

Economic assessment of climate risks and opportunities for Edinburgh and South East Scotland

Task 1: High level analysis of economic impacts

FINAL REPORT

April 2024

Citation: England K., Moxey, A. and Watkiss, P. (2024) Economic assessment of climate risks and opportunities for South East Scotland. Task 1: High level analysis of economic impacts and costs of adaptation

This report has been produced as part of the Climate Ready South East Scotland project. Climate Ready South East Scotland is led by Sniffer, working in partnership with the region's six local authorities: City of Edinburgh, East Lothian, Fife, Midlothian, Scottish Borders and West Lothian.

The project is being delivered as part of the Edinburgh and South East Scotland Regional Prosperity Framework, with support from Capital City Partnership. The project is funded by the UK Shared Prosperity Fund and Scottish Government.

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Executive Summary

As part of the wider Climate Ready South East Scotland project, PWA has been commissioned by Verture to undertake an economic assessment of the climate risks and opportunities for the Edinburgh and South East Scotland Region. Task 1 aimed to provide a high-level analysis of the regional economic impacts of climate change risks and opportunities.

Macroeconomic impacts of climate change

The study ran a large-scale macroeconomic model designed to simulate the effects on GDP of ESES City Region as a result of global climate change impacts. The model used a set of sectoral models on the impacts of climate change and paired it with a macroeconomic model. The results show that climate change is projected to reduce the total future GDP for the ESES City Region significantly under all warming scenarios except for the highest RCP8.5-SSP5 scenario. Note that this is the additional impact over and above the current effects of climate variability and extremes (hence values only start in 2015). The total costs would be higher if these current impacts are also included.

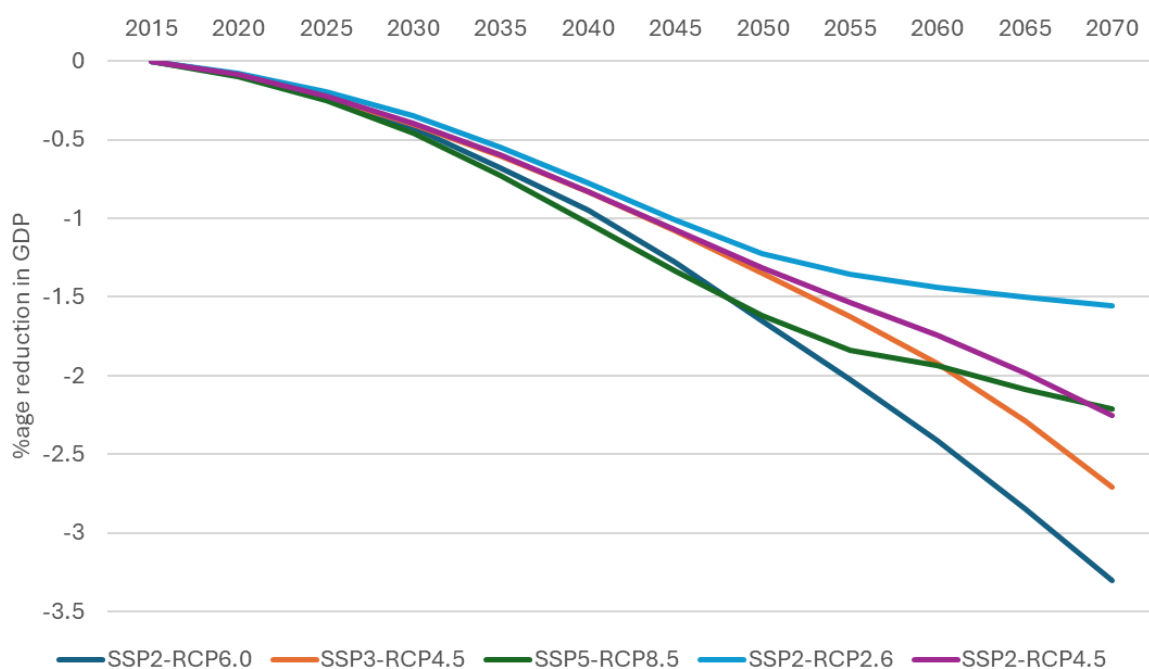


Figure 1: Modelled costs of climate change for Edinburgh and South East Scotland City Region as a % reduction in GDP. High Investment Mobility. Source: Authors based on Bosello et al., 2019.

The trajectories are similar through to the 2040s, at which point they begin to diverge, with higher impacts at higher levels of warming. By 2030, climate change is projected to mean that GDP is 0.3%–0.5% lower per year compared to a 2015 baseline. This increases to 1.2%–1.6% by 2050. By the 2070s, the impacts rise to between 1.5% for an RCP2.6 scenario and 3.3% for an RCP6.0 scenario. The main drivers of macroeconomic impacts from climate change across Europe are sea-level rise, river floods and crop yield changes. The study also considered a range of sensitivities, including the mobility of investment. This highlighted that it is possible to experience high economic losses also in low climate change scenarios.

A second study also explored the impacts of climate change and trade effects, expressed as a percentage of GDP. This used a different set of impacts, climate and socioeconomic scenarios but also disaggregated the results by local authority. In this study, the current policies scenario projects GDP to be 1.2% a year lower across the 2011–2030 period, relative to a 2000 baseline, rising to around 3.4% lower by the 2041–2060 period, and finally rising to 8% by 2081–2100. Under a ‘high mitigation’ scenario, the impacts are still reduced, but the analysis still suggests that there will be

significant impacts of around 2.6% by the 2050s. The results are fairly unevenly distributed across the SES area, with significantly higher impacts in West Lothian, East Lothian and Scottish Borders

Finally, the study applied these percentage reductions to future GVA projections for the region, using the future socioeconomic projections developed for the third UK Climate Change Risk Assessment. The results show that without adaptation, the impact of climate change is a reduction in GVA by the tens to hundreds of millions in the 2020s. This rises to £1.1bn-£3bn/year by 2050.

Impacts of flooding

The study also explored the potential costs of flooding to the region. Flooding is one of the largest impacts of climate change the current and near-term risk, as well as the cross-cutting impact across the City Region. The study reviewed the flood risk management plans for the region. This estimates there are around 99,200 homes and businesses at risk from flooding. This may increase to 126,000 homes and businesses by the 2080s due to climate change (UKCP09, High Emissions). However, this is a partial estimate since, no climate change data was provided for the Tay Estuary plan.

To make these results specific to South East Scotland, this study reviewed the proportion of homes and businesses in relevant council areas for the five relevant flood risk management plans. This showed that 65% of the at-risk homes and businesses in the plan districts are in South East Scotland. This percentage also stays consistent in the 2080s. The five plans state that the collective expected annual cost of flooding over a long period of time is around £98.4 million, though no information was provided on the assumptions behind this figure. Applying this ratio suggests that a similar cost of £64 million would be relevant to the ESES area.

The study then reviewed the future flood risk projections from the third UK Climate Change Risk Assessment to provide future estimates. The study applied the above percentage of homes and businesses at risk from the review of the SEPA Flood Risk Management Plans above to the Sayers estimates of direct and indirect damage expected for the same five Local Plan Districts. These indicate average annual damage of £93m/year in the present day.

Looking forward, the risks and costs of flooding increase over time. For the RWS scenario, with average population growth, the results indicate that flood damages increase to the 2050s, before increasing again in late century. With no further action, costs rise from £93m/year in the present day to between £128m/year and £166m/year by the 2080s. However, adaptation actions result in significant reductions in these costs.

The CCRA3 forecast considers climate, population growth and adaptation scenarios but it does not account for economic growth which will also impact the value of flood damage in the future, reflecting the damage to a higher value at risk. To account for this, the study constructed a series of GVA per capita estimates using GVA forecasts in CCRA3. The growth rate in this series was then applied to the original EAD series provided to generate a series which accounts for economic growth. This leads to much higher damages with EAD for the 2050s rising to between £182m/year – £212m/year in the 2050s, and £375m/yr – £484m/yr by the 2080s.

Conclusions

Climate change will have a significant economic impact on the ESES economy. The results reinforce the case for strong, ambitious mitigation and net zero targets in Scotland as part of global efforts to reduce emissions. Importantly, the study highlights that ESES will continue to experience annual costs of climate change, even after Scotland achieves its net zero targets in 2045. The historic emissions, lags of the climate system and current trajectory of global emissions reduction indicates that there will still be significant costs through to 2050 and these can only be reduced by adaptation.

Therefore, this analysis presents a strong economic case for the development of an adaptation strategy for the ESES region and associated investment in adaptation to reduce the costs of these damages.

Introduction

As part of the wider Climate Ready South East Scotland project, PWA has been commissioned by Verture to undertake an economic assessment of the climate risks and opportunities for the Edinburgh and South East Scotland Region.

Objectives

The objective of the project is to provide a more detailed understanding, in monetary terms of the current and future economic costs (and benefits) of climate change for the Edinburgh and South East Scotland region.

Task 1 aimed to provide a high-level analysis of regional economic impacts of climate change risks and opportunities. To do so it sought to answer the question:

“How will global climate change impacts affect the local economy of Edinburgh and South East Scotland?”

In addition, this task will be used as an input and framing for the more detailed examination of risks and opportunities and adaptation costs in Task 2. Task 2 will estimate the costs of specific local risks and opportunities to the Edinburgh and South East Scotland in monetary terms, to provide a relative comparison of the economic impacts.

Method

The study undertook two parallel pieces of analysis to help establish a high-level view on the costs of climate change for Edinburgh and South East Scotland. The first was to review estimates impacts of climate change on Gross Value Added (GVA)¹. The second task was to review the region-wide costs of flooding. This is shown below:

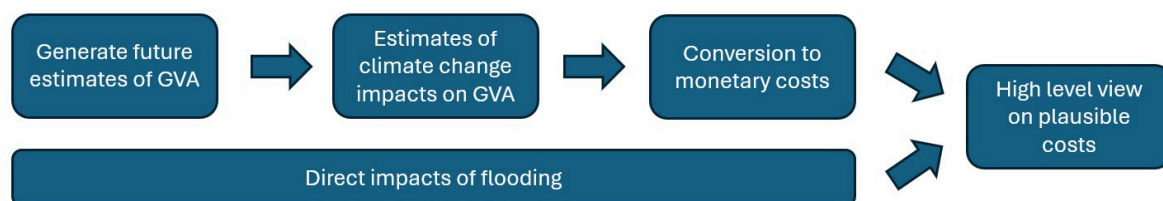


Figure 2: High level method for estimating costs of climate change in the study. Source: Authors.

This was a three-stage process. Stage 1 generated estimates of the regional GVA using baseline data from UKCCRA3. These provide consistent socio-economic projections for the Local Authority level out to 2100. Prices were updated to 2023 to take account of inflation. Given the modest resource, a single scenario (the central scenario) was used. This is shown in Figure 3 below:

¹ GVA is defined as the value generated by any company, economic sector or place engaged in the production of goods and services in a given period of time. In this context, it refers to the value generated by economic activity within the Edinburgh and South East Scotland City Region.

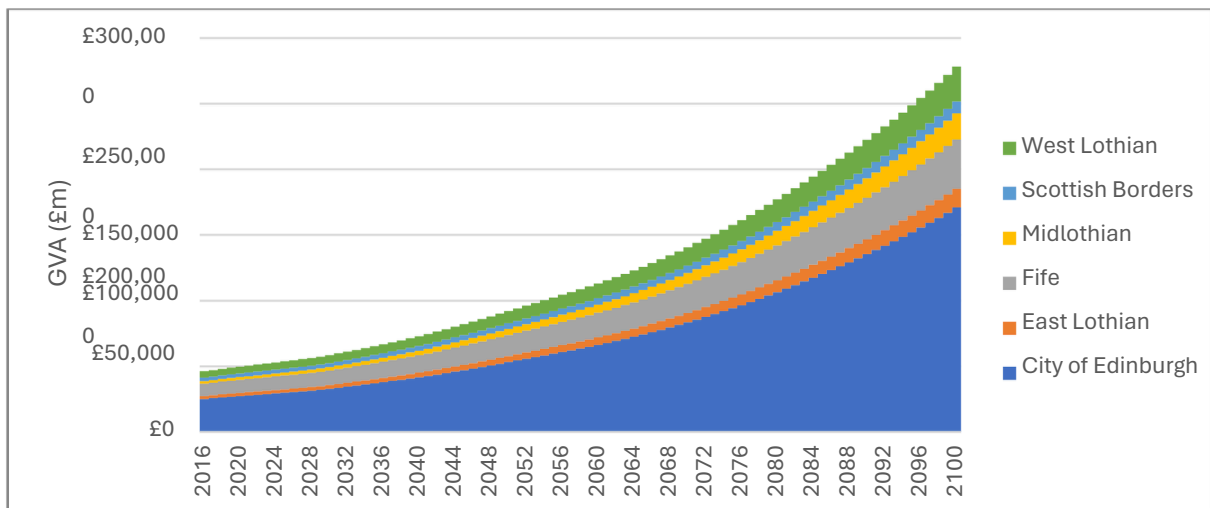


Figure 3: Projected GVA for Edinburgh and South East Scotland, £m. Central Scenario, (2023 prices). Source: Authors based on Cambridge Econometrics, 2019.

Stage 2 involved generating a range of estimates of the impact on GVA. Finally these were then translated into impacts on regional GVA in monetary terms. In parallel, costs of the direct impacts of flooding under climate change generated for UKCCRA3 were examined for the four relevant Local Plan districts. Further details of the methods used in the study are included in Appendix A.

Relationship to the main CRSES risk assessment methodology

Whilst Task 1 has focused on broad macroeconomic costs, the method has been designed to align to the wider Climate Ready South East Scotland risk and opportunity method (Sniffer, 2024)ⁱ, which in turn aligns to the UKCCRA3 and 4 methods. In particular, the parameters include:

- **Time period** – the study sought to consider the risks and opportunities out as far as the 2080s.
- **Climate and socioeconomic scenarios and uncertainty** – The study considered a wide range of uncertainty in future emissions scenarios – including a focus on high end emission scenarios (RCP8.5). It also considered the combination of emissions scenarios with a range of socioeconomic scenarios (SSPs)², notably SSP2, SSP3 and SSP5.
- **Geography** – the study has sought to explore the impacts across the Edinburgh and South East Scotland City Region and its constituent Local Authority areas: Edinburgh. East Lothian. Fife, Midlothian, Scottish Borders and West Lothian. This has focused on using the most granular level of data possible. However, because the geography is not an established statistical unit, in some cases approximations have been used – e.g. NUTS2 regions. More detail on this is provided in Appendix A.

² Note: The baseline scenarios of the Shared Socio-economic Pathways (or SSPs) are quantitative projections of how society, demographics, land use and economics may change over the next century in the absence of additional climate policy. They are used as inputs in the climate models. RCPs, or Representative Concentration Pathways set pathways for GHG concentrations and therefore the amount of warming that could occur by the end of the century. They are combined with impact models to explore plausible climatic changes and associated impacts.

Findings

To generate estimates of the impacts of climate change on the Edinburgh and South East Scotland City Region, the study explored multiple lines of evidence on the economy-wide impacts. This looked at macroeconomic costs, as well as the costs of flooding.

Macroeconomic costs

Firstly, the study ran a large-scale macroeconomic model designed to simulate the impacts on the GDP of ESES City Region as a result of global climate change impacts. This is a representation of the impacts of European climate change across all economic sectors – this includes local impacts within the ESES City Region, but also impacts across Europe and the subsequent effects on trade and investment. This is different to the direct costs of climate change impacts within the region, which will be explored in Task 2.

The model used in this study was generated by the [COACCH](#) project (Co-designing the Assessment of Climate Change). COACCH was a major Horizon 2020 European research project into the macroeconomic impact of climate change, building on over a decade of research under the EU 7th Framework Programme and Horizon 2020 Research and Innovation programme. These have developed the state of the art on the economics of climate change and adaptation (from major projects such as [MEDIATION](#), and [ECONADAPT](#)). COACCH used a set of sectoral models on the impacts of climate change developed by the University of Graz and paired it with a macroeconomic computable general equilibrium (CGE) model (Bosello et al., 2020)ii.

CGE models are large numerical models which combine economic theory with real economic data to derive the impacts of policies or shocks in the economy. CGE models fit economic data to a set of equations which aim to capture the structure of the economy and behavioural response of agents (firms, households, government). This provides a framework to simulate policy changes and trace the impact on key economic variables, including income and expenditure flows. (Scottish Government, 2016)iii.

The model provides outputs of aggregate economic impact across nine SSP-RCP scenario combinations, taking highest and lowest values from nine sectoral assessments (shown in Appendix A), which are in turn based on climatic and socioeconomic models. These are translated into a cross-sectoral macroeconomic assessment, with the aim of providing a common economic metric (% change in GDP with respect to the baseline) of the impacts of climate change at the regional (NUTS2) across the EU27 and the UK.

The model has a range of variables to allow exploration of the impacts. For the purposes of this study, the key variables and the criteria used to generate the results are outlined below.
Table 1: COACCH variables and selected values for the study. Source: Authors.

Variables	Value Selected
Data model	All_Impacts_(EPIC)
Investment Mobility	High
Band of results (High, Med, Low)	Medium
Impacts included:	Agriculture, Energy Demand, Energy Supply, Fisheries, Forestry, Labour Productivity, River Floods, Sea Level Rise, Transport.
Climate and Socioeconomic Scenarios (Representative Concentration Pathways-Shared)	SSP2-RCP2.6, SSP2-RCP4.5, SSP3-RCP4.5, SSP2-RCP6.0, SSP5-RCP8.5.

Socioeconomic Pathway combinations)	
Time periods	2015 (baseline) to 2070, in 5-year increments.

In particular, the economic impacts arise from the following climate impacts and the associated macroeconomic costs:

- Agriculture - crop yield changes induced by climate change
- Changes in Energy Demand – change in energy demand in agriculture, industry, services, and the residential sector.
- Changes in Energy Supply – climate change impacts on wind and hydropower supply
- Fisheries - changes in marine fish catches.
- Forestry - changes in net physical wood production induced by climate change
- Labour Productivity - climate change effects on labour productivity (temperature)
- River Floods - direct physical and economic consequences from riverine floods
- Sea Level Rise - direct physical and economic consequences from sea level rise
- Transport - direct economic losses from climate change impacts on road transportation.

It is important to stress that the analysis does not consider important non-market impacts including on health and on biodiversity and ecosystem services. It also does not include the potential impacts of climate or socio-economic tipping points. These would all be expected to increase GDP losses, and introduce much stronger impacts for high-warming scenarios.

More detail on the model is provided in Appendix A. The results are shown below:

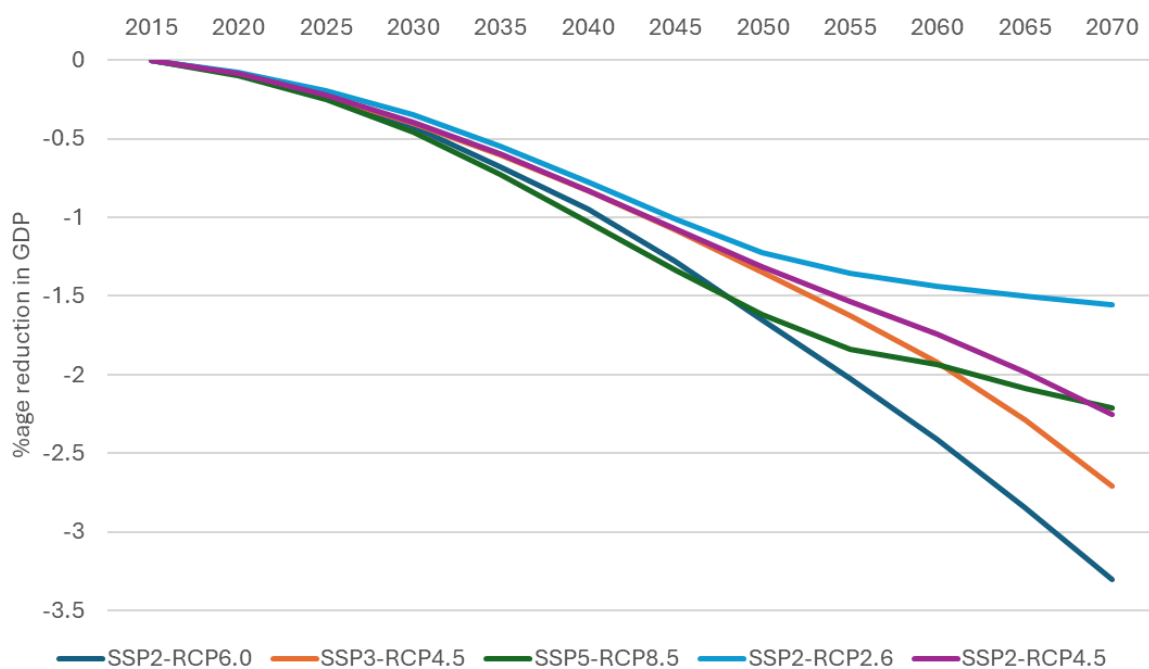


Figure 4: Modelled costs of climate change for Edinburgh and South East Scotland City Region as a % reduction in GDP. High Investment Mobility. Source: Authors based on Bosello et al., 2019.

The results show that climate change is projected to reduce the total future GDP for the ESES City Region significantly under all warming scenarios except for the highest RCP8.5-SSP5 scenario. Note that this is the additional impact over and above the current effects of climate variability and

extremes (hence values only start in 2015). The total costs would be higher if these current impacts are also included.

The trajectories are similar through to the 2040s, at which point they begin to diverge, with higher impacts at higher levels of warming. By 2030, climate change is projected to mean that GDP is 0.3%–0.5% lower per year compared to a 2015 baseline. This increases to 1.2%–1.6% by 2050. By the 2070s, the impacts rise to between 1.5% for an RCP2.6 scenario and 3.3% for an RCP6.0 scenario.

The main drivers of macroeconomic impacts from climate change across Europe are sea-level rise, river floods and crop yield changes. Impacts on fishery and forestry (that in the majority of EU regions result in GDP gains) are roughly comparable in magnitude with negative impacts on labour productivity, energy supply and demand (the latter inducing GDP losses), follow. Less relevant in terms of GDP effects (with some regional exceptions) are interruptions of road networks.

Interestingly, the results show that towards the end of the century the region experiences higher costs under the SSP2-RCP6.0 and SSP3-RCP4.5 scenarios than the SSP5-RCP8.5 scenario. This is because within the modelling benefits to agriculture, forestry and fishing that increase with climate change can result in lower net losses (or higher net gains) in a stronger climate signal scenario like RCP8.5 than in a more moderate one like RCP4.5 (Bosello et al, 2019). Losses are more widespread in southern EU regions, but they can affect northern areas mostly because of sea-level rise.

To explore this, the study also explored the relative sectoral contributions to the overall reductions in GDP under an RCP8.5-SSP5 scenario. This showed that the GDP gains in fisheries and forestry are offset by reductions in all other sectors.

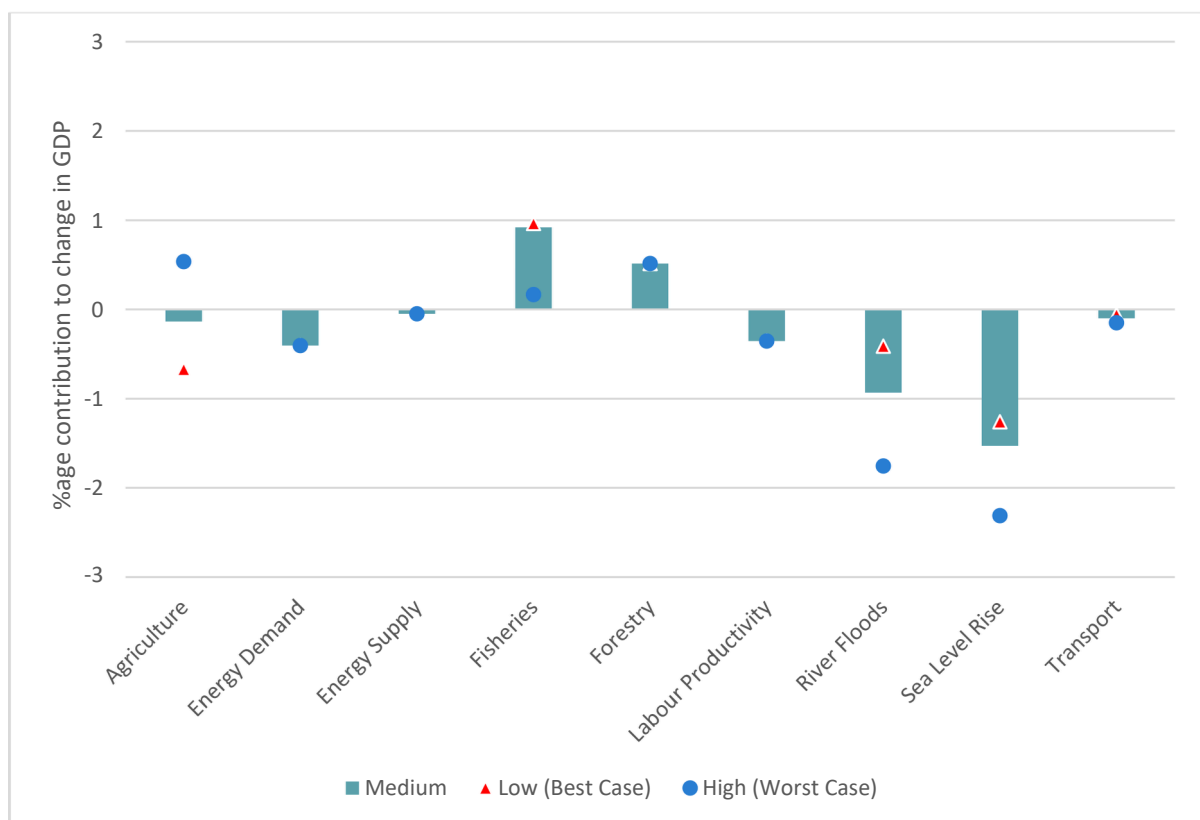


Figure 5: Relative contributions of European impacts to reductions in CRSES GDP. 2070.RCP8.5-SSP5.0 High Investment Mobility Source: COACCH.

Whilst the analysis of the RCP8.5-SSP5 scenario shows more limited economic impacts for ESES, it is important to highlight that there are significant dangers with higher levels of warming. For example, the study did not include non-market effects such as on health, ecosystems or biodiversity. Nor did it include any assessment of tipping points. Therefore, these results should not be interpreted as more limited consequences, but more a limitation in the modelling.

Sensitivity analysis

The study also explored the sensitivity of these results to Investment Mobility. The concept of Investment Mobility relates to the extent to which the financial impacts of climate change spreads across wider economies. In the COACCH model, two plausible scenarios for investment mobility were included 'High' and 'Low' (see Box 1).

Box 1: Investment Mobility in the COACCH model (based on Bosello et al., 2019)

The COACCH project modelled two scenarios of Investment Mobility – low and high, to account for how economies and capital flows respond to climate change impacts.

In the high scenario investment is free to move internationally and inter-regionally seeking the highest return. Under the 'low' investment mobility scenario international investment flows are allocated across countries according to the usual rule of pursuing the highest return, but then are allocated inter-regionally following a proportionality criterion. In the high scenario, investment is more sensitive to differences across regions in the rate of return to capital (e.g. more likely to pursue investments where rates of return are higher).

This has a direct influence on how climate impacts propagate across regions, especially when the regional capital stock (i.e. the plant, equipment, and other assets that help with production) is affected. This applies mostly to sea-level rise and river flooding as these two impacts affect the regional capital assets. In the “high investment mobility” scenario there is a higher transmission of negative shocks from one place to others. Under “low investment mobility”, losses tend to remain more confined in the region of origin. Each assumption is feasible and therefore presented to illustrate the potential range of economy-wide impacts. In reality, the original model authors believe the actual behaviour lies in the middle.

The study compared the % reductions in GDP under both scenarios. The results are shown below: *Table 2:*

Sensitivity analysis of GDP impacts to Investment Mobility. Source: Authors.

Scenario	Investment mobility					
	2030		2050		2070	
	Low	High	Low	High	Low	High
SSP2-RCP2.6	-0.09	-0.35	-0.01	-1.22	0.42	-1.55
SSP2-RCP4.5	-0.15	-0.39	-0.15	-1.32	0.06	-2.25
SSP3-RCP4.5	-0.17	-0.40	-0.41	-1.35	-0.76	-2.71
SSP2-RCP6.0	-0.11	-0.42	-0.09	-1.65	0.04	-3.30
SSP5-RCP8.5	-0.14	-0.46	0.02	-1.62	0.70	-2.21

In line with the general model criteria, the results show that under a 'low investment mobility' scenario, the reductions in GDP for the ESES area are significantly lower, and potentially could see positive growth generated in the high emissions scenario.

This highlights that a significant driver of the costs of climate change in ESES area depend on the extent to which losses from elsewhere are transmitted from across Europe and the UK.

At a European level, this eventually originates the possibility of net GDP gains in regions generally located in the central and northern EU regions. In low emission scenarios, this is due to potential gains in agriculture, forestry, and fisheries in many EU regions. At the same time, negative impacts from other drivers are small in economic terms, though may have significant impacts on individuals or communities.

Whilst the results in the low investment mobility scenario highlight positive GDP growth for ESES, GDP growth can be associated with scenarios that are not desirable from a societal perspective. For example the major socio-economic impacts arising in such scenarios which may have large consequences for ESES that were not modelled in the study (e.g. migration).

It is also important to note that investment mobility was one of the highest sources of uncertainty in the overall modelling. *This analysis conveys important messages. It stresses the possibility to experience high economic losses also in low climate change scenarios. Uncertainty associated with the impact models, which in our case often coincides with climate sensitivity, has the potential to be a larger driver of economic losses than climate scenarios themselves.*

A second study has explored the impacts of climate change and trade effects, expressed as a percentage of GDP. (Rising et al., 2022)^{iv}. This used a different set of impacts, climate and socioeconomic scenarios but also disaggregated the results by local authority. The results are shown below:

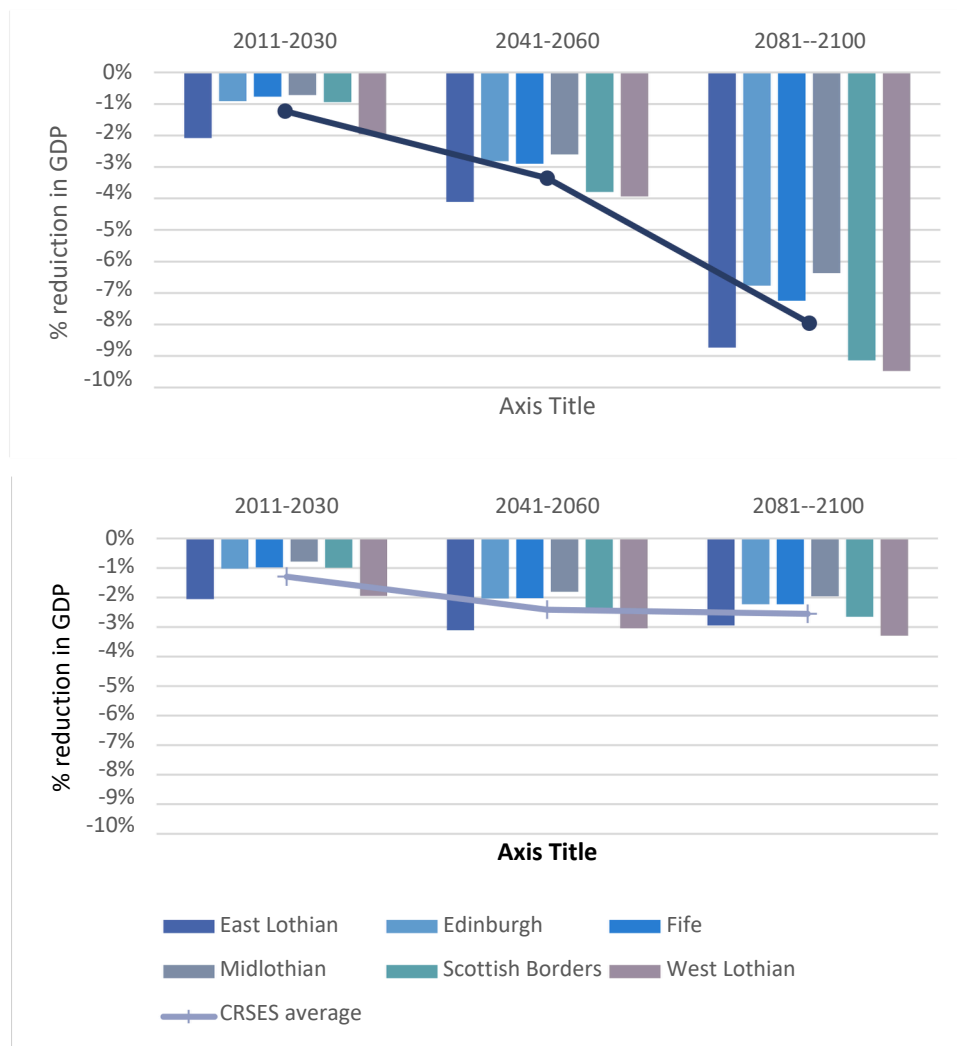


Figure 6: Impacts of climate change for ESES City Region under current policies (top), and 'high mitigation' scenario (bottom). Source: Authors, based on Rising et al., 2022.

In this study, the current policies scenario projects GDP to be 1.2% a year lower across the 2011-2030 period, relative to a 2000 baseline, rising to around 3.4% lower by the 2041-2060 period, and finally rising to 8% by 2081-2100. Under a 'high mitigation' scenario, the impacts are still reduced, but the analysis still suggests that there will be significant impacts of around 2.6% by the 2050s. The results are fairly unevenly distributed across the SES area, with significantly higher impacts in West Lothian, East Lothian and Scottish Borders. The individual breakdowns are included in Appendix B.

The Rising et al. study generates higher impacts on GDP which are not directly comparable with the GDP estimates from COACCH due to differences in method. This is because the studies:

1. Use different shared socioeconomic pathways (SSPs), and warming scenarios.
2. include different set of impact channels and associated economic costs (e.g. heat and cold-related mortality).
3. use different modelling approaches - The Rising study is based on direct impacts expressed as a proportion of GDP, whilst the COACCH reductions include these, but also European impacts and subsequent effects of trade.

The Rising et al. study also includes an uplift for 'missing' risks – estimated as a fraction of known risks. It also included a 'best estimate' of the risks of catastrophic climate change impacts (defined as 25% or more of global GDP lost), which significantly increases the values. This value is only indicative and represents a possible but not certain level of risk

Monetary impacts

To provide a sense of the real impacts of these impacts in the region, the study subsequently applied the percentage reductions from the studies outlined above to GVA to provide estimates of the costs of climate change through to 2050. The relationship between GDP and GVA is shown below:

$$GVA+Taxes-Subsidies =GDP$$

GDP is equivalent to GVA plus taxes (less subsidies) on products. In the national accounts, GDP can be measured using three different approaches: production, income and expenditure. The COACCH model assesses effects on GDP using the production approach, for which the ONS assumes GVA to be a proxy (ONS, 2020)v. Therefore, the percentage reductions from the COACCH model can be applied directly to UK estimates of regional GVA. These are shown below, with select scenarios included at the Local Authority level in Appendix B:

Table 3: Projected annual reductions in GVA for Edinburgh and South East Scotland from baseline, £m. 2023 prices. Source: Authors, based on Bosello et al, 2019, Rising et al., 2022 and Cambridge Econometrics, 2019.

Study	Scenario	Year			
		2020	2030	2040	2050
COACCH	SSP2-RCP2.6 (1.6 Degrees)	£37	£204	£566	£1,125
	SSP2-RCP4.5 (2.4 Degrees)	£44	£230	£608	£1,212
	SSP3-RCP4.5 (2.4 Degrees)	£41	£234	£608	£1,243
	SSP2-RCP6.0 (2.8 Degrees)	£41	£248	£693	£1,519
	SSP5-RCP8.5	£49	£267	£751	£1,489
Rising et al.	SSP1-RCP2.6	£644	£758	£1,760	£2,221
	SSP3-RCP7.0	£613	£722	£2,452	£3,094

The results show that without adaptation, the impact of climate change is a reduction in GVA by the tens to hundreds of millions in the 2020s. This rises to £1.1bn-£3bn/year by 2050. Note that the reduced impacts from the RCP8.5 scenario are not shown here since the reduced impacts do not start to be felt until the 2060s.

Impacts of flooding

The final task was to explore the potential costs of flooding to the region. This analysis was included because flooding is one of the largest impacts of climate change the current and near-term risk, as well as the cross-cutting impact across the City Region.

Flooding involves events of many different sizes and probabilities, and so damages are averaged and commonly expressed in the form of Average Annual Damage (AAD) or Expected Annual Damage (EAD).

To estimate the costs of flooding to Edinburgh and South East Scotland, two sources of evidence are explored. The first are the SEPA Plan District Flood Risk Management Plans and the second is the estimates of future flood damage from UKCCRA3 (Sayers et al, 2020)vi

National Flood Risk Management assessment and SEPA Local Plan District Flood Risk Management Plans

Detailed efforts to assess flood risk were conducted for the ESES area as part of the National Flood Risk Assessment in 2018. Detailed estimates of flood risk were provided by SEPA for this study and are shown below:

Table 4: Flood risk to homes and businesses in ESES area. Source: SEPA, based on NFRA, 2018.

Local Authority	Receptor	Return Period			
		10 year	200 year	1000 year	200 year w. climate change
Edinburgh	Homes	4,020	24,820	36,840	36,310
	Businesses	830	3,320	4,730	4,880
East Lothian	Homes	1,180	4,270	6,700	6,470
	Businesses	370	910	1,060	1,260
Fife	Homes	3,360	8,690	12,540	11,870
	Businesses	1,160	2,810	3,500	3,750
	Homes	550	1,660	2,230	2,270
Midlothian	Businesses	210	480	540	560
	Homes	2,910	6,750	8,310	8,520
Scottish Borders	Businesses	1,220	2,580	3,020	3,190
	Homes	1,210	4,520	5,680	5,800
West Lothian	Businesses	340	1,060	1,300	1,350
	Totals	17,360	61,870	86,450	86,230

Whilst helpful, SEPA were unable to provide detailed estimates of the expected annual damages for these risks. Instead, the study sought to use publicly available information from Flood Risk Management Plans. Efforts to assess and reduce the risk of river, coastal and surface water flooding across Edinburgh and South East Scotland is mostly undertaken across the broader geography of five Local Plan Districts (Forth Estuary, Solway, Tay, Tay Estuary and Montrose, and Tweed, SEPA, 2021)³.

The Flood Risk Management plans estimate that there are around 99,200 homes and businesses at risk from flooding. This may increase to 126,000 homes and businesses by the 2080s due to climate change (UKCP09, High Emissions). However, this is a partial estimate since, no climate change data was provided for the Tay Estuary plan.

To make these results specific to the CRSES geography alone it was necessary to determine how much of the damage takes place in the CRSES geography. This study calculated this value by using the number of homes and businesses which are at risk of flooding in each council area as a proxy for damage expected. Each of SEPA's 2021 Flood Risk Management Plans contains estimates for the number of homes and businesses which are at risk of flood damage for each of the Potentially Vulnerable Areas (PVAs) (SEPA, 2021).

³ A very small part of Fife also fall within the "Forth" and "Tay Estuary Local Plan districts. However none of the Potentially Vulnerable Areas in those districts are in Fife, so they were excluded from this analysis.

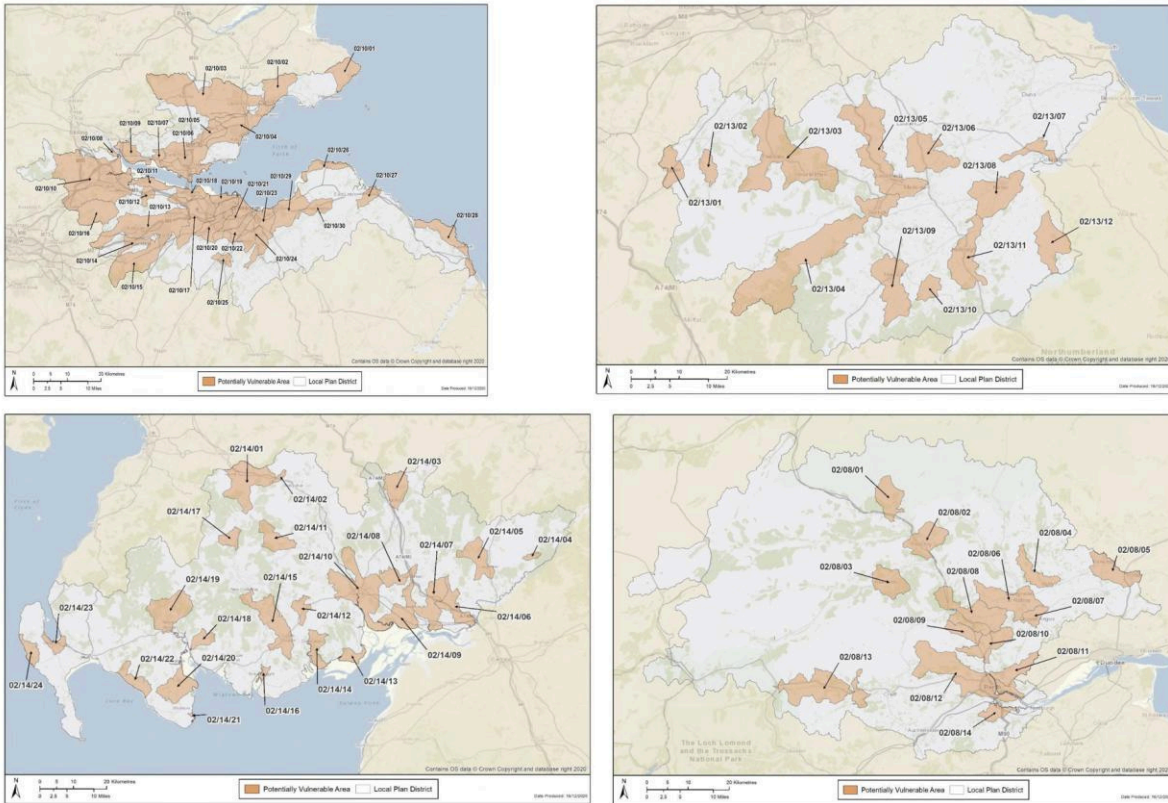


Figure 7: Illustrations of SEPA’s Potentially vulnerable areas in four of the five Local Plan Districts covered by CRSES. Forth Estuary (top left), Solway (bottom left), Tweed (top right), and Tay (bottom right). Source: SEPA, 2021. Note: Areas do not show flood extents or depths, merely areas designated for management plans based on their current or future risks from all sources of flooding.

By summing the number of homes and businesses at risk for the PVAs in each council area it was possible to determine that currently, 65% of the at-risk homes and businesses in the plan district are in the CRSES geography. This percentage also stays consistent in the 2080s.

The five plans state that the collective expected annual cost of flooding over a long period of time is around £98.4 million, though no information was provided on the assumptions behind this figure. Applying this ratio suggests that a similar cost of £64 million would be relevant to the ESES area.

UKCCRA3 – Sayers et al.

The second source of data is the evidence provided for UKCCRA3. The CCRA3 dataset provides the current residential and non-residential EAD from fluvial, coastal and surface water flooding as well as projections for how this value will change by the 2050s and the 2080s for the combined area covered by the four Local Plan Districts. The source provides 12 alternative outputs from the climate model which consider multiple possible combinations of climate scenarios (2oC / 4oC change by 2100), population growth scenarios (low growth / high growth), and level of adaptation (Current, RWS, EWS)⁴. More detail is shown in Box 2 below:

⁴ EWS - Enhanced whole system adaptation and RWS - Reduced whole system adaptation.

Box 2: Adaptation scenarios for future flood risk (summarised from Sayers et al) **No additional action: Leading to**

Reduced Whole System (RWS) adaptation. The baseline policy is one of ‘no additional action’. This assumes adaptation to flood risk continues but implementation is in-line with a lower level of ambition (for example existing defence standards are maintained). However, investment in conventional defences fails to keep pace with climate change; there is limited take up of innovative catchment-based or urban run-off measures; pressure for development and economic growth lead to continued new development on the floodplain; receptor (property) level flood resilience (PFR) continues to experience limited take-up amongst existing properties. This provides the baseline counterfactual for future risk to measure additional adaptation.

Current Levels of Adaptation (CLA). The ‘current objectives’ policy response assumes flood risk management policies continue to be implemented as in the recent past and take on board anticipated changes that are likely to result from recent changes in policy. For example, the influence of new and emerging policy frameworks such as the 25 Year Environment Plan and the National Planning Policy Framework (in England). They are also likely to encourage greater uptake of Natural Flood Management (NFM) and PFR measures than achieved in recent years. The influence of assessments such as the Long-Term Investment Scenarios (LTIS - Environment Agency, 2019) also encourage greater investment in flood risk management (FRM) (and in the short term are consistent with the announcement in the 2020 Budget for additional funding for flood risk management in response to the widespread flooding in winter 2019/20). The precise value of overall investment is difficult to determine, but Defra expect it to be at least £1bn per year for England (as recommended from LTIS).

Enhanced Whole System adaptation (EWS). This scenario goes beyond the current implementation of policy (and recently introduced policy) to represent an ‘Enhanced Whole System’ (EWS) approach to adaptation i.e. implementation is in-line with the higher level of ambition. For example, investment in flood defence increases (including in more socially disadvantaged neighbourhoods) and land use planning policy is more successful in restricting development in the floodplain than currently achieved or anticipated. Awareness raising and a strengthening of building regulations and planning controls encourage greater receptor level resilience. Forecasting and warning systems develop with increased levels of sophistication. Opportunities for more integrated planning and implementation are sought (e.g. as presented for England in the 25 Year Environment Plan and the National Planning Policy Framework, MHCLG, 2019), together with increasing momentum towards a ‘net zero’ emissions future, nature-based solutions are increasingly promoted and greater resilience delivered (e.g. as promoted within the National Infrastructure Assessment, 2018).

The study applied the percentage of homes and businesses at risk from the review of the SEPA Flood Risk Management Plans above to the Sayers estimates of total damage expected for the same five Local Plan Districts.

The data for the present day are shown below. The results show the direct costs from fluvial (river) surface water flooding and coastal flooding for residential and non-residential properties. The total costs also include indirect costs (e.g. costs to public infrastructure and wider economic disruption) and intangible damages (such as trauma, ill health (mental) and loss of possessions etc) though these are calculated using a mark-up on the direct values. These indicate average annual damage of £93m/year.

Table 5: Present Day Expected Annual Damage (EAD) (£/year) (CCRA3) for ESES. Source: Authors, based on Sayers et al. 2020, updated to 2023 prices.

Damage category	Total	Fluvial	Coastal	Surface Water
Residential (Direct)	£19,051,336	£12,688,318	£1,644,104	£4,718,914
Non-Residential (Direct)	£33,160,191	£25,209,578	£4,213,759	£3,736,854
Total (direct and indirect)	£92,569,861	£66,964,087	£10,287,187	£15,318,589

Looking forward, the risks and costs of flooding increase over time. The results below show costs for the no additional adaptation (RWS) scenario for the three time periods (2020s, 2050s and 2080s) for

two scenarios (2 degrees and 4 degrees) for the average of the low and high population growth. For the RWS scenario, the results indicate that flood damages increase to the 2050s, before increasing again in late century. With no further action, costs rise from £93m/year to between £128m/year and £166m/year by the 2080s. However, adaptation actions result in significant reductions in these costs.

Table 6: Future expected annual damages (EAD) (CCRA3) for ESES area. Average population growth. Source: Authors based on Sayers et al. 2020, updated to 2023 prices.

Scenarios		Time periods			
Climate	Adaptation	Present	2020s	2050s	2080s
2C	RWS	£92,569,861	£110,098,535	£113,013,116	£128,697,376
4C	RWS	£92,569,861	£115,008,211	£132,575,048	£166,651,664
2C	CLA	£92,569,861	£103,849,489	£105,191,623	
4C	CLA	£92,569,861	£105,798,923	£117,651,70,480	
2C	EWS	£92,569,861	£96,332,789	£102,229,665	
4C	EWS	£92,569,861	£100,736,564	£107,639,114	

An analysis of the breakdown of these costs by residential and non-residential damage, and by flood source (coastal, surface and river flooding) is shown below for the three time periods for the RWS scenario. This indicates that the rise in future costs is driven by increases across all three flooding types.

Table 7: Future expected annual damages (EAD) (CCRA3) for ESES area by flood source. Source: Authors based on Sayers et al. 2020, updated to 2023 prices.

	2C	Fluvial	Surface	Coastal	Total
	Residential (direct)	£15,234,768	£5,015,819	£1,794,445	£22,394,726
Non-Residential (direct)	£24,780,339	£3,774,560	£4,403,311	£33,094,819	
Total including direct and indirect	£71,072,636	£15,946,809	£10,895,075	£98,811,173	
4C	Fluvial	Surface	Coastal	Total	
Residential (direct)	£15,870,442	£6,012,933	£1,794,434	£23,677,809	
Non-Residential (direct)	£25,552,666	£4,251,406	£4,403,311	£34,207,384	
Total including direct and indirect	£68,885,281	£18,651,964	£10,157,634	£103,140,390	
2050	2C	Fluvial	Surface	Coastal	Total
Residential (direct)	£15,574,653	£7,350,454	£2,142,723	£25,067,831	
Non-Residential (direct)	£21,887,682	£4,657,086	£4,586,349	£31,131,117	
Total including direct and indirect	£66,800,900	£21,882,909	£11,867,968	£100,551,776	
4C	Fluvial	Surface	Coastal	Total	
Residential (direct)	£17,434,862	£8,378,812	£3,429,511	£29,243,185	
Non-Residential (direct)	£23,885,504	£5,552,063	£6,711,510	£36,149,077	
Total including direct and indirect	£73,731,596	£25,358,250	£17,925,637	£117,015,483	
2080	2C	Fluvial	Surface	Coastal	Total
Residential (direct)	£16,240,644	£9,269,863	£3,092,539	£28,603,046	
Non-Residential (direct)	£22,831,050	£5,609,400	£6,013,765	£34,454,215	
Total including direct and indirect	£69,670,009	£27,148,721	£16,099,223	£112,917,954	
4C	Fluvial	Surface	Coastal	Total	
Residential (direct)	£20,228,055	£11,341,235	£5,947,865	£37,517,155	
Non-Residential (direct)	£27,452,607	£6,578,759	£9,683,682	£43,715,048	
Total including direct and indirect	£85,102,736	£32,732,237	£27,763,202	£145,598,175	

Finally the CCRA3 forecast considers climate, population growth and adaptation scenarios but it does not account for economic growth which will also impact the value of flood damage in the future, reflecting the damage to a higher value at risk. To account for this, we have constructed a series of GVA per capita estimates using GVA forecasts in CCRA3 ([Cambridge Econometrics, 2019](#)). The growth rate in this series was then applied to the original EAD series provided by Sayers (2021) above to generate a series which accounts for economic growth. This leads to much higher damages with EAD for the 2050s rising to between £182m/year – £212m/year in the 2050s, and £375m/yr – £484m/yr by the 2080s.

Table 8: Future expected annual damages (EAD) (CCRA3) for ESES area by flood source. With Growth. Source: Authors based on Sayers et al. 2020, updated to 2023 prices.

	2C	Fluvial	Surface	Coastal	Total
	2020	Residential (direct)	£15,234,768	£5,015,819	£1,794,445
Non-Residential (direct)		£24,780,339	£3,774,560	£4,403,311	£33,094,819
Total including direct and indirect		£71,072,636	£15,946,809	£10,895,075	£98,811,173
4C		Fluvial	Surface	Coastal	Total
Residential (direct)		£15,870,442	£6,012,933	£1,794,434	£23,677,809
Non-Residential (direct)		£25,552,666	£4,251,406	£4,403,311	£34,207,384
Total including direct and indirect	£68,885,281	£18,651,964	£10,157,634	£103,140,390	
2050	2C RWS	Fluvial	Surface	Coastal	Total
	Residential (direct)	£28,277,838	£13,345,719	£3,890,397	£45,513,954
	Non-Residential (indirect)	£39,739,975	£8,455,554	£8,327,122	£56,522,650
	Total including direct and indirect	£121,285,849	£39,731,308	£21,547,861	£182,565,018
	4C	Fluvial	Surface	Coastal	Total
	Residential (direct)	£31,655,293	£15,212,839	£6,226,730	£53,094,862
Non-Residential (indirect)	£43,367,285	£10,080,503	£12,185,631	£65,633,419	
Total including direct and indirect	£133,869,442	£46,041,249	£32,546,360	£212,457,050	
2080	2C	Fluvial	Surface	Coastal	Total
	Residential (direct)	£54,011,354	£30,828,696	£10,284,826	£95,124,876
	Non-Residential (direct)	£75,929,004	£18,655,128	£19,999,920	£114,584,052
	Total including direct and indirect	£231,700,879	£90,288,240	£53,541,032	£375,530,151
	4C	Fluvial	Surface	Coastal	Total
	Residential (direct)	£67,272,247	£37,717,436	£19,780,756	£124,770,439
Non-Residential (direct)	£91,298,870	£21,878,915	£32,204,928	£145,382,713	
Total including direct and indirect	£283,025,351	#####	£92,331,814	£484,214,448	

Conclusion and Recommendations

Climate change will have a significant economic impact on the ESES economy and could lead to GVA being around 1.6% lower a year by the 2050s, around £1.5bn a year. An analysis of the potential uncertainty around these values also indicates there could be potentially higher risks (for higher warming scenarios or if more uncertain extremes are included).

Flooding also represents a significant cost, with annual damages potentially rising from £93m a year today to £182m-£212m a year by 2050s. However, it is likely that the flood costs are an underestimate, for two reasons. First, anecdotal discussions with Midlothian Council suggested that a number of the LA areas have housing growth rates that are 6 times the national average (Campbell, W, 2024), whilst the growth factors applied here are representative of the national average. Second, new modelling approaches are showing that climate change is having an impact on the spatial distribution of events. New modelling shows that for fluvial flooding, climate change is

changing the spatial and temporal distribution of flood events that mean future impacts may be significantly underestimated (Sayers et al., 2024).vii

The results reinforce the case for strong, ambitious mitigation and net zero targets in Scotland as part of global efforts to reduce emissions. Importantly, the study highlights that ESES will continue to experience annual costs of climate change, even after Scotland achieves its net zero targets in 2045. The historic emissions, lags of the climate system and current trajectory of global emissions reduction indicates that there will still be significant costs through to 2050 and these can only be reduced by adaptation. **Therefore, this analysis presents a strong economic case for the development of an adaptation strategy for the ESES region and associated investment in adaptation to reduce the costs of these damages.**

Finally, the study has a number of limitations. Each of the studies considered, as well as the underlying GVA growth projections has significant uncertainty. Each impact study also has considered limited impact channels, and makes a number of assumptions (explored further in the Appendix). For example, the COACCH study does not include non-market effects or tipping points, whilst the Rising et al. study makes use of multiple studies with differing underlying assumptions and includes an arbitrary uplift for 'missing' and 'catastrophic' risks. With this in mind, the results in this study should be considered indicative only, and further research is needed to better understand and quantify impacts in economic terms.

Appendix A: Method details

This appendix sets out more detailed information on the process used to generate the figures used in the report.

Step 1) Generating future estimates of regional GVA.

The study started by building a baseline illustration of future GVA for the South East Scotland Area. This was generated using the set of socioeconomic dimensions for the UK (Cambridge Econometrics, 2019)viii.

The data relied on the 'Central' GVA scenario, which is in turn built on central GDP and population scenarios. In the Central scenario all sectors experience a similar growth pattern based on the Central GDP growth rates, in line with the methodology developed Distribution, transport, accommodation & food and Public administration, education & health are the major contributors to growth.. The average annual GVA growth over the entire projected series is about 2.1%. This was felt appropriate given the UK government's stated commitment to a 2.5% annual growth rate by the end of this parliament. However, this could be perceived as over-optimistic, and therefore may overstate the final results.

The outputs were used as the basis to monetise the percentage reductions of the various studies on GDP reduction in the literature. A limitation of this approach is that because the future GVA data was based on historic performance, the economic impacts of COVID-19 and its impact on the economy were not represented in the data.

Step 2) Generating estimates of climate change impacts on GDP.

To estimate the aggregate impact of climate change on the region's economy, the study evaluated the impact on Gross Domestic Product (GDP) and Gross Value Added (GVA). To do this the study evaluated two different, complementary lines of evidence:

- The first was the outputs from the Horizon Europe project, COACCH (CoAssessment of Costs of Climate Change). The COACCH project uses sectoral climate impacts linked to a global macroeconomic model.

- The second was a recent paper from the London School of Economics (Rising et al., 2022). This study takes a different approach, estimating direct impacts as a proportion of GDP

Stage 2) Linking GDP estimates to GVA.

The aggregate percentage figures of GDP were linked to monetary GVA. The relationship between GDP and GVA is shown below:

$$GVA + Taxes - Subsidies = GDP$$

GDP is equivalent to GVA plus taxes (less subsidies) on products. In the national accounts, GDP can be measured using three different approaches: production, income and expenditure.

The COACCH model assesses effects on GDP using the production approach, for which the ONS assumes GVA to be a proxy (ONS, 2020)^{ix}, whilst the Rising study expresses damages as a proportion of GDP. Therefore, the percentage reductions from the COACCH model can be applied directly to UK estimates of regional GVA.

Finally, in parallel the study looked at the estimated costs of flooding. This involved reviewing existing estimates of current and future flood risk. This included those for current and future flood risk generated in the Forth Estuary. A Local Authority level review of the domestic damages for households were explored using the existing licence from Sayers and Partners that was agreed. This used the Reduced whole system scenario, with uplifts modelled to account for economic growth.

These three lines of evidence were used to form an expert view on the ongoing annual economic costs to South East Scotland.

[The scenario framework for climate research: RCPs and SSPs and the scenario matrix architecture.](#)

For the purposes of policy analysis and modelling, climate modellers in recent years has been have developed ‘common scenarios’ - shared scenarios amongst the research community analysing climate change impacts, adaptation and mitigation. Such common scenarios allow for integration across research disciplines, make it easier to assess literature within and across research communities as well as at difference scales and in different places, and support researchers that are unable or prefer not to develop their own scenarios (van Vuuren et al , 2013)^x.

These common scenarios are supported by a common modelling framework, comprising two major building blocks These are:

- **Representative Concentration Pathways (RCPs).** The RCPs were developed to explore the magnitude and extent of climate change under different levels of radiative forcing of the climate system. These are divided into models based on their differing levels of global average radiative forcing in 2100, measured in W/m² – 2.6, 4.5, 6.0 and 8.5.
- **Shared Socio-economic Pathways (SSPs)** – a set of five alternative plausible trajectories of future global development, They include sets of assumptions for economic growth, population change and urbanisation, including projections of population, education, urbanisation, GDP and Gini coefficients, underpinned by a coherent narrative. As such SSPs are “reference” pathways of development that would occur in a hypothetical case without new climate policy interventions (mitigation and adaptation) and without being influenced by future climate change.

The SSPs are based on five narratives describing alternative socio-economic developments, including sustainable development, regional rivalry, inequality, fossil-fuelled development, and middle-of-the-road development. SSP1 describes a future where the challenges to adaptation and mitigation are both low, while SSP3 challenges to adaptation and mitigation are both ‘high’. In addition, the SSPs include two “asymmetric cases”, one where high challenges to mitigation are combined with low challenges to adaptation (SSP5), and one where the opposite is true (low mitigation challenges, high adaptation challenges (SSP4). Finally a central case (SSP2) describes a world with intermediate challenges for both adaptation and mitigation (SSP2). (Riahi et al, 2017)xi

The SSP scenarios are particularly relevant for subsequent impact studies, since it facilitates the superposition of physical climate changes on top of the SSP scenarios to derive consistent estimates of impacts (or adaptation). Whilst the SSPs did not include dimensions of adaptation, they present very different sets of challenges to adaptation (e.g. adaptive capacity) as well as the effectiveness of adaptation policies (O’Neill et al., 2014). More detail on SSPs and SPAs can be found in Riahi et al., (2017).

The socio-economic information, the SSPs, the RCPs and the associated climate change projections were integrated to develop scenarios for use by the climate change research community. In each scenario , a level of anthropogenic forcing intersects with one set of socioeconomic assumption, representing possible scenarios that combine elements of mitigation and adaptation policy. The framework for this integration is referred to as the Scenario Matrix Architecture. The matrix of this relationship is shown below:

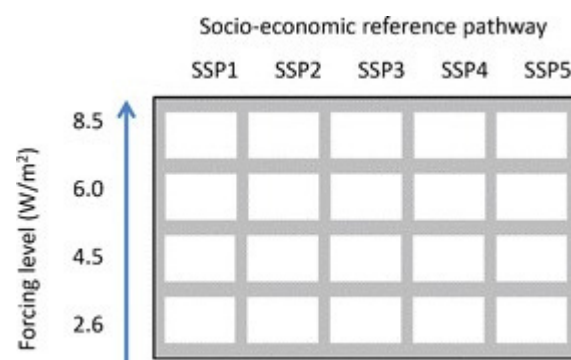


Figure 8: The scenario matrix architecture. The architecture combines different socio-economic reference assumptions as described by SSPs with different future levels of climate forcing. The SSP numbers correspond to five different storylines as further discussed. Source van Vuuren et al., (2013).

The matrix is used to guide scenario development at different scales, ensuring that each scenario represents the range of climate and modelling uncertainty inherent in the approach.

The framework can be used to explore the impact of different socio-economic development on forcing levels, how different impacts of similar forcing levels manifest themselves across the SSPs, or the costs and benefits of mitigation and adaptation policies.

These scenarios are important since, The mitigation effort required to achieve a specific climate forcing target, as well as the adaptation effort required to achieve a certain level of climate resilience depends greatly on the SSP baseline scenario.

To achieve certain targets of warming and climate resilience, the scenarios also rely on mitigation and adaptation policy. These policies are termed Shared Policy Assumptions and are often included as a third axis on the chart:

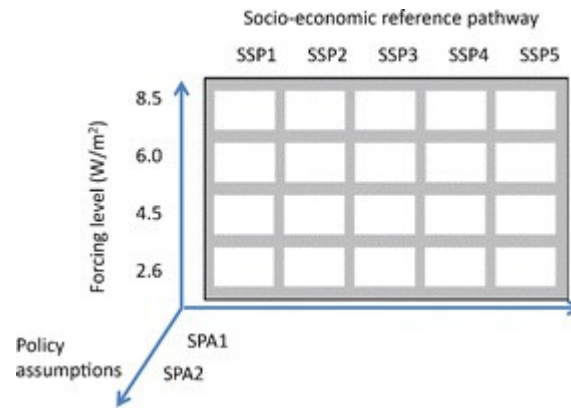
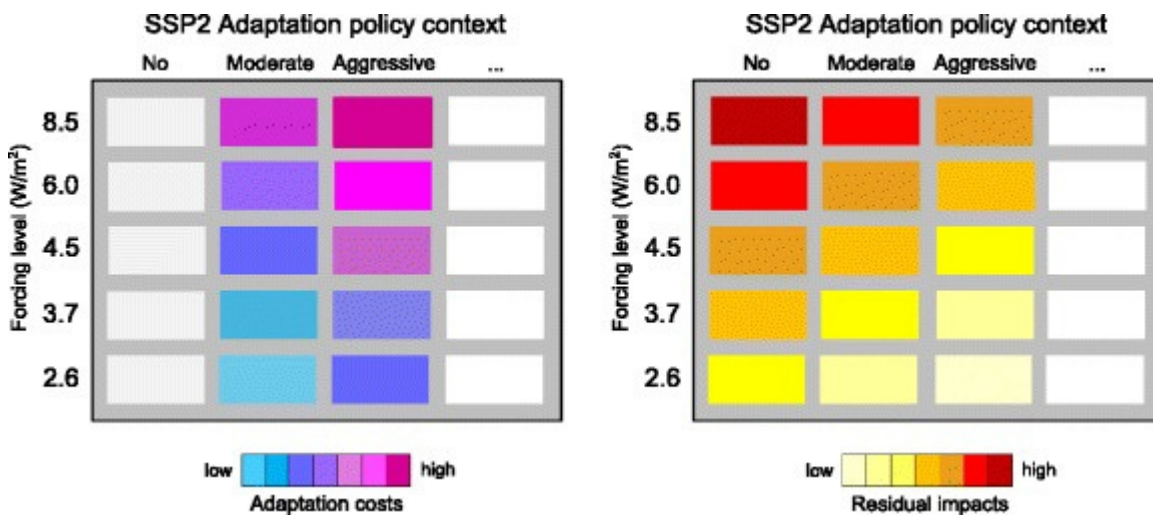


Figure 9: Shared policy reference assumptions (SPAs) within the Scenario Matrix architecture. Source: van Vuuren et al., 2014.

For mitigation SPAs, these generically describe the most important characteristics of future mitigation at a high level. Issues include the extent and timing of international cooperation as well as the stringency of mitigation over time. But they can also be used as the basis for adaptation policy (Kriegler et al., 2014)xii.



Macroeconomic modelling approaches for this study

This study makes use of the scenario-matrix architecture to explore the macroeconomic costs of climate change for Edinburgh and South East Scotland. Further information on the two modelling approaches explored in this study are set out below.

COACCH

COACCH was a major European research project into the macroeconomic impact of climate change.

The project provided outputs of aggregate economic impact for nine of the 20 possible SSP-RCP scenario combinations. The selected scenarios are shown below:

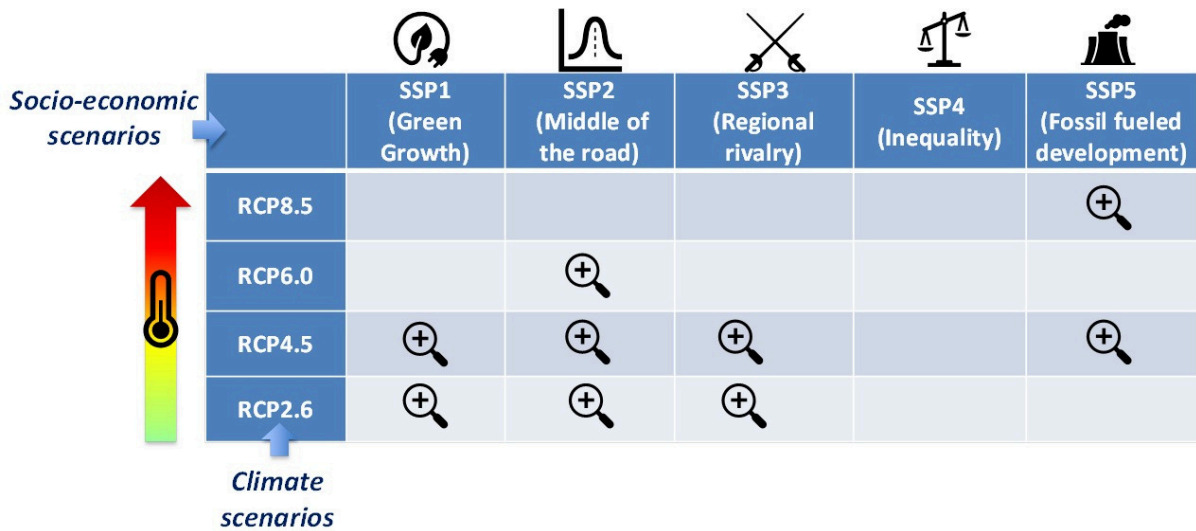


Figure 10: COACCH core set of scenarios. Source: COACCH, 2021

The project quantified 9 sets of impacts across each of these scenarios. Each impact was first quantified in physical terms or direct economic losses by specific process based or econometric models. Then physical impacts and direct losses were then translated into macro economic costs, i.e. impacts on economic performance by a regionalized computable general equilibrium model (Bosello et al., 2020)⁵, with the aim of providing a common economic metric (GDP) of the impacts of climate change at the NUTS2 level across European Regions and the UK.

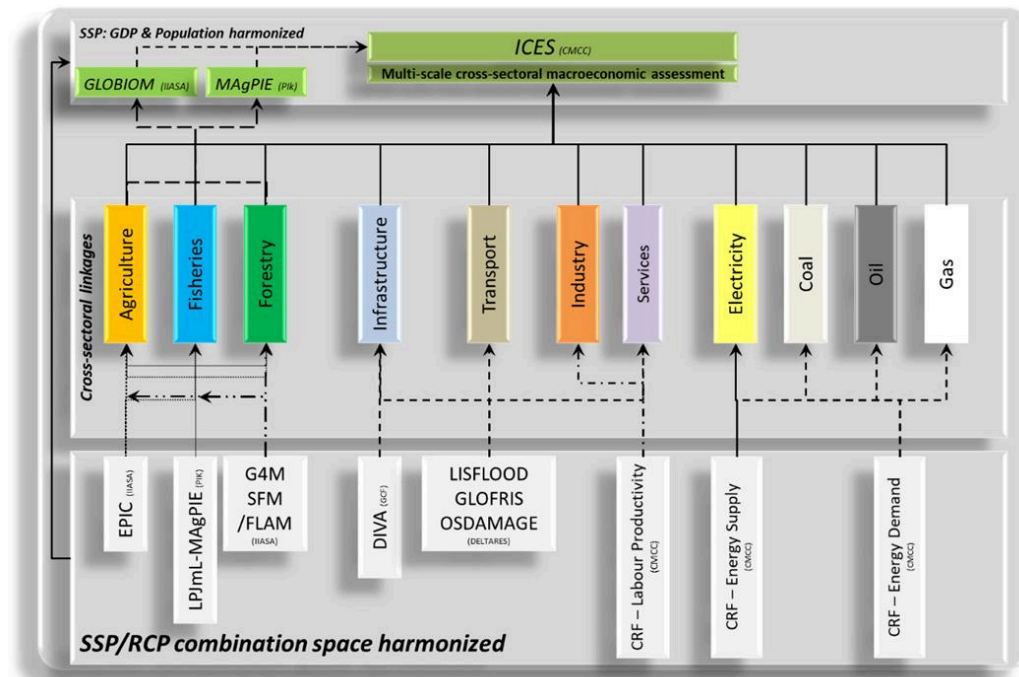


Figure 11: Representation of the vertical and horizontal integrated information exchange flows within the COACCH project. Source: Bosello and Parrado (2018).

It is important to stress that the analysis does not consider important non-market impacts including on health and on biodiversity and ecosystem services. It also does not include the potential impacts

⁵Bosello F., Standardi G., Parrado R., Dasgupta S., Guastella G., Rizzati M., Pareglio S., Schleyppen J., Boere E., Batka M., Valin H., Bodirsky B., Lincke D., Tiggeloven T., van Ginkel K. (2020). [D2.7. Macroeconomic, spatially-resolved impact assessment](#). Deliverable of the H2020 COACCH project.

of climate or socio-economic tipping points. These would all be expected to increase GDP losses, and introduce much stronger impacts for high-warming scenarios.

The economic components are provided by the Intertemporal Computable Equilibrium System (ICES) model. The model's general equilibrium structure allows for the analysis of market flows within a single economy and international flows with the rest of the world. This implies going beyond the "simple" quantification of direct costs, to offer an economic evaluation of second and higher-order effects within specific scenarios either of climate change, climate policies or different trade and public-policy reforms in the vein of conventional CGE theory. The model structure is shown below:

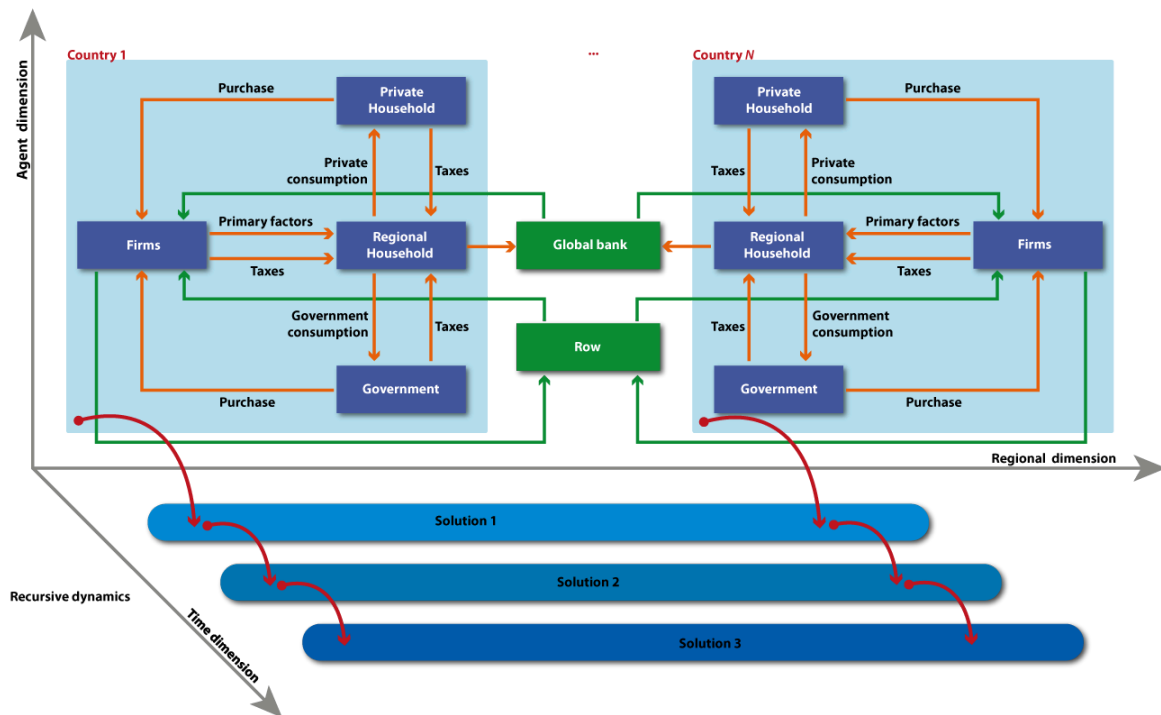


Figure 12: A snapshot of the main ICES elements. Source: ICES

The subnational analysis relies on a regionalized version of the ICES model. This model considers 125 sub-national regions in the European Union plus the 12 NUTS-1 regions in UK. The figure below summarises the interlinked structure of the regionalised ICES. The trade structure involves trade flows to other regions inside the country, to regions outside the country and to other countries.

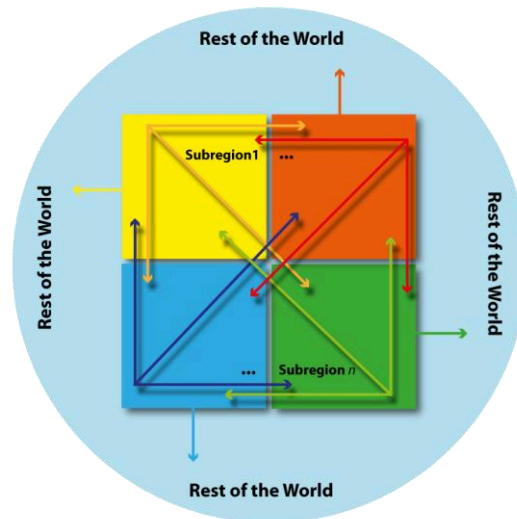


Figure 13: Trade flows in the regionalized model. Source: ICES

To fully characterize uncertainty, impacts are specified for a worst, a medium and a best impact case. The range is obtained using the highest and the lowest value produced by the sectoral impact assessment exercises as an input to the macroeconomic model, for each impact, in each year, in each region. These, on their turn, depend mostly upon the different climate model used to perturb the sectoral impact model.

Rising et al.

The work by Rising et al explored two future scenarios (SSP3-RCP7.0, and SSP1-2.6). It uses bottom-up projected model data and top-down warming projections to produce gridded exposure-based disaggregation and estimates of trade effects. The study works by taking reported values at lowest level geographies from the underlying studies and linking them to temperature changes to generate damage functions. It then applies these to the downscaled temperature effects. The grid cell level impacts and damage functions are then aggregated to the region and administrative levels.

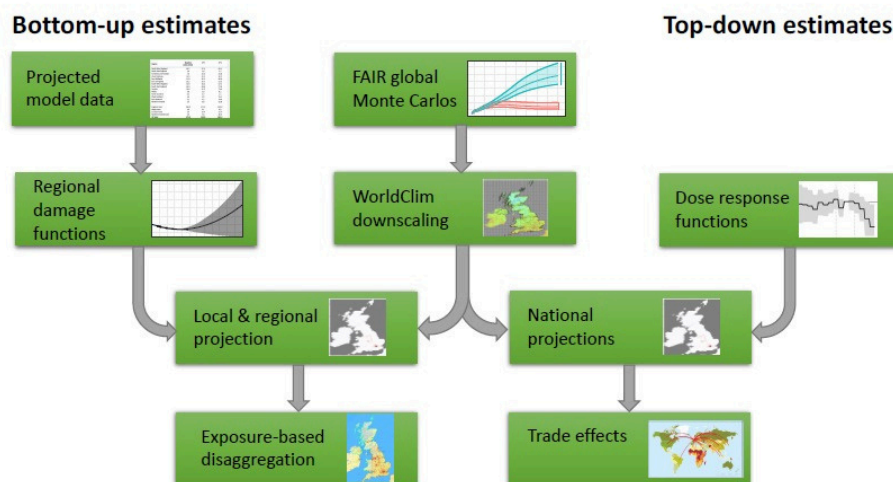


Figure 14: Steps to estimate consistent damage results. Source: Rising et al. (2022)

The sectors in the study were drought and flooding, agriculture, livestock and fisheries, ecosystems, energy supply and demand, labour productivity, health and coastal impacts. The work also includes non-catastrophic 'missing' risks (equal to 25% of the known channels), as well as an estimate of the incremental damage effects of catastrophic events (defined as 25% or more of global GDP lost).

The study uses the socio-economic assumptions (such as population growth or future economic performance) underlying each model, rather than providing a coherent representation of future effects. Where multiple studies are available, or there are multiple baselines available statistical analysis (a hierarchical Bayesian model) is used to combine the results and provide a common baseline compared to the year 2000.

Appendix B: Local Authority Tables

This appendix includes a subset of Local Authority level breakdowns of figures from the overall analysis conducted from the City Region.

Table 9: Local Authority breakdowns of percentage impacts of climate change on GDP from Rising et al., 2022.

Local Authorities	Percentage reductions					
	Current Policies (SSP3-RCP7.0)			High Mitigation (SSP1-RCP2.6)		
	2011-2030	2041-2060	2081-2100	2011-2030	2041-2060	2081-2100
East Lothian	-2.087%	-4.110%	-8.733%	-2.053%	-3.110%	-2.946%
Edinburgh	-0.915%	-2.814%	-6.769%	-1.022%	-2.029%	-2.227%
Fife	-0.768%	-2.901%	-7.243%	-0.973%	-2.021%	-2.229%
Midlothian	-0.720%	-2.603%	-6.376%	-0.784%	-1.804%	-1.961%
Scottish Borders	-0.947%	-3.790%	-9.136%	-0.987%	-2.458%	-2.653%
West Lothian	-1.959%	-3.935%	-9.472%	-1.948%	-3.047%	-3.298%
CRSES average	-1.233%	-3.359%	-7.955%	-1.295%	-2.411%	-2.552%

Table 10: Projected annual reductions in GVA from baseline, 2023 prices (£m). SSP2-RCP4.5. Source: COACCH

Local Authority	2020	2025	2030	2035	2040	2045	2050
City of Edinburgh	£24	£66	£129	£222	£347	£507	£701
East Lothian	£2	£6	£11	£19	£30	£44	£60
Fife	£9	£23	£44	£72	£111	£157	£211
Midlothian	£2	£5	£10	£18	£29	£44	£62
Scottish Borders	£2	£6	£12	£19	£30	£42	£55
West Lothian	£5	£12	£24	£40	£62	£90	£122
CRSES Total	£44	£119	£230	£391	£608	£883	£1,212

Appendix C: Glossary

Term	Definition
Adaptation deficit	The current level of losses resulting from society's deficit of adaptation to current weather and climate.
Average Annual Damage (AAD)	Annual Average Damages are the theoretical average economic damages caused by flooding when considered over a very long period of time . It does not mean that damage will occur every year: in many years there will be no damages, in some years minor damages and in a few years major damages may occur

Term	Definition
Economy	The production distribution, trade and consumption of goods and services and supply of money within the Edinburgh and South East Scotland area.
Expected Annual Damage (EAD)	The annual probability of a property (residential and non-residential) being flooded and the associated direct and indirect economic damages.
Flooding	Flooding can be caused by a large amount of rain in a short period, exceptionally long periods of rainfall, rapidly melting snow, high river levels caused by heavy rain/snow in other areas, or a combination. Flash flooding is when areas flood very quickly, normally due to heavy rain, and because of this it can happen in areas where there are no water sources, such as rivers. As the Met Office describes, “heavy rain only usually causes flash flooding when there are other factors, for example, when drains in the road are blocked so that the water cannot drain away, or at the bottom of steep hills as there is nothing to catch the water as it runs down the hill”.
Gross Domestic Product	GDP measures the monetary value of final goods and services -that is, those that are bought by the final user - produced in a country in a given period of time.
Gross Value Added	GVA is the value generated by any company, economic sector or place engaged in the production of goods and services in a given period of time.
Macroeconomic model	A macroeconomic model is an analytical tool designed <i>to describe the operation of the problems of economy of a country or a region.</i>
UKCCRA3	Third UK Climate Change Risk Assessment

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