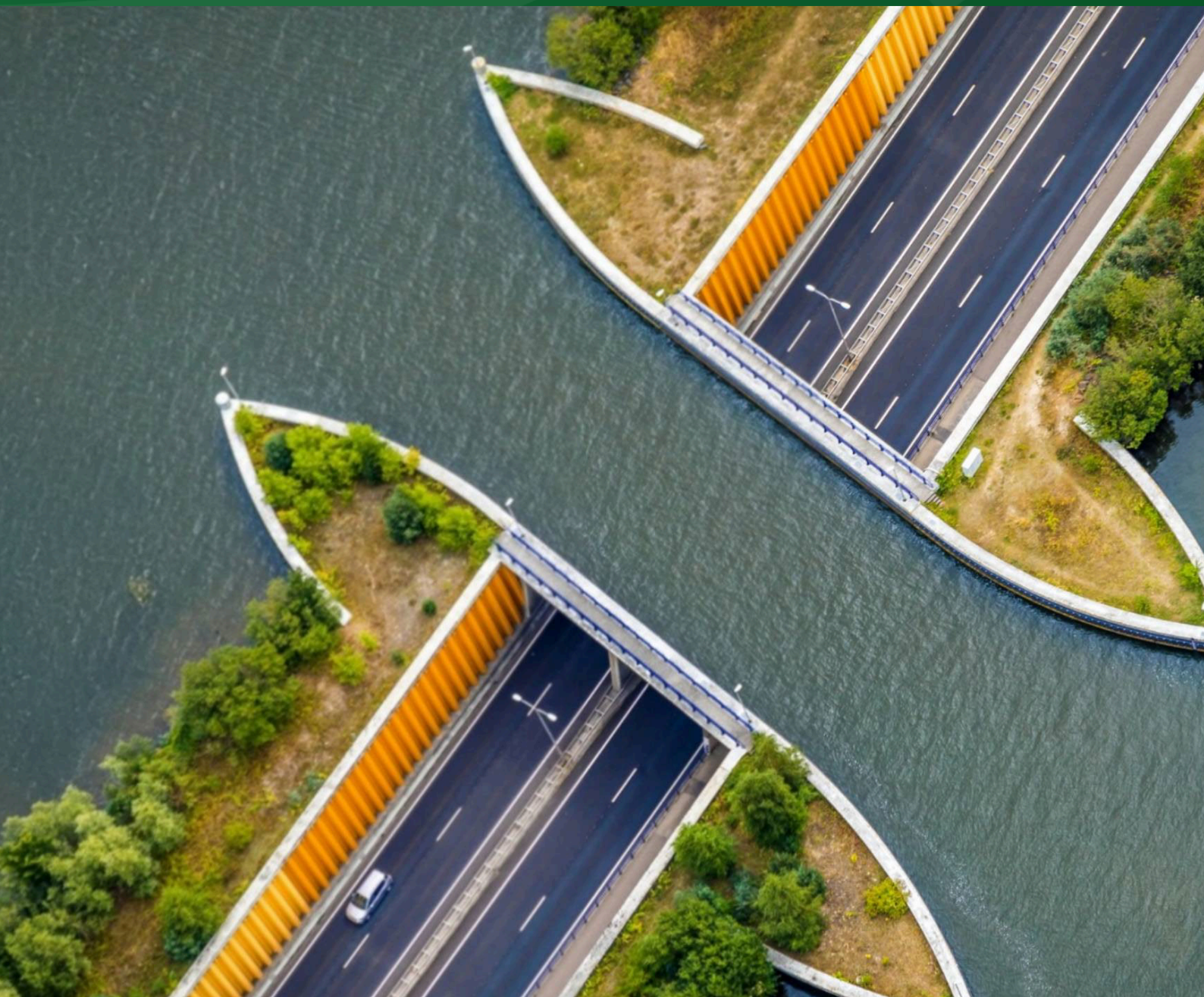


# Selected evidence on the economic costs of climate change impacts

## Background note

2026 OECD Green Growth and Sustainable Development Forum on  
“The economics of climate change adaptation”

1-2 July 2026



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## Abstract

This note synthesises recent OECD evidence on the economic costs of climate change, highlighting the growing urgency of adaptation. It shows that climate hazards are intensifying across multiple dimensions, with rising exposure of populations and assets. Drawing on ex-post and forward-looking evidence, it finds that economic costs are already substantial and unevenly distributed across households, firms, and regions, reflecting differences in exposure, vulnerability and resilience. Looking ahead, while estimates vary, projections consistently point to rising GDP losses as global temperatures increase under current policy trajectories. It also identifies key analytical gaps, including in capturing vulnerability and compounding risks, analysing household preferences regarding adaptation, and integrating adaptation into macroeconomic modelling.

## Acknowledgements

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## Key messages

Understanding the nature and scale of the economic costs of climate change is essential for designing effective adaptation policies. Adaptation, which can be broadly defined as the set of actions that reduce exposure and vulnerability to climate hazards, requires understanding where the greatest risks lie, how they are transmitted through the economy, and how they are likely to evolve. However, while evidence on climate risks and their economic impacts is increasing, the picture remains incomplete.

This paper synthesises evidence from recent OECD studies to provide a multi-hazard picture of what is known and what remains uncertain on the economic costs of climate change.

### Four main messages emerge:

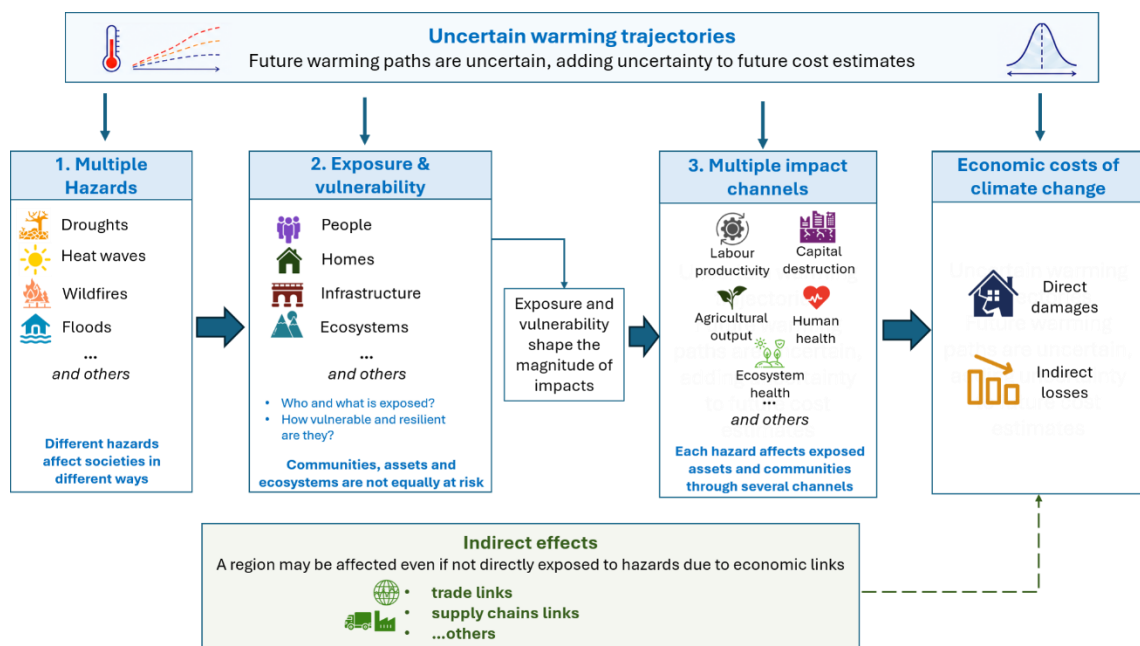
- **Analysis confirms that climate hazards are increasing and are projected to continue to do so as global temperatures rise.** Observed trends and projections point to increases in the frequency, duration and intensity of multiple hazards, although these changes vary across regions and dimensions. For example, the population exposed to prolonged heat rose by around 12% between 1979 and 2023 in OECD and partner countries, and the share of global land exposed to drought has doubled since 1900. These trends are projected to continue under current policies. Importantly, impacts are uneven across regions: lower-middle income countries are projected to experience nearly three times more additional hot days per year by 2100 than high-income countries.
- **The economic costs are already substantial and fall disproportionately on more vulnerable and less resilient households, firms, and regions.** On average, the cost of severe weather disasters is estimated at around 0.35% of GDP per year over 2006–2018, including direct and indirect costs, across OECD countries. Similarly, research suggests that today's global GDP would be about 1.6 % higher without the level of global warming observed since the pre-industrial period (around 1.5°C). Firm-level evidence shows that smaller and less productive firms bear a disproportionate burden from heat stress. Evidence at the regional level indicates that less diversified and fiscally constrained areas recover more slowly from extreme weather shocks. Additionally, the literature has long pointed to the higher vulnerability of poorer households.
- **The economic impacts of extreme weather persist over time and spread across regions through trade, supply chains, and migration, affecting economies well beyond the initial shock.** A severe disaster can lower the GDP of affected regions by 2.2%, with losses of around 1.7% persisting after five years. Furthermore, impacts can propagate to other regions through supply chains and other economic linkages: some estimates suggest that a severe disaster occurring within 100 km of a region leads to a 0.5% decline in its GDP. Similarly, projected economic impacts of additional global warming are considerably higher when supply chain linkages are considered.
- **Looking forward, while the precise magnitude is uncertain, modelling consistently points to growing GDP losses as warming increases. Under current policies, associated with warming of around 3°C by 2100,** evidence across models suggests that global GDP could be between 1-18% lower than in the absence of climate change by 2050, and between 2-36% lower by 2100.

## Introduction

Given limited public budgets and competing policy priorities, determining where adaptation investments are most needed requires credible estimates of the scale and distribution of climate change-induced damages.

**Four main challenges complicate estimating the economic cost of climate change to date and their projections to the future.** First, climate change increases the likelihood and severity of multiple hazards, including extreme weather events (e.g. droughts, heatwaves, wildfires) and slow-onset processes (e.g. sea-level rise, land degradation), all of which need to be taken into account when estimating overall costs. Second, it is necessary to identify which communities, assets and ecosystems are exposed to which hazards, and to assess their vulnerability.<sup>1</sup> This local dimension is particularly challenging to capture in models. Third, hazards can create economic costs through multiple channels (e.g. labour productivity, capital destruction). Fourth, both direct and indirect effects should be considered. In fact, regions can be indirectly affected by disasters in distant areas of the world through economic channels such as trade and supply chains. Uncertainties around future warming trajectories and potential tipping points (and their cascading impacts) adds to the complexity of estimating future economic costs (see Figure 1).

**Figure 1. Economic costs of climate hazards**



Source: Authors' elaboration.

This paper brings together recent OECD work to provide a multi-hazard overview of the economic costs of climate change to support a more coherent understanding of climate-related economic risks and inform the prioritisation of adaptation efforts. It combines physical evidence on changing climate hazards and exposure (Section 1) with analysis of how climate hazards translate into economic outcomes across sectors, regions and transmission channels (Section 2). Section 3 concludes and highlights some key knowledge gaps. Importantly, this paper does not assess the costs and benefits of specific adaptation measures, nor the design of adaptation policy.

<sup>1</sup> Exposure is defined as the presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected by a climate hazard (IPCC, 2014<sub>[36]</sub>). Vulnerability refers to the propensity or predisposition to suffer adverse effects and/or the lack capacity to cope or adapt if exposure were to occur (IPCC, 2014<sub>[36]</sub>).

## 1. Changing climate hazards and exposure

The economic costs of climate change are driven by changes in climate hazards, the exposure of people and assets to these hazards, as well as their vulnerability and resilience. Each of these drivers raises distinct measurement challenges that complicate their combined assessment.

Measuring changes in climate hazards requires addressing two related challenges: distinguishing the different dimensions of hazard evolution (e.g. frequency, duration and intensity), and selecting appropriate metrics to track change within each dimension. For instance, frequency can be defined as the number of days with temperatures above a certain threshold for heatwaves, or as the number of days with exceptionally strong winds for storms. Intensity can be assessed by observing that heatwaves are becoming longer and/or hotter compared to the past. Importantly, a hazard can intensify with respect to one dimension while remaining stable or even decreasing in another.

Measuring changes in exposure and vulnerability presents their own measurement challenges. An exposed entity's vulnerability is not always directly observable and must instead be inferred through indicators reflecting its underlying sensitivity and capacity to cope and adapt (e.g. age, income). Aspects of vulnerability are interlinked, can influence one another, and vary in importance across hazards (e.g. age is a key risk factor for heatwaves but less so for other hazards) and the entity being analysed (e.g. households, assets or ecosystems), further complicating the measurement of resilience and vulnerability.

This section builds on recent OECD research to provide evidence on the changing severity and exposure of selected climate hazards. The discussion builds mostly on OECD International Programme for Action on Climate (IPAC) indicators (see Box 1 and Box 2) that develop specific metrics to consistently monitor changes in hazard severity and population exposure across countries. This is complemented by evidence from recent OECD hazard assessments (OECD, 2025<sup>[1]</sup>; OECD, 2025<sup>[2]</sup>; OECD, 2023<sup>[3]</sup>). **Error! Reference source not found.** provides an overview of historical and projected changes in selected climate hazards (rising temperatures, extreme heat and droughts).

**Table 1. Historical and projected changes in selected climate hazard indicators**

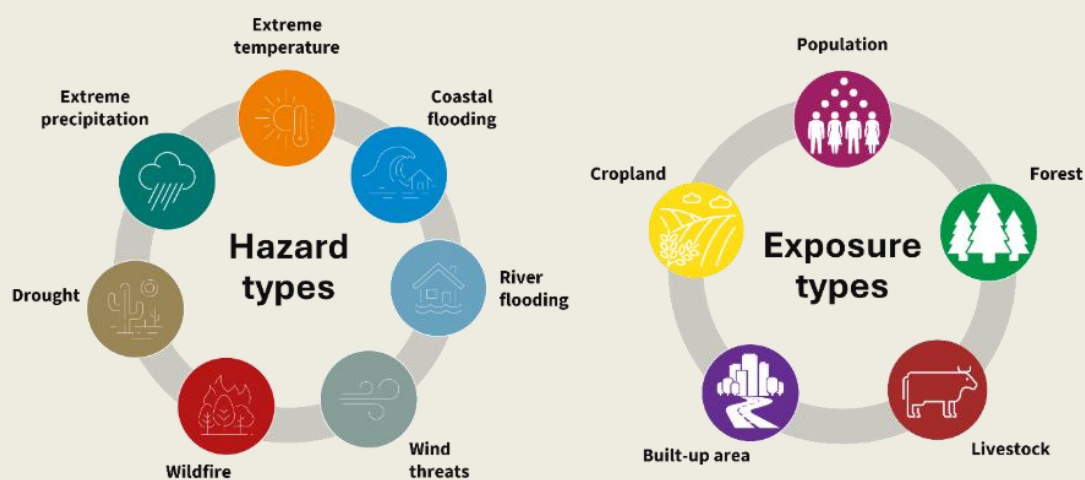
| Anomaly Indicator                       | Unit        | Historical values                                |       | Projected values                                                                      |       |
|-----------------------------------------|-------------|--------------------------------------------------|-------|---------------------------------------------------------------------------------------|-------|
|                                         |             | 2020-2024 compared to climate baseline 1981-2010 |       | Business-as-usual scenario, SSP2-4.5 2080-2099 compared to climate baseline 1995-2014 |       |
|                                         |             | OECD                                             | World | OECD                                                                                  | World |
| Rising temperatures and extreme heat    |             |                                                  |       |                                                                                       |       |
| Land surface temperature                | °C          | +0.9                                             | +1.1  | +2.88                                                                                 | +2.82 |
| Hot days                                | days/year   | +3.9                                             | +5.7  | +16                                                                                   | +18.9 |
| Tropical nights                         | nights/year | +4.5                                             | +5.7  | +19.3                                                                                 | +21.6 |
| Population exposed to hot days          | days/year   | +3.78                                            |       | +11.6                                                                                 |       |
| Population exposed to tropical nights   | nights/year | + 12.87                                          |       | +27.4                                                                                 | +31.8 |
| Population exposure to heat stress days | days/year   | +17                                              | +25   |                                                                                       |       |
| Droughts                                |             |                                                  |       |                                                                                       |       |
| Land soil moisture                      | %           | -1.93                                            | -3.35 |                                                                                       |       |
| Cropland soil moisture                  | %           | -3.06                                            | -3.73 |                                                                                       |       |
| Long-term drought                       | SPEI Index  |                                                  |       | -0.31                                                                                 | -0.37 |

Note: Hot days are defined here as days where the maximum daytime temperature exceeds 35°C. Tropical nights are defined here as nights where the minimum nighttime temperature exceeds 20°C.

Source: OECD calculations using data from OECD (2026), “Historical exposure to extreme temperature,” OECD Data Explorer ([database](#)); OECD (2025), “Projected exposure to extreme temperature,” OECD Data Explorer ([database](#)); OECD (2026), “Historical exposure to drought,” OECD Data Explorer ([database](#)) and OECD (2026), “Projected exposure to drought,” OECD Data Explorer ([database](#)).

### Box 1. A joint OECD - IEA methodology for monitoring past and future exposure to climate-related hazards

In 2022, the OECD and International Energy Agency jointly developed a set of indicators to monitor how people and assets are exposed to seven hazard types: extreme temperature, extreme precipitation, drought, wildfire, wind threats, river and coastal flooding (Maes et al., 2022<sup>[4]</sup>).



Source: OECD calculations OECD, WBG, GGGI and OECD (forthcoming), *New Data for Africa's Changing Climate: Mapping Risks, Readiness and Policy Action*.

The set has recently been extended to include forward-looking indicators to monitor future exposure of people and assets to three major climate-related hazards: extreme temperature, extreme precipitation and drought (Maes et al., 2025<sup>[5]</sup>). The new methodology builds on projected data from the World Bank Climate Change Knowledge Portal and relies on multi-model ensembles based on 30 different climate models to better capture uncertainty in climate projections, covering a range of climate scenarios: the Shared Socioeconomic Pathways. By calculating anomalies in hazard-exposure projections and changes up until 2100, the indicators offer evidence to better support mitigation and adaptation action.

### Extreme temperatures

**Extreme temperatures are becoming more frequent and affecting a growing share of the global population.** Countries are experiencing more frequent extreme heat, with an average increase of around six hot days (above 35°C) and around six tropical nights (above 20°C) per year in 2020-2024 compared to the climate baseline 1981-2010 (OECD, 2026<sup>[6]</sup>). Among OECD and partner countries, exposure to extreme heat is increasing, with an estimated additional 12% of the population exposed to more than two weeks of hot days between 1979 and 2023 (OECD, 2024<sup>[7]</sup>). There are large variations in exposure across and within countries. In India, for instance, changes in the number of hot days and tropical nights range from 14 fewer days in Puducherry to 26 additional days in Tripura, despite a national average increase of 2.5 days (OECD, 2025<sup>[2]</sup>). In Spain, an average of 37% of the population was exposed to hot

days for a period of less than two weeks in 2024 (OECD, 2026<sup>[6]</sup>). In certain regions, however, such as Cantabria, La Rioja, Valencian community and Melilla, exposure was around 90% (OECD, 2026<sup>[6]</sup>).

**Projections indicate that frequency and population exposure to extreme temperatures will continue to increase.** Extreme heat is projected to increase under all climate scenarios, though unevenly across regions: lower-middle income countries are projected to experience a yearly increase of 36 hot days, while high-income countries are projected to experience an increase of 10 hot days by 2100 under an intermediate emissions scenario (Maes et al., 2025<sup>[5]</sup>). Across OECD countries, the population exposed to extreme heat is projected to experience around 11 additional hot days and 27 additional tropical nights relative to the 1995–2014 baseline (OECD, 2025<sup>[8]</sup>).

## ***Droughts***

**Droughts have become more intense and more frequent.** The global land area affected by drought has doubled since 1900 (OECD, 2025<sup>[11]</sup>). Cropland soil moisture has declined by 3.06% in OECD countries and by 3.73% globally in 2020-2024 compared to 1981-2010 (OECD, 2026<sup>[9]</sup>). Around 40% of global land experienced an increase in both the average number of droughts and their average intensity<sup>2</sup> between 1950-2000 and 2000-2020 (OECD, 2025<sup>[11]</sup>). Most-affected areas include the western United States, South America, southern and eastern Europe, southern Australia, northern and southern Africa, and Russia (OECD, 2025<sup>[11]</sup>).

**Future projections suggest further increases in intensity, duration and exposure.** Under a current-policy scenario (SSP2-4.5), which projects warming of around 3°C by 2100, the Standardised Precipitation Evapotranspiration Index (SPEI) – a measure of the balance between precipitation and evaporation and a key driver behind drought occurrence and severity – is projected to decline from -0.08 in the climate baseline to -0.31 in OECD countries by 2100 (and from -0.09 to -0.37 globally), reflecting worsening drought conditions on land (OECD, 2026<sup>[10]</sup>). Global drought frequency could increase by 30% by 2100 (Zhou et al., 2023 in (OECD, 2025<sup>[11]</sup>)) and could double or triple in regions such as Canada, the United States and Mediterranean Europe (IPCC, 2022 in (OECD, 2025<sup>[11]</sup>)). Global average drought duration is also projected to rise by 50% under the intermediate-emissions scenario (Zhou et al., 2023 in (OECD, 2025<sup>[11]</sup>)). Consequently, exposure of people and assets to droughts is only likely to increase.

## ***Wildfires***

**The duration of wildfire weather season has increased globally, while trends in area burned are more heterogeneous across regions.** The duration of the fire weather season grew by 27% globally between 1979 and 2019, with especially large increases in southern Europe, western and central Asia, South America, western North America, Australia and most of Africa (Jones et al., 2022 in (OECD, 2023<sup>[3]</sup>)). While area burned has declined globally over the past decades, burning has significantly increased in forested areas including in Canada, Australia, the United States, China, Russia, Central Africa and the Amazon (Jones et al., 2022; Doerr and Santín, 2016 in (OECD, 2023<sup>[3]</sup>)). The percentage of the population exposed to very high or extreme wildfire danger is around 2.3% and fluctuated between 1.6% and 2.7% within the period of 2000 to 2022 in OECD countries (OECD, 2025<sup>[11]</sup>) (see Table 2).

**Both wildfire weather and area burned are projected to increase** (OECD, 2023<sup>[3]</sup>). Under a 2°C warming scenario, the duration of the wildfire season is projected to increase in most regions, with a projected increase of at least 30 days in large parts of South America, Australia, Africa, the western United States, the Mediterranean and the Middle East, northern Europe, and many regions of Asia (OECD, 2023<sup>[3]</sup>). The frequency of fire weather conditions is likely to increase on all continents (OECD, 2023<sup>[3]</sup>).

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<sup>2</sup> Represented as a lower SPEI value.

For example, in southeastern Australia, extreme fire weather conditions<sup>3</sup> are projected to become at least twice as frequent by 2080 compared to 2022 (Herold et al., 2021 in (OECD, 2023<sub>[3]</sub>); Jones et al., 2022 in (OECD, 2023<sub>[3]</sub>)).

According to some estimates, annual global area burned is projected to increase by 19% by 2050 compared to 2000 under current warming trajectories (RCP 4.5) (Zou et al., 2020 in (OECD, 2023<sub>[3]</sub>)), though this figure is higher in many regions (e.g. the United States, where the projected increase is 54%, and Canada, with 64%). (Spracklen et al., 2009 in (OECD, 2023<sub>[3]</sub>); Marsh & McLennan Companies 2019 in (OECD, 2023<sub>[3]</sub>)).

**Table 2. Population and forest exposed to wildfire risks**

| Indicator                                      | Unit | Time | Historical values |       |
|------------------------------------------------|------|------|-------------------|-------|
|                                                |      |      | OECD              | World |
| Population exposed to areas at risk of burning | %    | 2022 | 2.35              |       |
| Forest exposed to areas at risk of burning     | %    | 2024 | 13.84             | 13.32 |

Source: OECD calculations using data from OECD (2025), “Exposure to wildfire,” [OECD Data Explorer](#) (database).

## 2. Economic Costs

**This section draws on a range of recent OECD work to build a multi-hazard picture of the economic costs of climate change.** Two broad types of evidence are presented: 1) observed (ex-post) evidence on the economic costs of specific climate-related hazards; and 2) forward-looking (ex-ante) projections of how costs could evolve over time under different warming scenarios, using computable general equilibrium models, spatial general equilibrium approaches and trend extrapolation techniques.

**Ex-post and ex-ante evidence help to answer different policy questions.** Broadly speaking, ex-post analysis provides evidence on the economic cost of specific hazards based on observed historical relationships, while ex-ante modelling explores how costs could change under different scenarios – e.g. the impact of climate change on GDP if the Paris agreement objective is met, or if temperature increases by 3°C.

Despite methodological differences (e.g. data, time horizons and modelling choices, impact channels included and policies assumed), **these exercises tell a consistent story: climate change damages are expected to increase over time as warming increases** and more people, capital and infrastructure are exposed to climate-related hazards.

In addition, the evidence shows that

- **The main channels through which climate hazards create economic costs vary, and impacts can be substantial even without physical capital destruction.** Some hazards cause direct and visible damage to physical assets (e.g. floods), whereas others can impose large economic costs without major asset destruction (e.g. heatwaves) through effects on labour productivity.
- **Damages can persist in the short term.** There is ongoing debate in the literature on whether climate damages are a one-off shock that temporarily reduce the level of GDP or whether they decrease the growth rate of economies. Evidence shows that severe weather events can leave

<sup>3</sup> Periods with high temperatures and wind and low relative humidity and rainfall.

lasting scars on regional economies, with GDP remaining below trend for at least five years after a severe event (Costa and Hooley, 2025<sup>[12]</sup>).

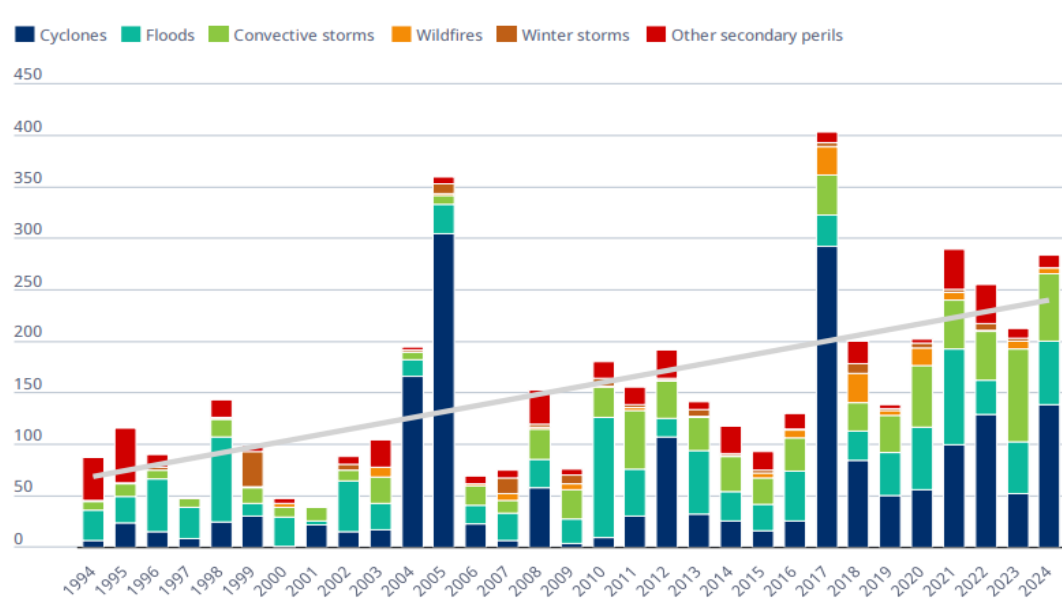
- **Impacts depend on vulnerability and resilience:** Firm-level evidence shows that smaller and less productive firms bear a disproportionate burden from heat stress. At the regional level, less diversified and fiscally constrained areas recover more slowly from extreme weather shocks. In addition, the literature has long pointed to the higher vulnerability of poorer households.

## 2.1 A rising toll: the costs of climate hazards across OECD economies to date

**Economic losses from climate-related disasters have increased steadily over the past three decades** (see Figure 2) (OECD, 2025<sup>[2]</sup>). As insurance coverage remains limited, the bulk of these costs fall directly on households, businesses, and public budgets. Recent data shows that 24 of 38 OECD Member countries have insured less than half of their natural hazard losses since 2000 (OECD, 2026<sup>[13]</sup>).

**Figure 2. Economic losses from climate-related disasters rose markedly over three decades**

Cumulative economic losses (USD billion, 2024 prices), OECD and OECD partner countries, 1994-2024



Note: The category "Other secondary perils" includes droughts and landslides.

Source: (OECD, 2025<sup>[2]</sup>) based on Swiss RE Institute data.

**These rising costs reflect the combined effect of several factors:** changes in hazard frequency and intensity, exposure, asset values, and, in some cases, increasing vulnerability (see Box 2). Disentangling the relative contribution of each factor is analytically complex. **Error! Reference source not found.** provides an overview of the available ex-post evidence. Further below, Table 4 summarises the forward-looking projections.

**Table 3. Selected recent evidence on observed (ex-post) economic costs of climate-related natural hazards**

| Hazard                 |  | Geography                                        | Key findings / estimates                                                                                                                                                                                                                                                                                                                                                         | Main impact channel(s)                                                                        | Reference                                                                            |
|------------------------|--|--------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| Wildfires              |  | Multiple OECD countries and region               | <ul style="list-style-type: none"> <li>The literature review shows evidence of large cost already: e.g. some estimates find average direct economic losses (2000–2017) of about EUR 3 billion per year in the EU and USD 2.3 billion per year in the USA.</li> <li>The wildland-urban interface is where most socio-economic losses and damages from wildfires occur.</li> </ul> | Various, depending on the study                                                               | Literature review outlined in OECD (2023 <sup>[3]</sup> )                            |
| Heatwaves              |  | Firm-level                                       | <ul style="list-style-type: none"> <li>Average impact of 10 extra days above 35°C in a year reduces firms' labour productivity by ~0.3%.</li> <li>Heatwaves reduce firms' labour productivity by 0.2%.</li> </ul>                                                                                                                                                                | Reduced cognitive/physical performance.                                                       | Costa et al. (2024 <sup>[14]</sup> )                                                 |
| Droughts               |  | Global (with sectoral level analysis)            | <ul style="list-style-type: none"> <li>Average drought costs have been rising by 3–7.5% per year since 2000, now costing at least twice what it did in 2000.</li> <li>Agriculture is the most vulnerable sector, with crop yields falling by up to 22% in particularly dry years</li> </ul>                                                                                      | Longer duration of droughts drives the trend.<br>Reduced crop volumes for agricultural impact | OECD (2025 <sup>[11]</sup> ), Tikoudis, Gabriel and Ouselati (2025 <sup>[15]</sup> ) |
| Extreme weather events |  | OECD countries (Nuts 3 Regional level estimates) | <ul style="list-style-type: none"> <li>Regional impact: severe disasters reduce level of regional GDP up to 2.2% below trend, with 1.7% loss still after 5 years. A severe disaster occurring within 100 km of a region leads to a 0.5% decline in GDP.</li> <li>National average impact: 0.35% of GDP per year over 2006–2018, ~½ direct, ½ spillovers</li> </ul>               | Destruction of capital and employment. Transmission through supply chains                     | Costa and Hooley (2025 <sup>[12]</sup> )                                             |
| Floods                 |  | Firm-level                                       | <ul style="list-style-type: none"> <li>Direct exposure reduces firms' capital stock by around 2.7% yearly over four years, with effects peaking after three years and only partially recovering.</li> <li>Impacts spill over to nearby firms</li> </ul>                                                                                                                          | Destruction of capital, Transmission through supply chains                                    | Unsal et al. (forthcoming <sup>[16]</sup> )                                          |

Note: Estimates are not directly comparable across rows. They differ in geography, time period, hazard definition, outcome variable, and method. Some estimates capture direct damages only, while others include indirect costs and broader economic losses.  
Source: Compiled by authors.

### Box 2. Moving beyond hazards and exposure: measuring vulnerability and resilience

The economic cost of climate hazard depends not only on the hazard itself and on exposure, but also on the vulnerability (i.e. the susceptibility to harm) and resilience (i.e. the capacity to absorb, adapt and recover from shocks) of exposed communities, assets and ecosystems.

Measuring vulnerability is inherently challenging, however It depends on a large and variable number of factors (e.g. age, income) whose importance varies across hazards (e.g. age is a key risk factor for heatwaves but for flooding) and across the unit of analysis (e.g. households, assets, or ecosystems). Data limitation and a lack of consensus on the most effective methodological approaches are additional barriers.

New OECD work on agriculture, which is one of the one of the most climate-sensitive sectors, highlights this complexity. OECD (2025<sup>[17]</sup>) develops 17 indicators to measure progress in the adaptation in the agricultural sector along four dimensions: exposure to extreme weather; adoption of resilient practices to reduce vulnerability; impacts of extreme weather; and the enabling conditions. The results show that

vulnerability indicators can move in different directions at the same time. For instance, crop diversity has decreased in around half of OECD countries, thus reducing the buffering that a diverse set of crops provide against weather shocks. At the same time, the suitability of crops to local climate conditions has increased in more than two thirds of OECD countries.

Ongoing OECD work, in collaboration with the University of Tokyo, aims to develop a set of indicators to monitor population vulnerability and risk to environmental hazards, with a specific focus on extreme heat and air pollution in Japan. This work combines Earth observation data with other sources (e.g., population census data) to characterise key dimensions of risk—namely hazards, exposure and vulnerability.

Source: (OECD, 2025<sup>[17]</sup>).

## *Floods*

**Flooding is among the largest sources of economic losses from natural hazards, with evidence pointing to rising impacts.** Average annual economic losses from flood events in OECD Member and accession candidate countries were almost 78% higher in the first few years of this decade (2020-2024) relative to the previous five years (2015-2019) (OECD, 2026<sup>[13]</sup>). Single extreme events can have particularly large economic costs. For instance, the July 2021 Central Europe floods caused USD 54 billion in overall losses and are described as the costliest flood event globally to date (Munich RE, 2020 in (Davies and Martini, 2023<sup>[18]</sup>)).

**New evidence suggests that flooding causes persistent capital losses at the firm level, with significant spillovers to nearby firms.** OECD firm-level evidence shows that floods primarily damage economic activity through the destruction of physical capital. Capital stock of firms directly exposed to a flood reduces by around 2.7% yearly over the four years following the event, with effects peaking after three years and only partially recovering. Impacts also spill over to nearby firms: those within 100 km experience capital losses exceeding one-third of the direct effect, reflecting disruptions to supply chains, infrastructure, and local demand (Unsal et al., forthcoming<sup>[16]</sup>). Importantly, evidence suggests that vulnerability varies: smaller and less liquid firms suffer larger losses and recover more slowly (Unsal et al., forthcoming<sup>[16]</sup>).

**Numerous hazards can compound with floods, leading to higher costs.** For instance, intense wildfires reduce the capacity of soils to absorb water, while warmer temperatures increase the atmosphere's capacity to hold water, thus potentially leading to more intense rainfall. When the subsequent rainy season arrives, the lack of canopy interception and the altered soil chemistry mean that rainfall cannot infiltrate the ground. Slow onset events, such as sea-level rise can also increase coastal flood risks and associated economic costs. For instance, sea-level rise-induced coastal floods have caused an estimated USD 11 billion in losses and damages in Japan, USD 3 billion in the Netherlands, and over USD 1 billion in Mexico and Vietnam<sup>4</sup> (OECD, 2019<sup>[19]</sup>; OECD, 2021<sup>[20]</sup>).

## *Droughts*

**Droughts impose large and rising economic costs, though these are often less visible than other sudden-onset events.** Analysis of global disaster loss databases finds that average drought costs have been rising by 3–7.5% per year since 2000, meaning that costs have at least doubled since 2000 (OECD, 2025<sup>[11]</sup>; Tikoudis, Gabriel and Oueslati, 2025<sup>[15]</sup>). These trends reflect the combined effect of changes in

<sup>4</sup> Figures from the EM-DAT database, as reported in (OECD, 2021<sup>[20]</sup>).

hazard frequency and duration, growth in exposed assets, and increasing vulnerability in certain sectors, including in the agricultural sector (OECD, 2025<sup>[1]</sup>; OECD, 2025<sup>[17]</sup>).

**Agriculture is the sector most vulnerable to droughts but others can also be severely impacted.**

Crop yields have been estimated to fall by up to 22% in particularly dry years (OECD, 2025<sup>[1]</sup>; Tikoudis, Gabriel and Oueslati, 2025<sup>[15]</sup>). Other sectors, including power generation and river transportation can also be harshly affected. Severe droughts have reduced fluvial trade volumes by up to 40% in central Europe and cut hydroelectric production by more than 25%, with cascading effects on supply chains and energy prices (OECD, 2025<sup>[1]</sup>; Tikoudis, Gabriel and Oueslati, 2025<sup>[15]</sup>). An OECD case study on drought risks in the Paris metropolitan area estimates that regional indirect effect of a severe drought can reach EUR 330 million for other French regions and up to EUR 170 million for European regions (see Box 3) (OECD, 2025<sup>[21]</sup>).

**OECD reviews of data suggests that droughts can have compounding impacts.** Droughts can contribute to increasing wildfire risk by degrading soil and vegetation (OECD, 2025<sup>[1]</sup>). For instance, there is some evidence that the 2018 Camp Fire in the United States, the 2017 wildfires in Portugal and Chile, and the 2020 wildfires in Arctic Siberia were fuelled by exceptionally dry conditions (Hawkins et al., 2022 in (OECD, 2025<sup>[1]</sup>); OECD, 2023 in (OECD, 2025<sup>[1]</sup>) Ciavarella et al., 2021. in (OECD, 2025<sup>[1]</sup>)). Similarly, drought-induced soil cracking reduced infiltration capacity, hindering the ability of soil to absorb rain. This contributed to making the 2023 Emilia Romagna flooding in Italy particularly severe (Ronco et al., 2026<sup>[22]</sup>).

**Evidence is inconclusive as to how long the negative GDP effect of a dry shock can last.** One estimate suggests that precipitation shocks reduce GDP growth by 0.05–0.15 pp for up to 14 years (Berlemann and Wenzel, 2018 in (OECD, 2025<sup>[1]</sup>)).

### Box 3. Drought risks in the Paris, France metropolitan area

The Paris metropolitan area (Île-de-France) has historically been resilient to drought but changing climatic conditions and increased water demand risk undermining the city's resilience.

Building on historical data, the OECD developed three scenarios to estimate the potential economic costs of future droughts under changing climate conditions. The baseline scenario assumes the same river flow rates as during the 1921 drought. The median scenario assumes the simultaneous occurrence of a drought and a heatwave. The adverse scenario considers a 20% reduction in river flow levels and water temperature warmer by 2°C compared to the 1921 event.

Results suggest that total economic costs could be EUR 1.4 billion by 2050 and EUR 2.45 billion by 2100 (equivalent to roughly 0.3–0.4% of regional GDP). Agriculture and manufacturing would account for around two thirds of the direct costs. The analysis also confirms the importance of considering how costs can spread to other regions through value chain links. Simulation suggests that: costs could reach up to EUR 330 million for other French regions and up to EUR 170 million for European regions.

Addressing governance gaps, including extending the planning horizon to 2050/2100, ensuring that risk assessments include projected changes in water supply and demand, and improved water demand management, are essential to limit future impacts.

Source: (OECD, 2025<sup>[21]</sup>).

## *Wildfires*

**Average annual economic losses from wildfires increased in OECD Member countries by 360% in 2015-2024 compared to the average over 2000-2014** (and by 371% in OECD Member and accession candidate countries overall) (OECD, 2026<sup>[13]</sup>). Worsening fire weather conditions and increasing exposure as human settlements and economic activities continue to expand into wildland areas are key drivers of these rising damages (OECD, 2023<sup>[3]</sup>).

**Evidence shows large direct costs.** Average direct economic losses from wildfires (2000-2017) were about EUR 3 billion per year in the Europe and USD 2.3 billion per year in the United States (Marsh & McLennan Companies 2019 in (OECD, 2023<sup>[3]</sup>)). However, particularly extreme wildfire events can considerably inflate these figures. For example, the 2018 Camp Fire in California and the 2019-20 fires in Australia caused direct economic costs amounting to USD 19 billion and USD 23 billion respectively (EM-DAT database in (OECD, 2023<sup>[3]</sup>)).

**Total economic costs are likely to be much larger but are complex to estimate.** These include impacts on human health, including through air pollution, impacts on ecosystems, tourism and others. For example, at the global level, wildfire-induced air pollution is associated with 340 000 premature deaths annually (OECD, 2023<sup>[3]</sup>). Some studies suggest that total economic losses from wildfires in the United States could range from USD 63.5 billion to USD 285 billion every year (Thomas et al., 2017 in (OECD, 2023<sup>[3]</sup>)).

**This is evidence of compounding impacts from wildfires.** For instance, Le Roux et al., 2022 shows that Amazon forests affected by wildfires are more vulnerable to droughts, which in turn increases the risk of subsequent fires (Le Roux et al., 2022 in (OECD, 2025<sup>[1]</sup>)).

## *Rising temperatures and heatwaves*

**Heat stress can cause significant economic damage, notably through reduced labour productivity and firm output.** Firm-level econometric evidence from 23 advanced economies shows that ten extra days above 35°C in a year reduce firms' labour productivity by ~0.3%. This effect is comparable to the decrease in productivity following a 5% rise in energy prices. Heatwaves, defined as five or more consecutive days above the local 95th percentile for historic temperature, reduce annual labour productivity by 0.2% (Costa et al., 2024<sup>[14]</sup>).

**Beyond its effects on productivity, heat stress can generate substantial economic costs through mortality and morbidity effects.** Research shows that high temperatures are linked to multiple negative health outcomes and increased pressure on health services through more hospital admissions, emergency department (ED) visits, and ambulance transports (Boudreault et al., 2025<sup>[23]</sup>). For instance, recent OECD research finds that excess ED visits linked to temperatures in the highest temperature decile for a country were associated with up to 1.1% additional total ED visits in a year, and up to 3.6% additional hospitalisations. The study finds that direct hospital-related costs of excess hospitalisations due to the highest temperatures are estimated to exceed 524 million USD (2024 PPP) per year in France, Italy and Spain of (Le Thi, Morgan and Suzuki, 2025<sup>[24]</sup>).

**Heatwaves and higher temperatures can also generate long-term economic costs by affecting human capital formation through education.** Exposure to high temperatures during the school year is associated with lower test scores and learning outcomes, especially where school buildings are poorly adapted (OECD, 2026<sup>[25]</sup>). For instance, Park et al. (2020<sup>[26]</sup>) estimates that each additional day above 26.7°C during the three years preceding an exam lowered PISA test scores by 0.18% of a standard deviation.

**Evidence points to heterogeneity in heatwave vulnerability.** Academic literature consistently highlights that lower socio-economic households are to be more vulnerable to heatwaves due to financial

constraints. While higher-income households can mitigate heatwaves through air conditioning, lower-income households frequently face barriers at both the extensive margin (buying the unit) and intensive margin (affording the electricity to run it). Costa et al. (2024<sup>[14]</sup>) shows that smaller and less productive firms are significantly more affected. On the whole, outdoor workers are more likely to be affected by the global increase in temperatures than workers working indoors (OECD, 2021<sup>[27]</sup>).

**As for other heatwave-related risks, there is clear evidence of compounding impacts.** This is particularly evident in the bidirectional and self-reinforcing relationship between heatwaves and droughts. On one hand, extreme heat can increase water consumption across multiple sectors, thus worsening water scarcity issues during droughts (Cárdenas Belleza, Bierkens and van Vliet, 2023 in (OECD, 2025<sup>[11]</sup>)). On the other hand, droughts can decrease soil moisture, thus strengthening heatwaves through land-atmosphere feedback mechanisms (Miralles et al., 2014<sup>[28]</sup>; OECD, 2025<sup>[11]</sup>). This compounding dynamic also exists between heatwaves and floods, which are often regarded as opposite. Heat increases the atmosphere's capacity to hold water, thus facilitating the occurrence of intense precipitation.

### *Evidence on persistence of impact*

A critical question for adaptation planning and long-run projections is whether climate disasters are temporary disruptions from which economies recover, or whether they leave lasting scars.

**Multi-hazard econometric analysis shows that severe disasters can leave medium-term scars on regional economies.** Climate-related disasters such as storms, floods and extreme temperatures cause sizeable and persistent losses in regional GDP, with stronger and longer-lasting effects in more exposed or less resilient regions. Estimates suggest that disasters can reduce regional GDP up to 2.2% below trend, with losses of 1.7% persisting after five years (Costa and Hooley, 2025<sup>[12]</sup>). The study also confirms heterogeneity in vulnerability: regions with greater fiscal space, more diversified economies and higher labour mobility recover faster (Costa and Hooley, 2025<sup>[12]</sup>). Industrial output falls by more than twice as much as services output, reflecting industry's greater dependence on fixed capital.

### *The importance of spillovers and adjustment mechanisms*

Climate damages can propagate through trade, supply chains, migration and regional demand, affecting economies far from the initial shock. This cross-regional transmission means that regions and countries can be negatively affected by hazards taking place in geographically distant areas.

Costa and Hooley (2025<sup>[12]</sup>) find that a severe disaster occurring within 100 km of a region leads to a 0.5% decline in its GDP. The authors also find that roughly half of the total estimated GDP costs of past extreme weather shocks is associated with spatial spillovers. Unsal et al.'s (forthcoming<sup>[16]</sup>) modelling analysis similarly finds that future estimated GDP losses are approximately 78% larger when domestic supply chain linkages are considered. Similarly, an OECD case study on water scarcity in the metropolitan region of Paris, France found that indirect economic losses transmitted through value chains can be as large as the direct losses incurred by sectors affected by drought (OECD, 2025<sup>[21]</sup>).

### **How large could these costs become over the century?**

The previous section provided evidence on the impact of extreme weather events on economic outcomes to date. But how large could these costs become looking forward? Addressing this question requires forward-looking modelling that combines climate scenarios with socio-economic projections and assumptions about how climate damages affect economic output.

This section presents evidence from recent OECD modelling studies on future impacts. While these differ along multiple dimensions, including modelling techniques, hazards and impact channels considered, they

consistently project increased climate change damage as global warming increases. Table 4 summarises the main results, and Box 4 provides some caveats for their interpretation.

#### Box 4. Key caveats for interpreting long-run climate damage projections

The projections reviewed in this section are scenarios, not forecasts. They differ substantially along various dimensions (e.g. hazards, warming scenarios, etc.) and should be interpreted considering several important caveats:

- **Damage functions are uncertain.** There is a longstanding debate in the literature on how to estimate the damage function for climate change; the difference between a low and high damage curve can be up to factor of 15. OECD (2025<sup>[29]</sup>). OECD/UNDP (2025<sup>[30]</sup>) address this uncertainty by testing alternative global damage functions. Unsal et al (forthcoming<sup>[16]</sup>) apply a different approach by leveraging micro-level estimates of specific hazard impacts, which provide greater granularity but necessarily cover only a subset of hazards.
- **Tipping points are not explicitly captured.** No current OECD model accounts for potential tipping points (e.g. a reversal of ocean circulation patterns), which could trigger abrupt and non-linear climate changes.
- **Simultaneous shocks:** As global warming increases, multiple shocks could take place simultaneously in the same region or in different regions connected through various socio-economic channels (e.g. trade, migration). This type of compounded impact is another important frontier for research.
- **Adaptation is not explicitly modelled.** Damages are projected without accounting for the possibility that adaptation investments could reduce them. Incorporating adaptation into these frameworks is the focus of future work (Section 3).

Source: Authors.

**Table 4. OECD-projected economic costs of climate change and selected climate-related hazards**

| Outcome                                                           | Modelling approach                                                                                                                                                                                          | Scenario                          | 2050 estimate                         | 2100 estimate        | Reference                                                                            |
|-------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|---------------------------------------|----------------------|--------------------------------------------------------------------------------------|
| Level of potential global GDP vs no warming                       | OECD Long-Term Model with new climate damage channel. Uses two damage functions. (Bilal and Känzig, 2026 <sup>[31]</sup> ; Howard and Sterner, 2017 <sup>[32]</sup> )..                                     | Current Policies (2.5°C)          | -4% and -17% by 2050                  | -9% and -36% by 2100 | OECD (2025 <sup>[29]</sup> )                                                         |
| Average global Drought Episode Cost                               | Trend extrapolation based on observed historical costs.                                                                                                                                                     | n.a.                              | +35% to +110% cost vs today (by 2035) | n.a.                 | Tikoudis, Gabriel and Oueslati (2025 <sup>[15]</sup> ), OECD (2025 <sup>[11]</sup> ) |
| Level of potential global GDP vs no warming                       | IEA Global Energy and Climate model combined with three damage functions (Bilal and Känzig, 2026 <sup>[31]</sup> ; Howard and Sterner, 2017 <sup>[32]</sup> ; Barrage and Nordhaus, 2024 <sup>[33]</sup> ). | Current Policies (+2.4°C by 2100) | - 1–18% in global GDP by 2050         | - 2–29% by 2100      | OECD/UNDP (2025 <sup>[30]</sup> )                                                    |
| Level of potential global GDP per capita vs no additional warming | Bottom-up approach using micro-founded estimates for specific hazards (e.g., heat, floods) calibrated on firm-level data (Unsal et al., forthcoming <sup>[16]</sup> )                                       | Current policies (SSP2-4.5)       | -- 3% by 2050.                        | -6.3% by 2100        | Unsal et al., (forthcoming <sup>[16]</sup> )                                         |

Note: Estimates are not directly comparable across rows as they differ across multiple dimensions (e.g. modelling approach, outcome variable, considered climate impact channels). The estimates should be read as complementary evidence on the scale and direction of future economic costs, rather than as alternative estimates of the same quantity.

Source: Compiled by Authors.

### *Projections using the ENV-Linkages CGE model and different damage functions*

OECD/UNDP (2025<sup>[30]</sup>) leverages the ENV-Linkages model, calibrated with NiGEM and informed by IEA scenarios to estimate the global macroeconomic impacts of National Determined Contributions aligned with the Paris Agreement objectives. Given uncertainties, the report leverages three different damage functions (Barrage and Nordhaus, 2024<sup>[33]</sup>; Howard and Sterner, 2017<sup>[32]</sup>; Bilal and Känzig, 2024<sup>[34]</sup>) to quantify the damages of climate change.

Estimates show that climate change would decrease global GDP by about 1–18% by 2050 and 2–29% by 2100 relative to a no-climate-damage baseline under a current policies/business-as-usual scenario (around +2.4°C by 2100), depending on the choice of global damage function (OECD/UNDP, 2025<sup>[30]</sup>). The study also finds a large variation in climate damages across countries, with lower-latitude and less-developed countries being more affected due to higher exposure and higher vulnerability, including because of the role that more climate-sensitive sectors (e.g. agriculture) play in their economies.

### *Projections using the OECD Long-Term Model and different damage functions*

The 2025 update of the OECD Long-Term Model (LTM) — covering 139 countries with projections to 2100 — considers six scenarios with differing assumptions about the speed of the climate transition, the pace at which mitigation costs decline and the extent of climate damages. Howard and Sterner<sup>5</sup> (2017<sup>[32]</sup>) and Bilal and Känzig's (2024<sup>[34]</sup>) damage functions are used to calibrate the model across these scenarios.

The estimations suggest that global GDP today is already about 1.6 % lower than it would have been under a no-warming scenario. By 2100, losses are projected to rise to around 9% of global GDP in a baseline scenario with a median damage curve relative to a no-climate-damage baseline<sup>5</sup> (BAU1, +2.5°C by 2100). Under a steeper damage curve, projected climate damages could reduce global output by up to around 36% by 2100 (OECD, 2025<sup>[29]</sup>).

### *Projections using the Climate and Adaptation Spatial General Equilibrium Model*

Unsal et al. (forthcoming<sup>[16]</sup>) combines micro-level empirical estimates of the economic impact of specific climate hazards with a quantitative spatial general equilibrium model. The Climate and Adaptation Spatial General Equilibrium Model (CASGEM) model links location-specific climate risks to economy-wide outcomes through trade, migration, production networks, and factor adjustments. The hazards included are heat stress, floods, changes in agro-climatic conditions, and sea-level rise.

Estimates suggest that GDP per capita would decline by 1.7% by 2050 and 3.1% by 2100 across OECD countries, and by 3% and 6.3% globally under a current-policy scenario (SSP2-4.5) relative to a no additional global warming scenario. Under a high-emissions scenario (SSP5-8.5), GDP per capita would decline by around 2.5% by 2050 and 9% by 2100 across OECD countries and by 6% and 18% globally. Across the considered hazards, heat stress emerges as the dominant driver of losses, followed by reductions in agro-climatic productivity. Flood damages and sea-level rise play more localised but economically significant roles in specific countries.

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<sup>5</sup> In this specification, the model assumes that there are not cost from climate change.

Interestingly, the model also highlights the importance of trade and labour mobility as channels through which local climate shocks are transmitted, amplified or mitigated. For instance, global GDP per capita losses in 2100 are projected to be roughly 9 percent lower when migration and changes in trade patterns are considered. However, this aggregate improvement hides redistribution across countries with some regions seeing their damages decreased and others experiencing an increase due to migration and changes in trade patterns. As OECD/UNDP (2025<sup>[30]</sup>), the study finds large heterogeneity in impacts with countries in West and Central Africa, South Asia and parts of the Middle East facing much higher GDP losses (up to 30% by 2100).

#### *Projections based on extrapolation techniques*

Tikoudis, Gabriel and Oueslati (2025<sup>[15]</sup>) project future drought costs based on econometric estimation of historical cost trends based on the EM-DAT global database and the U.S.-focused National Centers for Environmental Information (NCEI) dataset.

The analysis projects a marked increase in drought costs by 2035 with loss and damages set to continue to rise at about 3.0–7.5% per year, implying the average drought episode in 2035 would be at least a third more costly than in 2025. This rising toll is attributed mainly to longer and more frequent episodes, rather than higher intensity of droughts. Duration is estimated to have increased by roughly 6% annually since 2000 and, assuming a similar growth rate in the future, projected to double by 2035 (OECD, 2025<sup>[1]</sup>; Tikoudis, Gabriel and Oueslati, 2025<sup>[15]</sup>). Data limitations prevent evaluating whether drought costs would be larger or grow faster in OECD countries vis-à-vis the rest of the world.

### **3. Conclusions and knowledge gaps**

OECD evidence points to a clear overall message: climate-related hazards are intensifying, and the associated economic costs are already significant and rising.

As Section 2 demonstrates, many climate hazards are becoming more severe, although the nature of these changes varies. Depending on the hazard, this is reflected in more frequent events, greater intensity, longer duration, and/or broader exposure of people and land.

OECD work documents increasing losses from climate-related disasters and shows that these losses occur through multiple channels. Some hazards, such as floods and wildfires, cause direct and visible damage to physical assets and infrastructure. Others, such as heat stress and drought, can generate substantial costs with less visible physical destruction, for example through reduced labour productivity, lower agricultural output, health impacts, and disruptions to transport and energy systems.

Importantly, economies often take several years to recover from climate-related shocks. There is ongoing debate in the literature over whether climate damages constitute one-off shocks that temporarily reduce the level of GDP or whether they decrease the growth rate of economies. Evidence suggests that severe weather events can leave lasting scars on regional economies, with GDP remaining below trend for at least five years after a severe event.

Impacts also depend on vulnerability. At the firm level, smaller and less productive firms appear to bear a disproportionate burden from heat stress. At the regional level, less diversified and poorer economies tend to recover more slowly from extreme weather shocks. More broadly, the literature has long highlighted the greater vulnerability of poorer households, who are often more exposed and less able to protect themselves and absorb losses when shocks occur.

Looking ahead, projections consistently point to rising GDP losses over time. While estimates vary across studies due to differences in hazards considered, assumed transmission channels, and modelling techniques, they consistently indicate increased climate change damages as global warming increases.

For instance, OECD/UNDP (2025<sup>[30]</sup>) estimates that climate change could decrease global GDP by about 2–29% by 2100 relative to a no-climate-damage baseline under a current policies scenario, while OECD (2025<sup>[29]</sup>) estimates losses of 9–36% by 2100. Focussing on a selection of climate hazards, Unsal et al. (forthcoming<sup>[16]</sup>) finds a decrease of 6.3% in global GDP by 2100.

The evidence reviewed also highlights some key knowledge gaps and identifies possible areas of future work. Overall, five main areas stand out:

- **Integrating adaptation into macroeconomic modelling:** The integration of climate damages into macroeconomic models is a significant methodological advance. The next frontier is to integrate adaptation into these frameworks. Upcoming OECD work aims to model the effects of both mitigation and adaptation policies on macroeconomic growth and fiscal stances.
- **Understanding compounding risks.** Climate hazards can occur simultaneously or in close succession, thus reinforcing one another. For instance, droughts can coincide with heatwaves, raising wildfire risk and reducing the water available to cool energy infrastructure. Understanding how multiple climate impacts interact — and how they combine with non-climate shocks — is an important area for further research.
- **Strengthening evidence on vulnerability and resilience.** The impacts of climate change depends on the intensity of the hazard but also on the exposure, value and vulnerability of people and assets. While there has been significant progress in measuring and projecting hazard exposure and intensity, vulnerability remains underexplored. The OECD is developing a new set of indicators to assess population vulnerability and risk, focusing specifically on extreme heat and air pollution.
- **Understanding household demand, risk perception and political economy.** Current models rely on multiple assumptions on household preference in relation to adaptation, including the extent of autonomous adaptation that can take place under a given warming trajectory, risk perceptions and willingness to pay for adaptation actions. The forthcoming OECD IMPACT (Individuals' Preferences for Measures and Policies to Adapt to Climate Threats) survey aims at providing comparable cross-country evidence on how households perceive climate risks, which adaptation measures and policy instruments they support, and how much they are willing to pay for various options.
- **Estimating the benefits and costs of adaptation.** While evidence on climate change damages is increasingly available, evidence on the benefits of adaptation is more limited. While evidence on climate change damages is increasingly available, evidence on the benefits of adaptation is more limited. Future research could investigate where adaptation action delivers the highest returns.

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