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Policy Brief on Economic Costs of Climate Change Impacts and Adaptation in Ireland: A Sectoral Analysis on Five Climate Change Impacts

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POLICY BRIEF ON ECONOMIC COSTS OF CLIMATE CHANGE IMPACTS AND ADAPTATION IN IRELAND: A SECTORAL ANALYSIS ON FIVE CLIMATE CHANGE IMPACTS

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SUMMARY

Understanding the impacts climate change will have on Ireland is of paramount importance to prepare our economy and society to implement the appropriate adaptation strategies. The consequences of climate change, including rising sea levels, crop failures, and extreme weather events such as heatwaves, floods, and wildfires, are causing significant impacts on our economic, social, and ecological systems. The Environmental Protection Agency (EPA) and Climate Change Advisory Council (CCAC) adaptation fellowship project has focused on creating a better understanding of climate change impacts for Ireland from an economic perspective as well as its adaptation policy landscape. It is important to note that the scope of the study and availability of data has resulted in some important caveats on the findings that are detailed in this summary.

This project has focused on five climate change impacts: coastal flooding, heat effects on labour productivity, human health, agricultural productivity and river flooding. In terms of initial impacts, the cost of the coastal impact[1] without adaptation could have an annual cost of approximately €2 billion for the year 2050 under the RCP4.5 climate scenario[2], which is considered the most likely future climate scenario given current policies (de Bruin et al., 2024a). Under the same climate and no-adaptation scenario the damage from river flooding is estimated to be a total annual cost of €60 million for the year 2050. Additionally, a 1°C increase in the outdoor Wet Bulb Globe Temperature will result in a 1.6% reduction in labour productivity and an increase in hospital emergency admissions of approximately 12% (de Bruin et al., 2024a).

Barley, potato and wheat crops are projected to increase in yield under the RCP2.6, RCP4.5 and RCP8.5 scenarios when the CO_2 fertilisation effect is considered (de Bruin et al., 2024a). The agricultural analysis is based on crop model results, where the crops considered make up less than 5% of agricultural gross value added in Ireland, i.e. impacts of the production of fruit and vegetables (FAO, 2024). Livestock analysis is not included as currently the models have not been developed (Hristov et al., 2020). Furthermore, the impacts of extreme weather events, flooding, storms and pests are not considered. If these elements were included, negative impacts for agriculture are likely to be significantly greater.

Primary impacts without adaptation under the RCP4.5 scenario indicate that there is a contraction of Ireland's GDP by over 2.5% in 2030, 2040, 2050 relative to the scenario without climate change. With no additional planned adaptation measures in place, coastal flooding has the largest negative impact on GDP in 2030, 2040 and 2050 (de Bruin et al., 2024b). This is a reduction of around 2% of Ireland's GDP in 2030, 2040, and 2050 compared to the Business as Usual (BaU) Scenario. The decrease in labour productivity due to temperature increases, results in a reduction of over 0.5% of GDP with respect to the BaU. River flooding and health impacts also reduce GDP but by a smaller amount. The primary agricultural impact without adaptation increases GDP, however this should be viewed with the abovementioned limitations in mind.

Agricultural, health, labour productivity, coastal flooding and riverine flooding impacts are progressive (de Bruin et al., 2024b). Impacts across households are found to effect wealthier households

[1] The Coastal modelling accounts for sea level rise as well as coastal erosion impacts.

[2] There are four main scenarios for different future climates based on different concentrations of Greenhouse Gas (GHG) emissions (IPCC, 2014). These scenarios are known as the Representative Concentration Pathways (RCPs) and they include RCP2.6, RCP4.5, RCP6 and RCP8.5. The RCP4.5 scenario has a medium level of GHG emissions. The two extreme scenarios are RCP2.6 where GHG emissions are significantly and RCP8.5 when GHG emissions are not mitigated. The global average temperature by 2100 is projected to be increased by 1.6°C in RCP2.6 and 4.3 in RCP8.5.

relatively more than lower socioeconomic cohorts. This is due to the larger share of capital income for richer households. Moreover, the government's welfare system increases benefits to poorer households in line with increased prices due to climate change impacts (de Bruin et al., 2024b).

Secondary impacts [3] without adaptation are larger than the initial impacts. Secondary impacts are important because markets adjust as a form of autonomous adaptation. Initial impacts in one sector or on one production factor (labour, capital) will also spill over to the rest of the economy. In comparison with the initial impacts, and without considering planned adaptation, coastal and riverine flooding have far larger secondary impacts (de Bruin et al., 2024b). Over 80% and over 95% of the total negative impacts for riverine and coastal flooding are secondary impacts whilst the remainder are primary impacts in 2030. This means that secondary impacts exacerbate the negative initial impacts. The agricultural secondary impacts are negative but are only 20% of total agricultural impacts, whilst the health secondary impacts are positive but are only 40% of total health impacts in 2030. The latter is likely because improving health expenditure benefits other people.

Adaptation can significantly reduce the real GDP losses associated with a given level of climate change. In 2040, for example, gross damages of over 2.7% of GDP can be reduced to residual damages of less than 1% at protection costs of 0.25% by applying adaptation policies (de Bruin et al., 2024c). Adaptation is able to significantly reduce the negative effect of climate change impacts on real GDP.

Mitigation costs outweigh climate change impacts costs when adaptation is applied. Resulting real GDP and sectoral value-added losses are highest for climate change impacts without planned adaptation with a loss of 2.6% of real GDP in 2030 (de Bruin et al., 2024c). Second highest are the impacts of mitigation policies (increased carbon tax and EU ETS price) with a loss of 1.3% in the same year. Climate change impacts with optimal adaptation result in the lowest losses of 0.6% of real GDP in 2030.

Results confirm the importance of Ireland's continued commitment to emission reduction helping to ensure a global effort to reduce emissions and hence climate change impacts. From a global perspective, international efforts to reduce emissions through the Paris Agreement will significantly decrease net climate change impacts for Ireland, where net impacts in 2040 under the Paris Agreement (RCP 2.6) are almost three times lower than in a no mitigation scenario (RCP 8.5), i.e. 0.56% decrease in real GDP as opposed to a 1.38% decrease in real GDP (de Bruin et al., 2024c). This highlights the importance of international cooperation on climate change mitigation.

Stakeholders identified education and planning as barriers preventing industries from responding to climate change impacts. More support is needed to help industries as they adapt to climate change. Information and clarity concerning impacts and policies is vital. Furthermore, responsiveness of the planning system is essential to allow stakeholders to adjust to both climate impacts and mitigation policies.

Policymakers must consider the secondary impacts when designing and implementing climate change policies. Further research is needed to understand the full range of climate change impacts Ireland is

[3] The research considers both initial and secondary impacts. Initial impacts occur as a direct result of a shock, for example, an increase in temperature might lead to an increase in yield of certain crops which, in turn, lower the prices of these crops. A secondary impact emerges when the change in the prices of crops leads to changes in the consumption decision of households and the levels of production in certain sectors, e.g., food sector, that use these crops as inputs. The secondary impacts can be treated as the impacts of a policy change on the resource allocation in the economy.

facing and the adaptation strategies that can be applied to reduce these impacts. Our results show that secondary impacts will play a pivotal role in both climate change impacts and adaptation. Policy assessments need to include secondary impacts to ensure adaptation policies are evaluated at their true economy wide costs.

Climate Change Initial Impacts

Various models have been used to analyse the impacts of climate change on our five impact categories. The results differ depending on the climate change scenario, the year and the impact. Key findings are summarized in Table 1 below.

Table 1: Summary of Climate Change Initial Impacts without Adaptation

Climate Change Impact Category	Model used	Findings		
		Climate Scenario	Year	Cost
Coastal Flooding	Coastal Climate Impact and Adaptation Model (CIAM) (Diaz, 2016)	SSP2-RCP4.5 Global sea level rise: 0.56m	2050	Projected annual cost for the year 2050 is approximately €2 billion.
			2100	Projected annual cost for the year 2100 is approximately €7 billion.
Labour productivity	Econometric analysis using Wet Bulb Globe Temperature (WBGT)	1°C increase in outdoor WBGT		1.6% decline in labour productivity. Average annual loss that ranges from €700 and €3,100 per worker per season.
Agriculture	Environmental Policy Integrated Climate (EPIC) and Geographic Information System (GIS)-based EPIC (Folberth et al., 2012; Izaurralde et al., 2006; Liu et al., 2007; Williams, 1995)	Most		Major Irish crops such as barley, wheat, and potato will experience an increase in yields in the future. The expected increase in yields ranges between 15% to 20%, depending on the specific crop and scenario considered.
Riverine flooding	GLObal Flood Risks with IMAGE Scenarios (GLOFRIS) (Winsemius et al., 2016).	SSP2-RCP4.5	2070	Projected annual cost for the year 2070 is €95 million.
Health	Panel fixed effects	NA	NA	Higher temperatures above the reference scenario of [10°C, 13°C) contribute to an increase in emergency hospital admissions.

Source: Based on results in de Bruin et al. (2024a).

The potential losses resulting from sea level rise under various climate change scenarios in Ireland were estimated using the state-of-the-art coastal assessment model, known as the Coastal Climate Impact and Adaptation Model (CIAM) (Diaz, 2016). These costs include property damages (capital losses due to storm surges and inundation), economic disruption (relocation costs of mobile capital) and wetland losses[4]. Estimations indicate that, under a moderate warming scenario of SSP2-RCP4.5, with a global mean sea level rise of 0.56 meters, the projected annual cost for the year 2050 would be

[4] Note that the CIAM model also projects deaths related to sea level rise, which we do not include in this analysis.

approximately €2 billion (de Bruin et al., 2024a). By the end of this century, these estimates increase to €7 billion in the absence of adaptation policies.

The impact of heat stress induced by climate change on the labour force will increase significantly as global temperatures continue to rise. Econometric estimates calculate how increasing levels of occupational heat stress, as indicated by the Wet Bulb Globe Temperature (WBGT), impact workers' productivity while accounting for seasonal and interaction effects (Dunne et al., 2013; Lemke & Kjellstrom, 2012). Findings indicate rising temperatures and humidity within workplaces in Ireland will result in decreased productivity, where a 1°C increase in outdoor WBGT results in a 1.6% decline in labour productivity. In economic terms, our estimated effect size indicates an average annual loss that ranges from €700 and €3,100 euros per worker, depending on the season (de Bruin et al., 2024a).

To assess the impacts of climate change on the agricultural sector, a crop simulation models (Environmental Policy Integrated Climate (EPIC) and Geographic Information System (GIS)-based EPIC) were applied (Folberth et al., 2012; Izaurralde et al., 2006; Liu et al., 2007; Williams, 1995). In addition to simulating plant growth under changing climatic conditions at a global scale including Ireland, these models also incorporate carbon and water cycles. They account for the positive impact of elevated CO_2 levels on crops' productivity thus mitigating some yield losses caused by climate change stressors. Furthermore, alterations in land allocation for different crops, adjustments in inputs used, as well as changes in overall areas dedicated to agriculture versus those dedicated to forestry and natural land are implemented. Based on the crop simulation models, it is projected that under most RCPs, major Irish crops such as barley, wheat, and potato will experience an increase in yields in the future. The expected increase in yields ranges between 15% to 20%, depending on the specific crop and scenario considered (de Bruin et al., 2024a).

It should be noted that these crop models, like others, have some important limitations. Firstly, they examine the impacts on crop yield of changes in climate but do not include the impacts of extreme weather and weather variability (Wang et al., 2022). Extreme hot days, extreme cold days, extreme winds and storms are expected to increase as global temperatures increase. These models focus on average changes in climate stimuli, which would underestimate the actual impacts of climate change. Secondly, these models focus on specific "subsistence" crops, not considering other agricultural such as fruit and vegetable tillage. These subsistence crops represent only approximately 57% of Irish Crop Gross Value Added (GVA) and only 5% of total agricultural GVA (FAO, 2024). Total climate impacts on agriculture are likely to be higher, however their magnitude has not been estimated (Flood, 2013).

The GLOFRIS model was used to examine the potential damages of climate-induced flood events in Ireland (Winsemius et al., 2016). This global framework covers major river basins and was applied to analyse various scenarios related to climate change, socioeconomic factors, and adaptation strategies. The findings reveal that without implementing additional adaptation measures, projected annual economic damage resulting from river flooding is expected to increase in the future. For instance, in the absence of additional adaptation measures, the projected annual cost for the year 2070 under a moderate warming scenario of SSP2-RCP4.5 is about €95 million (de Bruin et al., 2024a).

The impacts of climate change on human health are expected to be significant, including increased risks from extreme weather events and heat stress, as well as the spread of vector-borne diseases (Watkiss & Ebi, 2022; Woodland et al., 2023). These impacts can also have significant economic implications. The relationship between temperature and morbidity was investigated by analysing data on emergency hospital admissions between 2015 and 2019 using panel fixed-effects methods (de Bruin et al., 2024a). Even in a country with moderate climate conditions, it was observed that higher temperatures contribute to an increase in emergency hospital admissions. For example, in a week where the maximum temperature either reached or exceeded 22°C, but remained below 25°C, there were an additional 4.7 cases of emergency hospital admissions for every 100,000-population compared to a week with a maximum temperature falling within the reference range of [10°C,13°C) (de Bruin et al., 2024a). In terms of providing hospital services, the annual economic burden associated with this temperature-related morbidity varies from €156,000 to €364,000 for every 100,000 population, contingent on the disease category.

Methods

This work implements initial climate change impacts in a Computable General Equilibrium (CGE) model for Ireland, namely the Ireland Environment, Energy and Economy (I3E) model. Investigating impacts and adaptation in this framework will allow us to understand the economy wide impacts of such initial impacts. This is due to the model including interconnections between production sectors, households and the government as well as behavioural responses to shocks through price changes.

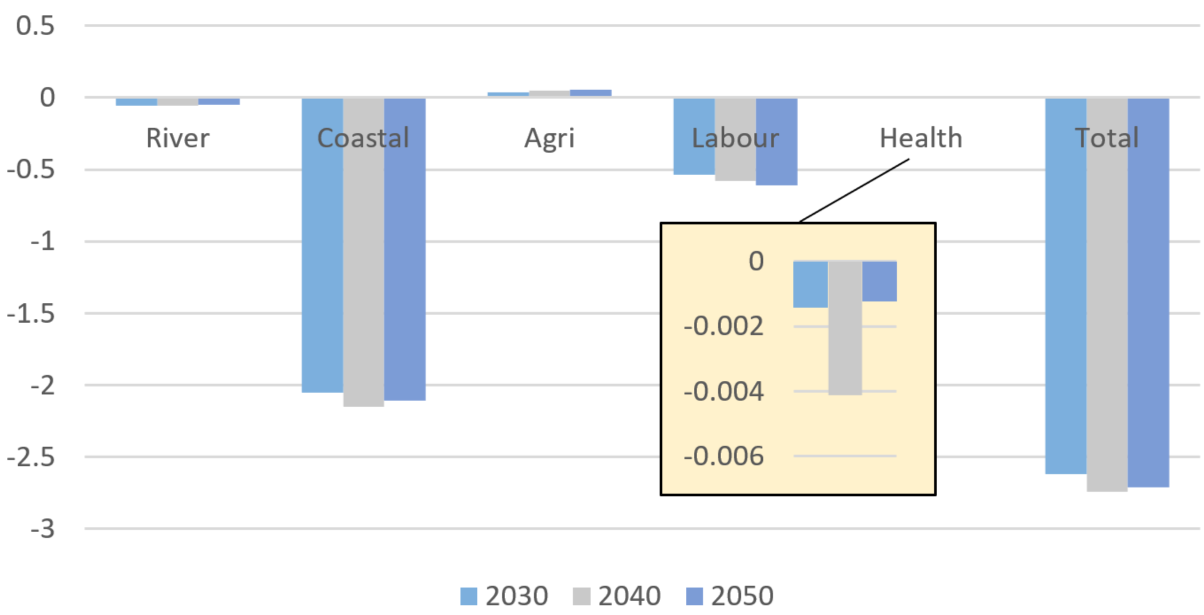
The I3E model is a multi-sectoral, multi-household, single-country small open-economy intertemporal CGE model. The following subsections explain the characteristics of each agent in a non-technical manner. Its technical description and the details of the Irish Energy Social Accounting Matrix (ESAM) used to calibrate the model are available in de Bruin & Yakut (2021a) and de Bruin & Yakut (2021b) respectively.

Based on a production function approach, riverine and coastal impacts are introduced as capital losses through an increased capital depreciation rate for production sectors. Labour productivity impacts are implemented by a reduction in overall labour productivity across skill types. Human health impact are introduced based on estimates of increase emergency hospitalisations, whose costs are borne by households and the government. Agricultural impacts on a subset of crops is introduced through a Total Factor Productivity shock on the agricultural production sector. Adaptation in the form of the building of coastal protection infrastructure is modelled as increased spending on construction by production sectors.

Including Climate Change Impacts in the Economic Model Without Adaptation

When the climate change impacts are included in the CGE model, their impact on GDP and employment can be calculated. From the initial impacts, it can be seen in Figure 1 that riverine flooding, coastal flooding and labour productivity impacts reduce real GDP relative to the Business as Usual (BaU) scenario without impacts (de Bruin et al., 2024b). Coastal flooding causes the largest reduction in GDP likely because of damage to capital, where new capital installation will require time and induce installation costs.

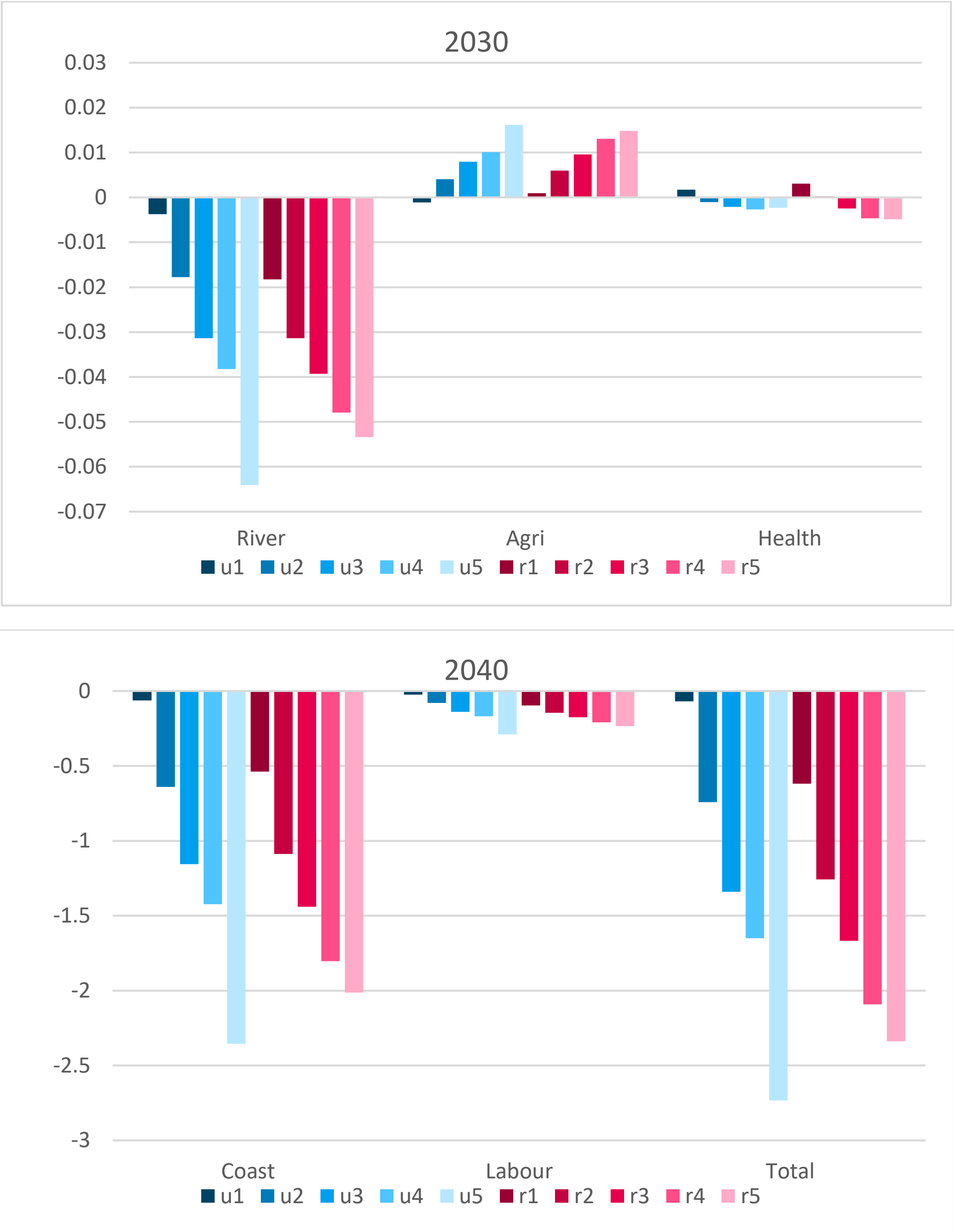
Figure 2: Real GDP by impact scenario, % change w.r.t. BaU by year for RCP4.5



Source: de Bruin et al. (2024b)

Although the climate change impacts, differ in whether they have a positive or negative effect on household income they are all progressive in that they effect richer households more than poorer households as shown in figure 2 (de Bruin et al., 2024b).

Figure 2: Real disposable income, % change w.r.t. BaU by year and household type for RCP4.5

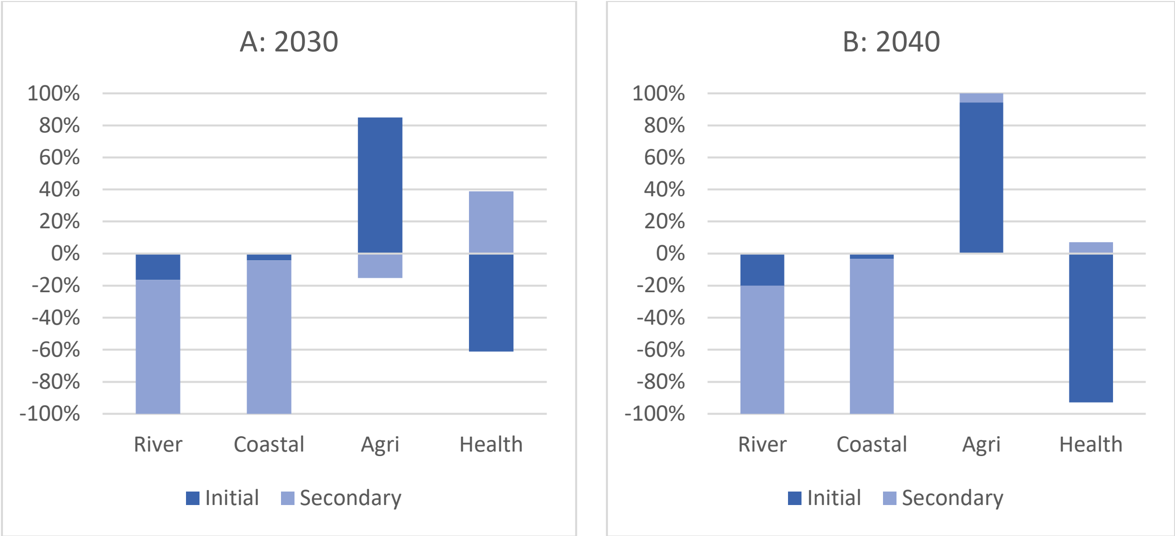


Source: de Bruin et al. (2024b)

Notes: u refers to urban households, r refers to rural households. 1 refers to the poorest quintile, 5 refers to the richest quintile.

Secondary impacts are larger than initial impacts for river and coastal flooding in both 2030 and 2040. The direction of initial and secondary impacts of a shock to the healthcare system stays the same (negative and positive, respectively); however, the secondary impacts are lesser. As climate change induced additional healthcare expenditures increase over time, this increases the negative impacts of crowding out of demand of other goods decreasing the initial secondary benefits of increased healthcare production (de Bruin et al., 2024b).

Figure 3: Initial versus secondary impacts by year for RCP4.5

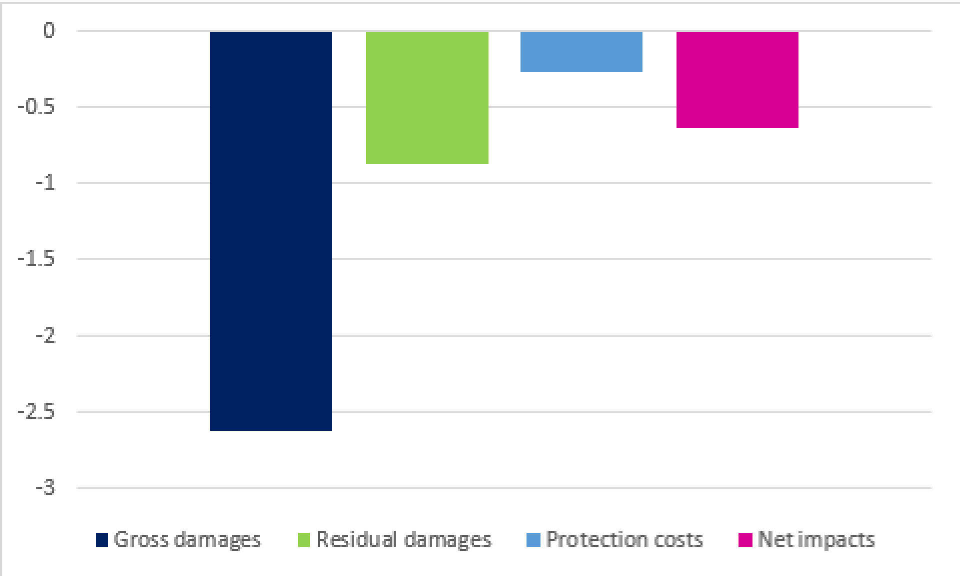


Source: de Bruin et al. (2024b)

INCLUDING ADAPTATION WITH CLIMATE IMPACTS

Overall, findings suggest that the resulting real GDP and sectoral value-added losses are highest for climate change impacts without planned adaptation with a loss of 2.6% of real GDP in 2030. Second highest are the impacts of mitigation policies (increased carbon tax and EU ETS price) with a loss of 1.3% in the same year. Climate change impacts with optimal adaptation result in the lowest losses of 0.6% of real GDP in 2030 (de Bruin et al., 2024c).

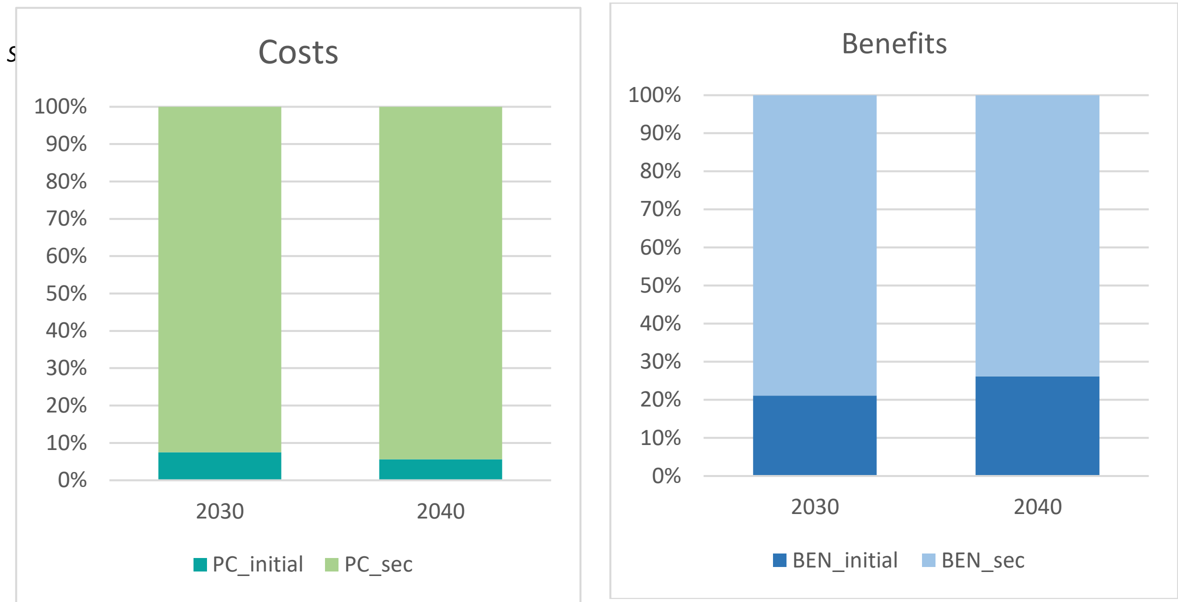
Figure 4: Real GDP by impact scenario, % change w.r.t. BaU in 2030 for RCP4.5



Source: de Bruin et al. (2024c)

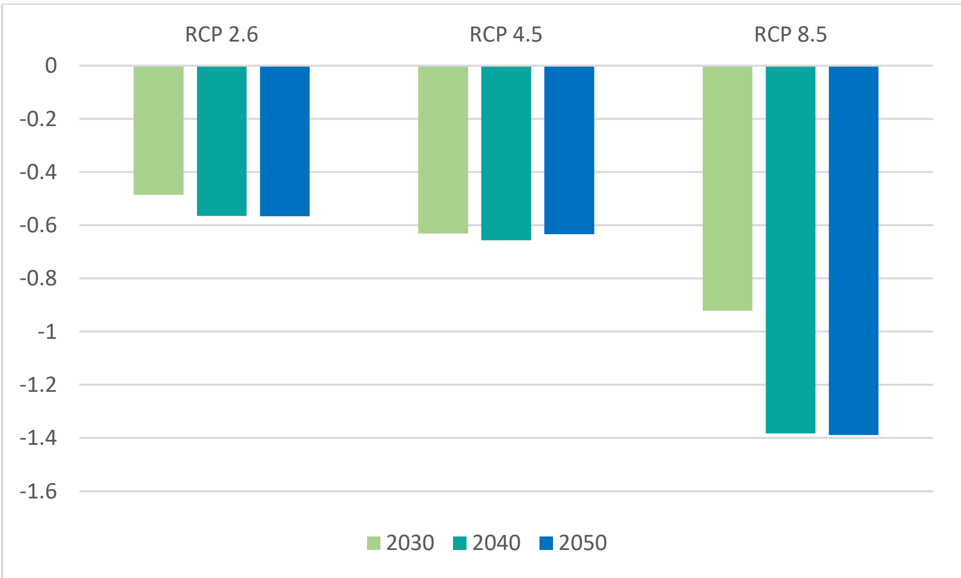
Secondary impacts are estimated through the mechanisms implicit in CGE modelling, where markets and behaviour adjust based on price changes. Initial adaptation costs are less than 10 percent that of secondary adaptation costs, whereas initial adaptation benefits are approximately 20 percent (de Bruin et al., 2024c). This means that when considering the economy wide (general equilibrium) impacts of adaptation policies; both adaptation costs and benefits are significantly higher and the factor by which they are higher is larger in the case of adaptation costs. These means that cost benefit ratios estimated without secondary impacts are likely to be overestimated.

Figure 5: Initial and secondary adaptation costs and benefits RCP4.5 by year



From a global perspective, international efforts to reduce emissions through the Paris Agreement will significantly decrease net climate change impacts for Ireland, where net impacts in 2040 under the Paris Agreement (RCP 2.6) are almost three times lower than in a no mitigation scenario (RCP 8.5), i.e. 0.56% decrease in real GDP as opposed to a 1.38% decrease in real GDP. This highlights the importance of international cooperation on climate change mitigation.

Figure 6: Net impacts of climate change, real GDP as % change w.r.t. BaU across RCP scenarios



Source: de Bruin et al. (2024c)

Limitations

Due to limited availability of data and/or methodologies, other climate change impacts such as extreme events, storms, livestock, tourism, ecosystem services, mental health effects and biodiversity were excluded from this analysis. Additionally, limited global and local estimates on adaptation resulted in only coastal and riverine adaptation being included in this programme.

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