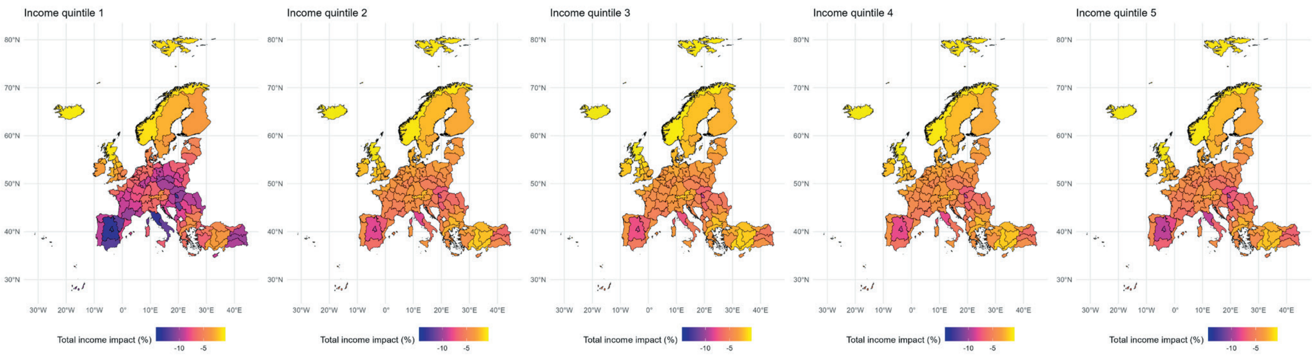


Figure 22. Total estimated income impacts from the combined effects (marginal effect x frequency) of HWdry, HWnondry, and DD, averaged across years 2004-2022, by household income quantile.

the change in the at-risk-of-poverty (AROP) rate in Europe. The indicates an average increase in AROP incidence of 1.1 percent, equivalent to an additional 5.6 million people, due to heatwaves, droughts, and CDHE over the period 2004-2022.[1]

Finally, the historically-derived relationships from the analysis of climate extremes and household income (above) were used to investigate the projected ***future*** impact of climate change for three global warming scenarios relative to pre-industrial levels: +1.5°C (close to the Paris Agreement goal of 'pursuing efforts to limit the temperature increase to 1.5°C'); +2°C (broadly consistent the RCP2.6 scenario); and +2.7°C (broadly consistent with current policies) by 2100.

The climate projections in all three scenarios show an increase in the number of heat wave days and drought months, but they are particularly high for the +2.7°C scenario. Due to the difference in the frequency in heatwave days, drought months and the simultaneous occurrence of both events, average household income in 2100 is 20 percentage points lower in the +2.7°C scenario (4 percentage points in the +2°C scenario), compared to the +1.5°C scenario (Figure 3). Similarly, the at-risk-of-poverty incidence is 13 percentage points higher in the +2.7°C scenario (2 percentage points in the +2°C scenario), compared to the +1.5°C scenario. Accounting for population projections, an estimated 68 million more people could be at-risk-of-poverty in 2100 in the +2.7°C scenario (9 million in the +2°C scenario), compared to the +1.5°C scenario, due to heatwaves and droughts. These results show that climate change will have important implications for the EU's target of reducing poverty by at least 15 million people by 2030 compared to 2019 (European Union, 2021), and highlight the importance of mitigation action for meeting these goals.

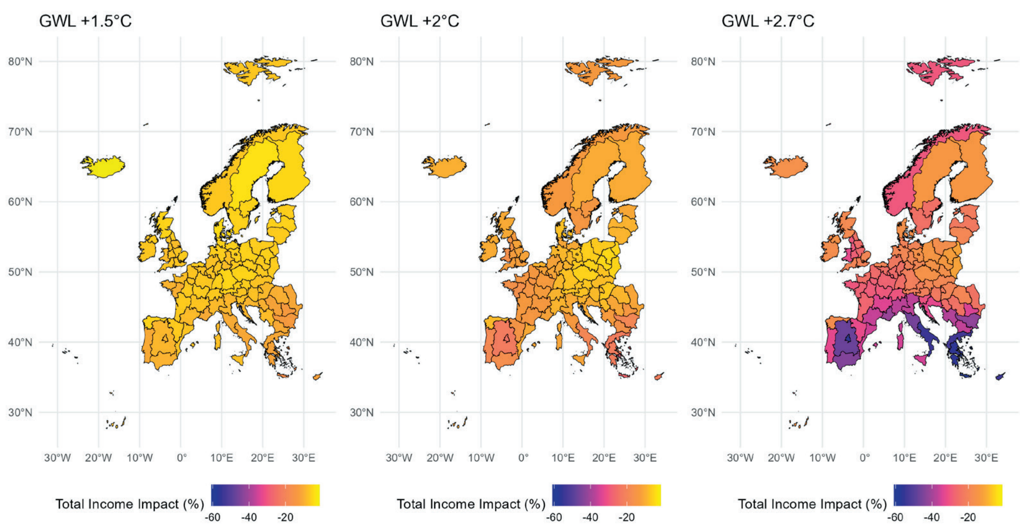


Figure 23. Projected reduction in household income (%) from the combined effects of HWdry, HWnondry and DD under global warming scenarios +1.5°C (left), +2°C (middle), and +2.7°C, relative to the reference period (+0.8°C to +1.4°C).

1 Using the relative threshold of 60% of the country- and year-specific median equivalised income.

Appendix

Table A1. Coastal EAD, and costs and benefits of adaptation, in the EU27. *Note values in 2020 (italics) are high as they represent adjustment costs in the starting period (2020) to the under-adapted current state (and adaptation deficit).*

EU27	**Baseline – Expected Annual Damage (€ Billion / year)**								
	2020	**2030**	**2040**	**2050**	**2060**	**2070**	**2080**	**2090**	**2100**
No additional adaptation (constant dyke height)									
RCP2.6	*7.2*	13.8	22.8	36.6	58.6	90.1	123.8	156.2	203.6
RCP4.5	*7.3*	14.3	23.5	41.3	69.5	108.0	151.6	202.3	252.4
RCP7.0	*7.1*	13.7	23.0	41.7	73.7	117.6	169.8	223.1	313.5
With adaptation	**Residual Damage – EAD WITH adaptation (€ Billion / year)**								
Constant flood protection									
RCP2.6	*3.8*	4.4	5.2	6.2	7.2	8.3	9.6	10.8	12.2
RCP4.5	*3.8*	4.5	5.3	6.2	7.3	8.5	9.9	11.4	13.0
RCP7.0	*3.8*	4.5	5.3	6.2	7.3	8.6	10.1	11.8	13.5
Economically optimal protection									
RCP2.6	*0.4*	0.5	0.6	0.7	0.7	0.8	1.0	1.2	1.3
RCP4.5	*0.4*	0.5	0.6	0.7	0.7	0.9	1.1	1.2	1.4
RCP7.0	*0.4*	0.5	0.6	0.7	0.7	0.9	1.1	1.3	1.5
	Adaptation costs (€ Billion / year)								
	2020	**2030**	**2040**	**2050**	**2060**	**2070**	**2080**	**2090**	**2100**
No additional adaptation (constant dyke height)									
RCP2.6	*5.6*	2.8	3.0	3.8	3.2	3.7	3.3	4.3	3.3
RCP4.5	*5.6*	2.8	3.2	3.7	3.4	3.7	4.6	5.5	11.3
RCP7.0	*5.6*	2.8	3.4	3.6	3.4	4.1	5.9	10.7	10.1
Constant flood protection									
RCP2.6	*7.0*	3.3	3.4	3.6	3.6	3.7	3.6	3.6	3.7
RCP4.5	*7.0*	3.3	3.4	3.7	3.8	3.8	3.9	4.0	4.4
RCP7.0	*6.9*	3.3	3.5	3.7	3.9	4.0	4.2	4.5	4.8
Optimal protection									
RCP2.6	*9.2*	2.3	2.4	2.5	2.5	2.6	2.5	2.5	2.6
RCP4.5	*9.3*	2.3	2.4	2.6	2.6	2.7	2.7	2.8	3.1
RCP7.0	9.2	2.3	2.4	2.6	2.7	2.8	3.0	3.2	3.4
	Adaptation Benefits (baseline – residual damage)								
	2020	**2030**	**2040**	**2050**	**2060**	**2070**	**2080**	**2090**	**2100**
Constant flood protection									
RCP2.6	*3.4*	9.3	17.5	30.4	51.4	81.8	114.2	145.3	191.4
RCP4.5	*3.5*	9.8	18.2	35.1	62.2	99.5	141.7	190.9	239.5
RCP7.0	*3.3*	9.3	17.7	35.4	66.4	109.0	159.7	211.3	300.0
Optimal protection									
RCP2.6	*6.8*	13.3	22.2	35.9	57.9	89.3	122.8	155.0	202.3
RCP4.5	*6.9*	13.8	22.9	40.7	68.8	107.1	150.5	201.0	251.0
RCP7.0	*6.7*	13.3	22.4	41.0	72.9	116.7	168.7	221.8	312.0

Values are presented as the total cost for the combination of climate and socio-economic change. They are presented as the undiscounted values in future years in current prices (€2023). It is stressed that there is a wide range of uncertainty around these central estimates reflecting the underlying uncertainty in global temperatures, sea-level response, and ice sheet melt.

Table A2. River flood EAD, and costs and benefits of adaptation, in the EU27.

	Baseline – Expected Annual Damage (€ Billion / year)		
No adaptation	**2030**	**2050**	**2080**
RCP2.6	26.7	41.7	79.2
RCP4.5	24.9	37.6	74.7
RCP6.0	26.2	39.1	74.4
RCP8.5	26.9	41.2	78.9
	Residual Damage EAD WITH adaptation (€ Billion / year)		
Constant flood protection	2030	2050	2080
RCP2.6	19.8	28.8	46.8
RCP4.5	19.2	27.8	47.1
RCP6.0	20.0	27.9	47.0
RCP8.5	20.7	29.9	48.0
Optimal protection			
RCP2.6	12.4	17.7	29.5
RCP4.5	12.1	17.2	29.0
RCP6.0	11.8	16.8	27.8
RCP8.5	12.6	18.0	30.2
	Adaptation costs(€ Billion / year) annual		
Constant flood protection	**over the period 2020–2050**		
RCP2.6	3.4		
RCP4.5	3.3		
RCP6.0	3.0		
RCP8.5	3.9		
Optimal protection			
RCP2.6	11.6		
RCP4.5	11.7		
RCP6.0	11.7		
RCP8.5	12.0		
	Adaptation Benefits (€ Billion / year)		
	2030	**2050**	**2080**
Constant flood protection			
RCP2.6	6.9	12.9	32.4
RCP4.5	5.7	9.8	27.6
RCP6.0	6.2	11.2	27.4
RCP8.5	6.2	11.3	30.9
Optimal protection			
RCP2.6	14.3	24.0	49.7
RCP4.5	12.8	20.3	45.7
RCP6.0	14.4	22.4	46.6
RCP8.5	14.3	23.1	48.7

Values are presented as additional costs relative to the baseline period, from the combination of climate and socio-economic change, and are presented as undiscounted values in future years in current prices (€2023). It is stressed that there is a wide range of uncertainty around these central estimates.

Table A3. Adaptation costs for agriculture (irrigation) (€billion/year) in the EU27.

	Adaptation costs(€ Billion / year)				
	2030	**2040**	**2050**	**2060**	**2070**
Low adaptation					
RCP2.6	1.5	1.1	0.9	0.7	0.6
RCP4.5	1.4	1.1	1.0	0.9	0.6
RCP7.0	1.5	1.1	1.0	0.8	0.7
Reference adaptation					
RCP2.6	2.3	2.2	1.9	2.2	1.5
RCP4.5	2.0	1.7	1.9	2.3	2.2
RCP7.0	2.2	1.8	1.7	2.1	1.9
High adaptation					
RCP2.6	7.0	7.9	4.7	5.0	4.5
RCP4.5	6.6	8.7	7.0	6.6	7.0
RCP7.0	6.7	8.0	7.5	6.4	7.0

Values are the annual costs of public capital investment and farmer maintenance and operation costs. They are presented as undiscounted values in future years in current prices (€2023). It is stressed that there is a wide range of uncertainty around these central estimates.

Table A4. Economic costs of climate change on effective labour in the EU27, including with adaptation for low activity (indoor) work. Note values in the future are scaled based on per capita income growth in SSP2 (by country).

EU27	Estimated Economic Cost (€ Billion / year)		
Low Activity Work (no adaptation)	**2030s**	**2050s**	**2070s**
RCP2.6	83.9	148	193.3
RCP4.5	70.6	186.8	449.1
RCP7.0	76.8	198.1	775
Low Activity Work WITH Adaptation	**2030s**	**2050s**	**2070s**
RCP2.6	61.2	108.4	143.3
RCP4.5	55.7	132.4	300.8
RCP7.0	59.5	139.4	468.7
Benefits of Adaptation (Low Activity)	**2030s**	**2050s**	**2070s**
RCP2.6	22.6	39.6	50.1
RCP4.5	14.9	54.4	148.3
RCP7.0	17.3	58.6	306.3

Values are presented as the total cost for the combination of climate and socio-economic change. They are presented as the undiscounted values in future years in current prices (€2023). It is stressed that there is a wide range of uncertainty around these central estimates. Note that positive and negative effects are summed in these values, but even for countries that have net positive effects overall, there will still be heat related impacts, which will require planned adaptation.

Table A5A. Economic cost (€billion/year) of heat-related fatalities in the EU for three time slices and three RCPs (central estimates) using the Value of a Life Year Lost for Valuation. The table also shows the estimated economic benefits (from reduction in heat-related fatalities) from the increase in residual AC (see energy table A6), again valued using VOLY.

Constant unit prices for VOLY with no adjustment for economic growth.

EU27	**Estimated economic costs (€ Billion /year)**		
	2030s	**2050s**	**2070s**
Baseline	Central VOLY		
RCP2.6	229	319	301
RCP4.5	235	338	383
RCP7.0	224	347	468
	Estimated economic benefits (€ Billion /year)		
Adaptation Benefits	Central VOLY		
RCP2.6	5	17	Not available
RCP4.5	8	19	
RCP7.0	7	19	

With VOLY increased in line with GDP growth

EU27	**Estimated economic costs (€ Billion /year)**		
	2030s	**2050s**	**2070s**
Baseline	Central VOLY		
RCP2.6	282	509	582
RCP4.5	290	541	740
RCP7.0	276	555	905
	Estimated economic benefits (€ Billion /year)		
Adaptation Benefits	Central VOLY		
RCP2.6	7	27	Not available
RCP4.5	10	30	
RCP7.0	8	31	

Values are presented as the total cost (VOLY) for the combination of climate and socio-economic change. They are presented as undiscounted values in future years in current prices (€2023). It is stressed that there is a wide range of uncertainty around these central estimates, from climate model projections, estimated impacts including potential acclimatisation, and valuation. Note that the use of the VSL would result in higher economic costs.

Table A5B Total morbidity costs based on **Willingness to Pay** (Constant unit prices) (Adélaïde et al., 2022).

EU27	**Estimated economic costs (€ Billion /year)**		
	2030s	**2050s**	**2070s**
Baseline	–		
RCP2.6	0.464	0.679	0.668
RCP4.5	0.475	0.720	0.848
RCP7.0	0.453	0.739	1.070

Total morbidity costs based on **WTP** (SPP2 growth scenario in costs)

EU27	**Estimated economic costs (€ Billion /year)**		
	2030s	**2050s**	**2070s**
Baseline	–		
RCP2.6	0.571	1.084	1.292
RCP4.5	0.585	1.151	1.641
RCP7.0	0.559	1.180	2.087

Table 6A. Projected annual net costs of cooling (capital and electricity) for the EU27 for three adaptation scenarios (low, reference and high).

	€ billion/year	
EU27	**2030**	**2050**
Low		
RCP2.6	3.2	0.9
RCP4.5	3.6	1.0
RCP7.0	3.3	1.1
Reference		
RCP2.6	8.0	5.9
RCP4.5	6.7	6.5
RCP7.0	7.1	9.4
High		
RCP2.6	8.4	6.4
RCP4.5	6.9	7.0
RCP7.0	7.4	10.1

Table A6B. Projected annual net costs of cooling in the agriculture, industry and commercial sectors (electricity only) for the EU27 for three adaptation scenarios (low, reference and high).

	€ billion/year		
EU27	**2030**	**2050**	**2100**
Low			
RCP2.6	0.7	1.1	0.9
RCP4.5	0.6	1.0	2.3
RCP7.0	0.6	1.6	3.7
Reference			
RCP2.6	15.9	19.6	16.2
RCP4.5	11.8	21.8	42.7
RCP7.0	12.8	31.9	78.5
High			
RCP2.6	16.1	20.3	17.7
RCP4.5	12.0	22.6	46.6
RCP7.0	13.0	32.9	85.7

Values are presented as undiscounted values in future years in current prices (€2023). It is stressed that there is a wide range of uncertainty around these central estimates. Electricity prices based on historical prices.

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