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Climate Extremes and Regional Growth in Greece: Evidence from 52 Regions

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Abstract

How much do heat waves, droughts, floods and wildfires cost the Greek economy, and what does this mean for the public finances? We combine regional accounts for Greece's 52 NUTS-3 regions over 2002–2023 with satellite and climate data for 2001–2025. Large wildfires hurt tourism-related services (trade, transport, accommodation and food) mainly in the season after the fire: a fire that burns 1% of a region's area lowers the sector's growth by about 0.8 percentage points over three years. A year of heat waves and drought like 2022 or 2023 lowers agricultural growth by about 3 percentage points in every region, with the islands most exposed, but has no clear effect on industry. Floods leave no measurable trace in annual growth; their cost falls on homes, infrastructure and the state budget. For the public finances, relief costs about twice as much as the revenue lost through lower output, but the annual disaster allocation already covers part of it; what pushes debt above plan is recurrence. A disaster year like 2023 every three years would leave public debt 1.0 to 3.0 percentage points of GDP higher by 2038.

Keywords: Climate change; Heat waves; Droughts; Floods; Wildfires; Regional growth; Public finances; Greece

JEL Classification: Q54; R11; Q10

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1 Introduction

In August 2026 a wildfire in Halkidiki forced around 500 tourists to be evacuated by sea, weeks after a fire near Athens burnt 110 km² of forest.[1] Across Europe, the same summer's heat waves, droughts and wildfires, which burnt about 400,000 hectares in Spain and France alone, were described by the President of the ECB as "a warning" that the costs of climate change are rising (Lagarde, 2026). Such events are becoming more frequent. Greece's heat-wave index more than doubled between 2002–2006 and 2018–2022, one of the three largest increases in the EU (Spiteri et al., 2026). The wildfires of 2021 and 2023 burnt more than 130,000 and 175,000 hectares respectively, and Storm Daniel, which flooded the Thessalian plain in September 2023, caused more than 2 billion euros of damage, about 1% of GDP (OECD, 2024).

Greece is also more exposed than most EU economies, because it relies more on the activities that climate extremes hit hardest. Agriculture accounts for 4.1% of gross value added (GVA), against 1.8% in the EU. Trade, transport, accommodation and food services, the sector through which tourism enters the regional accounts and which we call *tourism-related services* for short, account for 23.8% of GVA and 36.8% of employment.[2]

This note asks three questions. How much do climate extremes cost the Greek regional economy? Which sectors and regions bear the cost? And what does this mean for the public finances? Answering them is a natural task for parliamentary budget offices, which the OECD sees as well placed to assess the impact of climate change on the economy and the budget (OECD, 2022).

We use two tools. For wildfires and floods, which strike at a known time and place, we compare growth in the regions hit with growth elsewhere, before and after the event. For heat waves and droughts, which build up over months and affect most of the country at once, we use the machine-learning model of Spiteri et al. (2026) to simulate growth in a year as extreme as 2022 or 2023. The analysis covers Greece's 52 NUTS-3 regions and four sectors: agriculture, industry, manufacturing and tourism-related services.

Main findings.

- **Wildfires hit tourism in the following season.** A fire that burns 1% of a region's area lowers growth in tourism-related services by about 0.8 percentage points over three years. Most of the loss comes in the year after the fire, when relief payments have ended. For the Rhodes fire of 2023, this implies that by the third year after the fire, tourism-related services generate about 73 million euros less value added a year.
- **Heat and drought cut farm growth everywhere.** A year of heat waves and drought like 2022 or 2023 lowers agricultural growth by about 3 percentage points in every region, roughly 200 to 240 million euros of value added nationally. The islands of the North Aegean, the Ionian and Crete are most exposed. Higher farm prices do not offset the loss. The loss is smaller than the EU average, most likely because part of Greek farmland is irrigated. Heat and drought have no clear effect on industry or manufacturing.
- **Floods leave no trace in annual growth, but a large bill.** Even Storm Daniel does not show up clearly in regional growth. The cost of floods falls on homes, infrastructure and the state budget rather than on the year's output.

[1] Euronews (2026), 'Wall of fire' forces sea evacuation in Greece as wildfires continue across Europe, 14 August 2026.

[2] Shares of gross value added at current prices and of total employment in 2025, from the national accounts (Eurostat, 2026, nama_10_a10 and nama_10_a10_e).

- **Recurring disasters push up debt.** In a year like 2023, lower output from heat waves, drought and fires worsens the budget balance by about 0.16% of GDP, while relief after that year's fires and floods costs about 0.3% of GDP. The annual allocation of 600 million euros covers part of the relief, but if such a year recurred every three years, public debt in 2038 would be 1.0 to 3.0 percentage points of GDP higher than projected.

Policy recommendations.

1. Turn the annual allocation of 600 million euros for natural disasters into a multi-year fund that builds up in quiet years and is drawn down in disaster years; recurring disasters could add 1.0 to 3.0 percentage points of GDP to debt by 2038.
2. Report disaster-related contingent liabilities in the budget and the medium-term fiscal plan.
3. Widen insurance cover, especially for households, only about 14% of which are insured against natural hazards.
4. Shift spending from relief towards prevention, starting with the irrigation and water supplies that cushion Greek farming against heat and drought.
5. Continue support for fire-hit tourist destinations into the season after a fire, when the loss peaks.

The note builds on evidence that climate extremes have lasting economic costs. Across countries, an extreme drought reduces GDP growth by about 1 percentage point and a once-in-100-year heat wave by about half a point (Nguyen et al., 2026). In Europe, droughts leave regional output up to 3 percentage points lower four years later (Usman et al., 2025), wildfires in Southern Europe reduce growth and jobs in retail, tourism and transport (Meier et al., 2023), and water scarcity is the most material nature-related risk for the euro area (Ceglar et al., 2025). This note is the first to measure these costs for Greek regions and to link them to how Greece pays for disaster relief. Section 2 describes the data and Section 3 Greece's exposure. Sections 4 and 5 report the results for wildfires and floods and for heat waves and droughts. Section 6 discusses the public finances and policy, and Section 7 concludes.

2 Data

2.1 Economic data

The main variable is the annual growth of real gross value added per inhabitant in four sectors: agriculture, forestry and fishing (NACE A), industry excluding construction (B–E), manufacturing (C), and tourism-related services, that is trade, transport, accommodation and food services (G–I). Spiteri et al. (2026) study the first three. We add G–I because it is the sector through which tourism enters the regional accounts and the largest in the Greek economy. Nominal GVA by NUTS-3 region is deflated with the GVA deflator of the NUTS-2 region to which it belongs and divided by population, as in Spiteri et al. (2026). The sample covers all 52 NUTS-3 regions over 2002–2023.[3]

[3]We use the 52 NUTS-3 regions of Eurostat's classification. They differ from both the 51 former prefectures and the 74 regional units created under Kallikratis (Law 3852/2010), because Eurostat groups some regional units into a single NUTS-3 region. Argolida and Arkadia, for example, form one region, and the nine regional units of the Cyclades form another. Attica's eight regional units form seven NUTS-3 regions.

2.2 Climate indicators

The heat-wave and drought indicators come from the Copernicus European Drought Observatory (Copernicus, 2026) and follow Spiteri et al. (2026) (Table 1). Each index is measured against the long-term climate of the location and averaged over the grid cells of each region. The indicators record only abnormal conditions: values are kept when they signal a heat wave or low river flow (index above zero) or a drought (index at or below -1), and are set to zero otherwise.

Table 1: Climate indicators (Copernicus European Drought Observatory)

Indicator	What it measures	Counted as extreme when
Heat and Cold Wave Index (HCWI)	Heat waves (3+ days above local norms)	above 0
Standardised Precipitation Index, 1, 6, 12 months	Rainfall shortfall	−1 or lower
Low-Flow Index	Low river flow	above 0
Soil Moisture Anomaly	Dry soils	−1 or lower
fAPAR anomaly	Vegetation stress seen by satellite	−1 or lower

Notes: fAPAR switches from the MODIS to the VIIRS satellite product after 2022. Indicators are available monthly or at higher frequency for 2001–2025.

Two further indicators are used for floods and wildfires. **Extreme rainfall** is measured with ERA5-Land hourly precipitation from the Copernicus Climate Data Store for 2001–2025. For each region and year we compute the wettest day, the wettest five consecutive days, the number of days above 20 mm and the number of days on which any grid cell exceeds 50 mm.[4] **Burnt area** comes from the European Forest Fire Information System (EFFIS), which maps every fire of roughly 30 hectares or more from satellite images, together with the land cover inside it. Each fire is matched to the regions it crossed, and exposure is the share of each region's area burnt in a year. The public EFFIS database covers 2016–2026.[5]

3 Greece's Exposure to Climate Extremes

Exposure is concentrated in different parts of the country (Figure 1). Agriculture accounts for more than a quarter of GVA in Pella and Imathia in Central Macedonia and in Ileia in the western Peloponnese, against 4.1% for Greece as a whole. Tourism-related services dominate the islands, reaching 55% of GVA in Zakynthos and about half in the Cyclades and the Dodecanese. Heat and drought therefore matter most for regional income on the agricultural mainland, and wildfires and shifts in tourist demand on the islands.

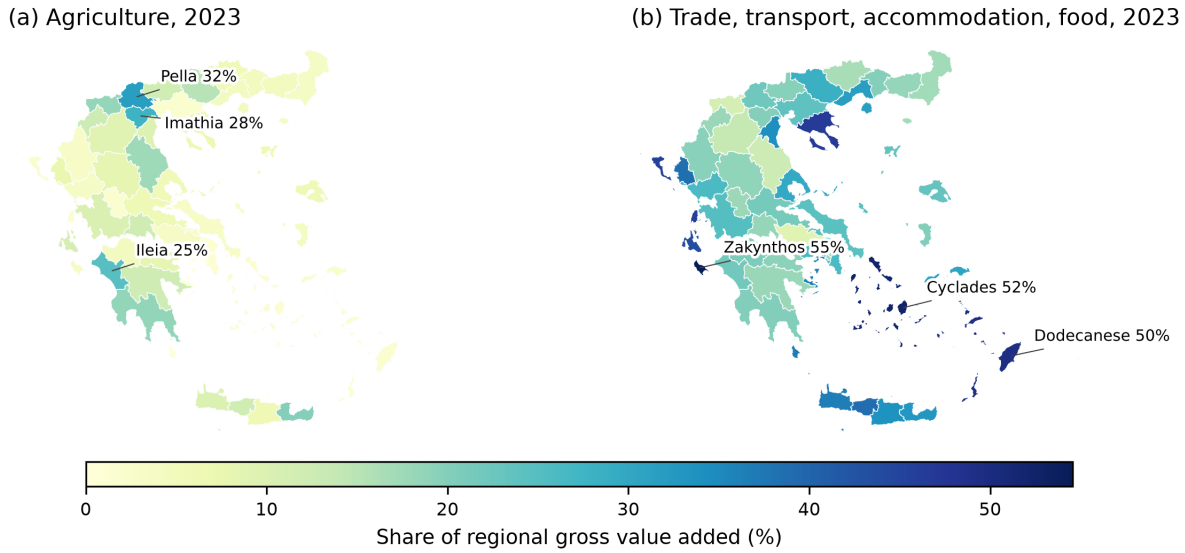
Agricultural output is also more volatile than the rest of the economy. Real agricultural value added rose by 14.6% in 2022 and fell by 14.1% in 2023, the year of the July heat waves, the wildfires and Storm Daniel, while total value added grew by 5.1% and 2.3% (Eurostat, 2026, nama_10_a10, chain-linked volumes). Leaving out 2020–2021, annual agricultural growth since 1996 has varied almost twice as much as growth in the whole economy, and by 2025 farm output was still 11% below its 2019 level.[6]

[4] ERA5-Land is preferred to the station-based E-OBS dataset, which records Storm Daniel as at most 45 mm a day in Thessaly, against 300–700 mm measured at individual stations (Katsanos et al., 2024).

[5] Burnt-area data for 2008–2015 are not available in the public EFFIS database; they would allow the wildfire analysis to start in 2010.

[6] Standard deviation of annual growth in real value added (chain-linked volumes), 1996–2025, excluding 2020 and 2021: 6.6 percentage points for agriculture against 3.8 for the whole economy, a ratio of about 1.7. Source: Eurostat (2026, nama_10_a10); authors' calculations.

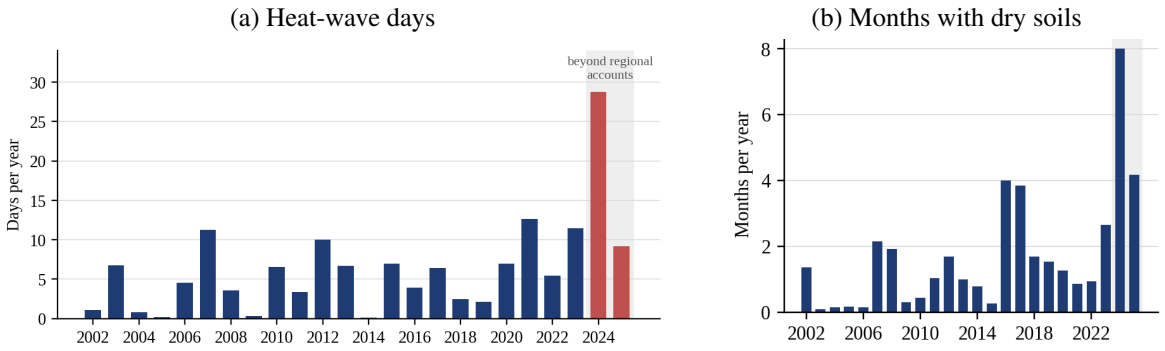
Figure 1: Sectoral exposure across regions



Notes. Share of each sector in the region's gross value added at current prices, latest year available. Labels show the three regions with the highest shares. Source: Eurostat (2026, nama_10r_3gva); authors' calculations.

The climate is moving against both sectors. Greece started from the lowest heat-wave index of all EU countries in 2002–2006 (0.35) and more than doubled it by 2018–2022 (0.82), the third-largest relative increase after Cyprus and Spain (Spiteri et al., 2026, Table A.1). Across the 52 regions, the number of heat-wave days between May and September rose from 2.7 a year on average in 2002–2006 to 13.5 in 2021–2025 (Figure 2a). The increase was largest in Evros (+22 days), the Athens area and East Attica (+18 to +20) and Evia (+17), and smallest on the islands. The years after the end of the regional accounts stand out: in 2024 the regional average reached 28.7 heat-wave days, more than twice any earlier year, and soils were dry for eight months (Figure 2b). Extreme rainfall, by contrast, shows no trend.[7]

Figure 2: Heat waves and dry soils in Greece, 2002–2025



Notes. (a) Average number of days between May and September with a positive Heat and Cold Wave Index, across the 52 regions. (b) Average number of months per year with a soil moisture anomaly of −1 or lower. The shaded years, 2024–2025, lie beyond the end of the regional accounts. Source: Copernicus (2026, European Drought Observatory); authors' calculations.

Tourism is concentrated in the months when heat and fire risk peak. Travel receipts reached 23.6 billion euros in 2025, equivalent to about 11% of GVA (Bank of Greece, 2026c; Eurostat, 2026).[8] July–September

[7] Averaged across the 52 regions, the wettest day of the year was 46.6 mm in 2002–2006 and 44.8 mm in 2021–2025, and the wettest five days 91.0 and 91.1 mm; neither shows a statistically significant linear trend over 2002–2025. Source: Copernicus (2026, ERA5-Land); authors' calculations.

[8] 23.6 billion euros of travel receipts divided by GVA of 214.2 billion euros in 2025 at current prices. Receipts measure visitors' spending rather than value added, so the ratio indicates scale only.

brought in 52% of the year's receipts and April–September 80%, against 4% in January–March. These are also the months in which climate projections show the largest loss of comfort for visitors (Lemesios et al., 2024).

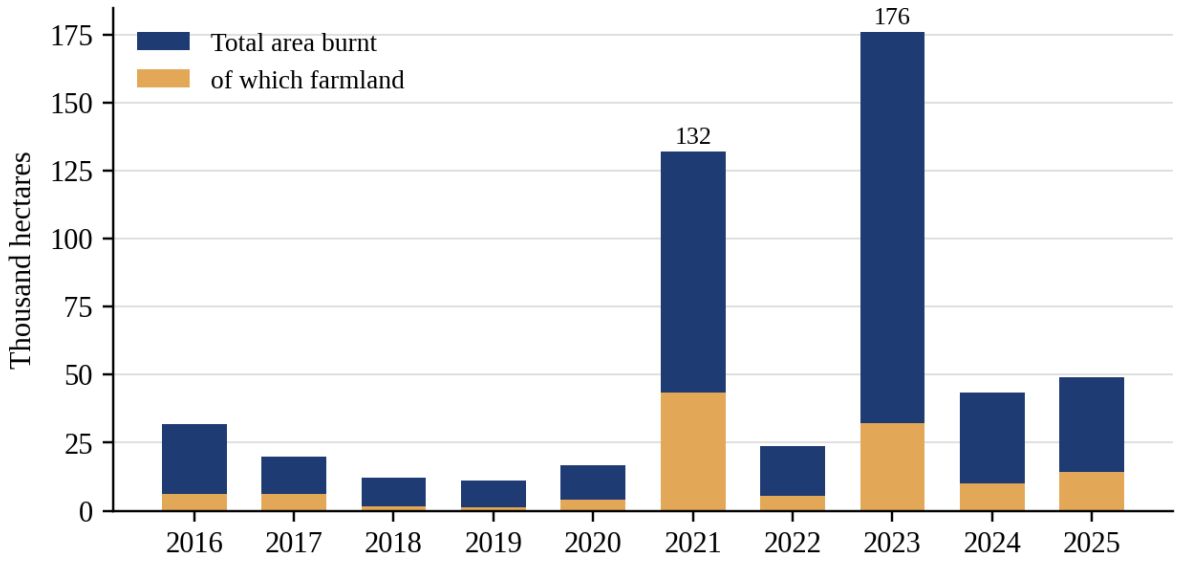
4 Wildfires and Floods: Evidence from Past Events

Wildfires and floods strike at a known time and place, so their effect can be measured directly. We compare growth in the regions hit by a fire or flood with growth in the other regions in the same year, from the year before the event to two years after. Comparing regions in the same year removes national shocks such as the pandemic, and comparing each region with its own past removes permanent differences between regions. The year before the event serves as a check: an event cannot affect growth before it happens, so a clear difference in that year would show that the regions hit were already on a different path. The approach follows the literature on natural disasters (Felbermayr and Gröschl, 2014; Meier et al., 2023); details are in Appendix B.

4.1 Wildfires

Wildfire losses are rising fast. Average annual losses from wildfires in OECD countries rose by 360% between 2000–2014 and 2015–2024, and Greece is among the countries that have recorded years with losses above USD 1 billion (OECD, 2026b). We measure exposure by the area burnt, since the damage depends on whether a fire breaks out, how large it becomes and what it burns. The EFFIS database holds 1,768 burnt areas in Greece between 2016 and September 2026. Fires burnt 131,900 hectares in 2021, a third of it farmland, and 175,700 hectares in 2023 (Figure 3, which stops at 2025, the last complete fire season). The Evros fire of 2023 alone burnt 22% of the region's area (Appendix Table C1).

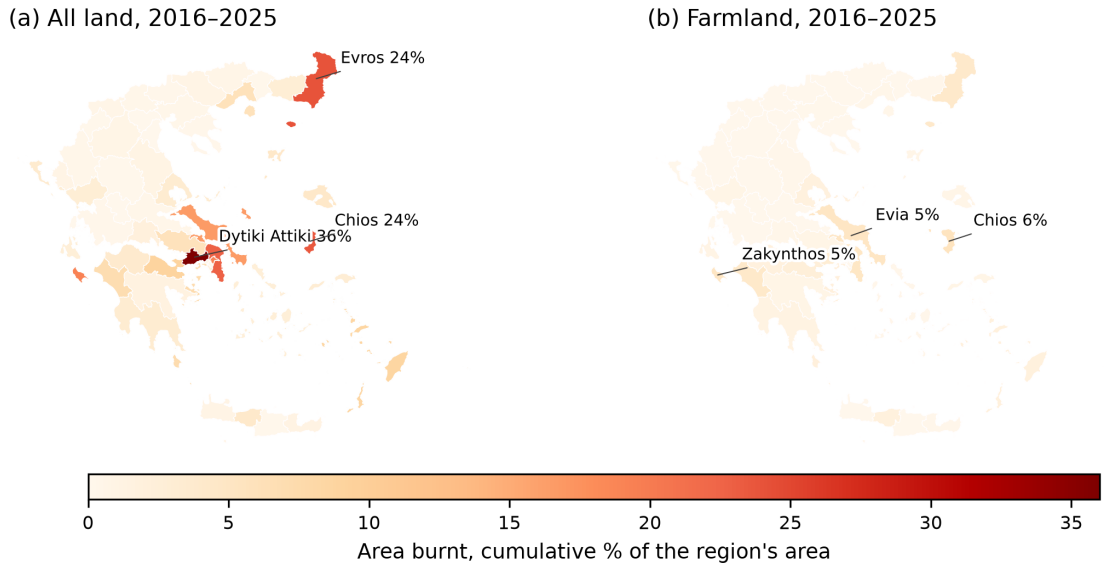
Figure 3: Area burnt in Greece by year, 2016–2025



Notes. Thousand hectares of satellite-mapped burnt area (fires of roughly 30 hectares or more), with the part classified as farmland by CORINE land cover. Source: Copernicus (2026, EFFIS burnt areas database); authors' calculations.

Burnt area is concentrated in a few regions (Figure 4). Between 2016 and 2025, fires burnt the equivalent of 36% of Dytiki Attiki, mainly in 2021 and 2023, and 24% of Evros and of Chios, while most regions lost less than 5%. Burnt farmland is far smaller, at no more than 6% of any region's area (Chios, Evia and

Figure 4: Area burnt by region since 2016

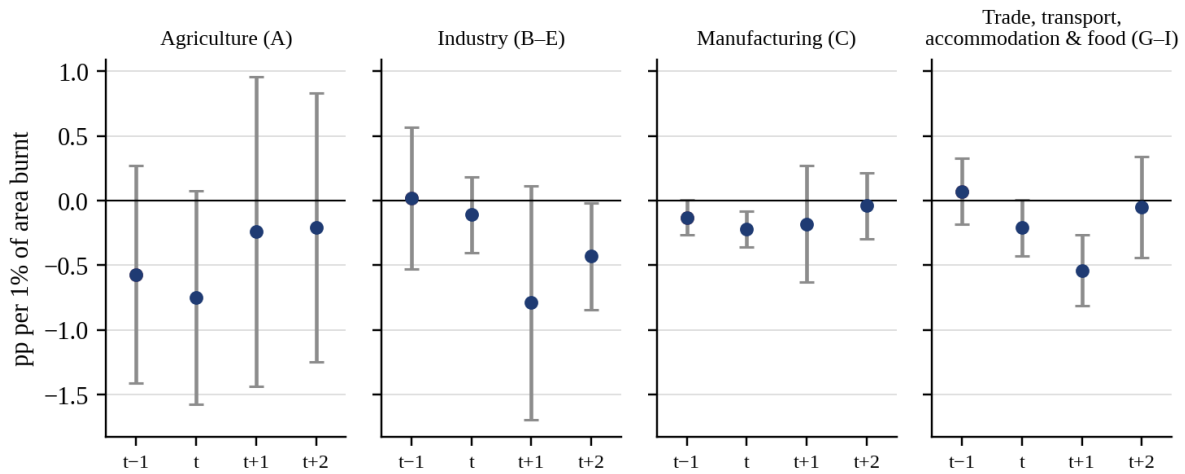


Notes. Sum of the annual area burnt as a share of the region's area, 2016–2025; land burnt more than once is counted each time. Labels show the three regions with the largest shares. Source: Copernicus (2026, EFFIS burnt areas database); authors' calculations.

Zakynthos), because large fires burn mainly forest and scrub.

Because two years after the fire are needed and the regional accounts end in 2023, the analysis covers the 52 regions over 2018–2023 (312 observations), with 27 unit-years in which at least 1% of the area burnt. Figure 5 and Appendix Table C2 show the results.

Figure 5: Growth before and after a wildfire, by sector



Notes. Change in growth of real GVA per capita, in percentage points, per 1% of the region's area burnt, with 95% confidence intervals. t−1 is the year before the fire (a check: there should be no effect); t is the fire year. Estimates are in Appendix Table C2.

The clearest result concerns tourism-related services. Before a fire, growth in the regions later hit is no different from elsewhere. It dips slightly in the fire year, by 0.21 percentage points for each 1% of the region's area burnt, and falls clearly in the following year, by 0.54 points, before returning to normal. Over the three years the loss adds up to 0.8 points for each 1% of area burnt, and the result holds when

each fire-hit region is dropped in turn and with sector-specific deflators (Section 5.2).[9] The timing fits what a fire does to a destination: bookings for the next season fall, and damaged infrastructure takes time to restore. A lost season cannot be rebuilt the way a road can, which helps explain why reconstruction spending supports output less after fires than after floods (Chrysanthakopoulos and Tagkalakis, 2026). The result matches Meier et al. (2023), who find that fires in Southern Europe cut jobs mainly in retail, tourism and transport.

To give a sense of scale, the Rhodes fire of July 2023 burnt 18,700 hectares, or 6.9% of the Dodecanese (Appendix Table C1). Assuming the effect rises in proportion to the area burnt, the estimate implies that by the third year after the fire, value added in the region's tourism-related services was about 4.8% lower in current prices, or roughly 73 million euros a year.[10]

Industry also grows more slowly after a fire, by 1.3 percentage points over three years for each 1% of area burnt, but this rests almost entirely on one event, the 2021 fire in northern Evia, which reached the island's mining area. Without Evia the effect is no longer significant. In agriculture and manufacturing, growth in the regions hit was already lower in the year before the fire, so the data cannot separate a fire effect from regions that were already doing poorly.[11]

4.2 Floods

Storm Daniel was the most destructive flood in Greece in recent decades. Between 4 and 7 September 2023, stations in Thessaly recorded 300–700 mm of rain (Katsanos et al., 2024). About 1,150 km^2 were flooded, of which 820 km^2 was farmland in the Thessalian plain, including about 30% of Thessaly's cotton area (He et al., 2024). The storm claimed at least 15 lives and caused more than 2 billion euros of damage (OECD, 2024).

The climate data capture the event well: 5–6 September 2023 appear six times among the 15 wettest region-days since 2001, with up to 259 mm in a single day over one 9 km $\times$ 9 km area of Karditsa–Trikala. The regional accounts, by contrast, register the flood unevenly (Figure 6). Agricultural growth fell by 22% in Karditsa–Trikala in 2023, the most flooded area, but rose by 13% in Larisa and was flat in Magnisia. Swings in ordinary years are larger: agricultural growth in Larisa and Magnisia rose by 37–39% in 2021 and fell by 25–26% in 2022. The flood came after the wheat harvest, followed a sharp fall in output in 2022, and was partly offset by compensation payments, all of which weaken the measured effect.

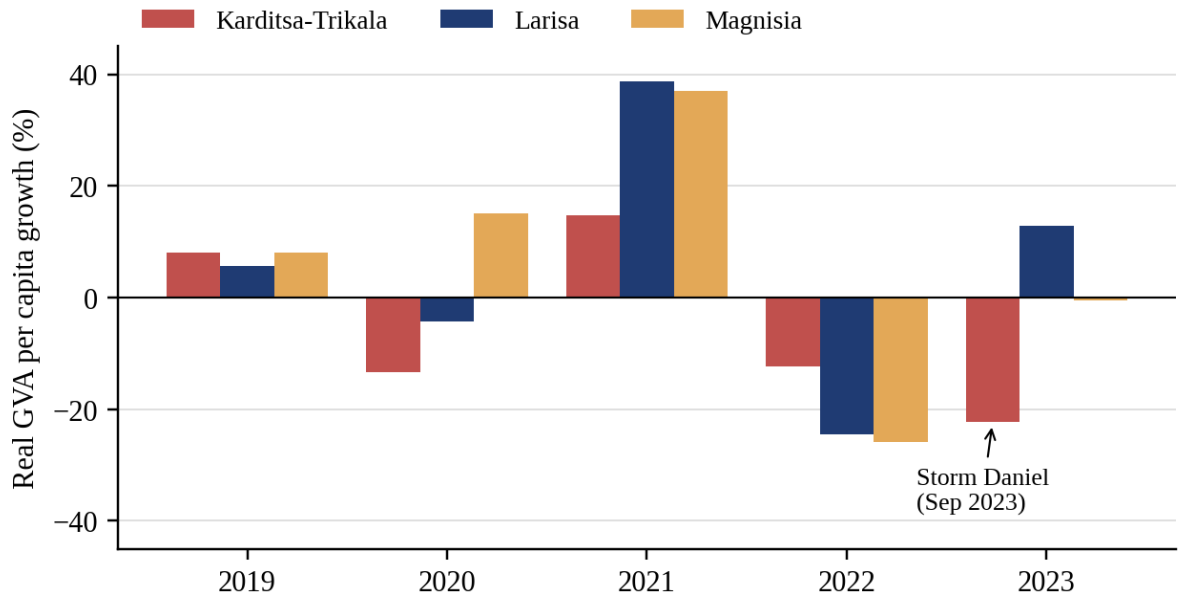
To see whether major floods lower growth more generally, we pool the 13 unit-years with extreme five-day rainfall since 2001, 11 of them within the estimation period and five of them from Storm Daniel (Appendix Figure C1). Because wet years in Greece usually bring good harvests, we control for the year's total rainfall. Floods have no statistically significant effect on growth in any sector (Appendix Table C3).

[9] We re-estimate the regression excluding, one at a time, each of the 23 regions in which at least 1% of the area burnt in a single year. The effect on tourism-related services in the year after the fire stays between -0.42 and -0.60 percentage points and significant at the 1% level, and the cumulative effect ranges from -0.58 to -0.90 points. The cumulative effect on industry falls to -0.81 points and loses significance when Evia is excluded ($p = 0.20$).

[10] The calculation has three steps. First, in each year, growth in the region's tourism-related services is lower by the share of area burnt, 6.9%, times that year's current-price effect (Appendix B): $6.9 \times 0.22 \approx 1.5$ percentage points in the fire year, $6.9 \times 0.41 \approx 2.8$ points in the following year and $6.9 \times 0.06 \approx 0.4$ points in the year after. Second, these shortfalls in growth add up, so value added is about 1.5%, 4.3% and 4.8% below its path without the fire in the three years; the last figure equals 6.9 times the cumulative effect of 0.69 in Table 2. Third, applying these percentages to the sector's value added in 2022, 1,533 million euros at current prices (Eurostat, 2026, nama_10r_3gva), gives shortfalls of $1.5\% \times 1{,}533 \approx 23$, $4.3\% \times 1{,}533 \approx 66$ and $4.8\% \times 1{,}533 \approx 73$ million euros. With the real effect of 0.80 points, the gap after three years would be about 5.5%.

[11] Three further limitations apply. The panel is short, with six years and 27 unit-years of significant fires. With many coefficients estimated across sectors, a few will appear significant by chance. And the largest fire, Evros in 2023, enters only in its fire year because the regional accounts end in 2023.

Figure 6: Agricultural growth in Thessaly's NUTS-3 regions, 2019–2023



Notes. Annual change in real agricultural GVA per capita. Storm Daniel hit Thessaly on 4–7 September 2023. 2023 data are provisional. Source: Eurostat (2026, nama_10r_3gva); authors' calculations.

Agricultural growth is lower in the flood year, but it was already lower the year before, and with so few floods the data cannot say more.

For floods, recorded damage is therefore a better guide than growth, because the damage falls mainly on homes, infrastructure and farmland rather than on the year's output. The OECD (2024) points to two further costs. Daniel cut road and rail links between northern and southern Greece, slowing national growth in the second half of 2023. And government compensation for the 2023 fires and floods amounted to about 0.3% of GDP, which supports incomes in the affected areas, reduces the measured fall in output and turns climate damage into a fiscal cost. Cross-country evidence points the same way: floods, wildfires and high temperatures weigh more on the public finances than on output (Chrysanthakopoulos and Tagkalakis, 2026).

5 Heat Waves and Droughts: How Sensitive Is Agriculture?

Heat waves and droughts build up over weeks or months and affect most of the country at once, so there is no clear event date and no unaffected group to compare with. We therefore ask a different question: how much lower would growth be in a year as extreme as 2022 or 2023 than in a year with no heat waves or drought? To answer it we use the machine-learning model of Spiteri et al. (2026), which predicts each region's growth from its past growth, employment, national growth, type of region and the climate indicators of Section 2.[12] We set every heat-wave and drought indicator to the most extreme value observed across Greek regions in the reference year, and compare predicted growth with the prediction when all indicators are set to zero. The model also allows heat and drought to compound, both across neighbouring regions and when a heat wave coincides with a drought (Appendix B).

We use two reference years: 2022, the year used by Spiteri et al. (2026), and 2023, which was harsher in

[12] With 52 regions instead of the 1,117 in the EU-wide sample of Spiteri et al. (2026), the Greek estimates are less precise, and national growth is identical across regions in each year.

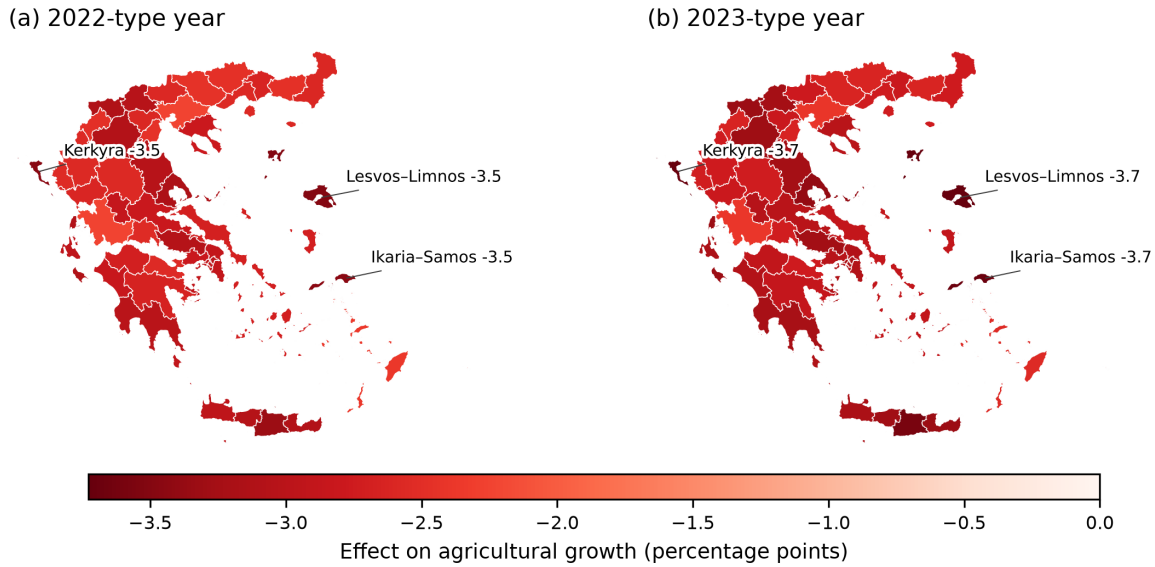
Greece. Heat-wave days averaged 11.5 across regions in 2023 against 5.4 in 2022, and soils were dry for 2.7 months against less than one. Later years cannot be used, because the regional accounts end in 2023. Because the model is built to predict rather than to identify causes, the results show how sensitive growth is to extreme conditions, not the loss to expect in a typical year.

5.1 Results

In a 2022-type year, the model predicts agricultural growth 2.82 percentage points lower than in a year without heat waves or droughts (Appendix Table C4). The effect is negative in all 52 regions, ranging from −3.50 to −2.25 points (Appendix Table C4), and is similar when the extremes are taken from all years (−3.08). A 2023-type year gives a slightly larger loss of 3.02 points on average, ranging from −3.73 to −2.40. The Greek loss is smaller than the EU average of −4.54 points reported by Spiteri et al. (2026) and close to their −3.9 points for Greece and Italy.

For the other sectors the model gives no reliable answer. The effects on industry and manufacturing are small and change sign with the reference year, and those on tourism-related services are positive (Appendix Table C4). The positive effects should not be read as heat raising tourism income: over 2002–2023 hot summers coincided with strong tourist seasons, including the post-crisis expansion and the rebound after COVID-19, and the model cannot separate the two.

Figure 7: Simulated effect of a heat-wave and drought year on agricultural growth, by region



Notes. Difference in agricultural growth between the extreme scenario and the scenario without heat waves or droughts, in percentage points. Both panels share the same colour scale. Labels show the three most affected regions. Source: authors' calculations.

The loss is similar across the country (Figure 7). In a 2022-type year it is largest on the islands, in Lesvos–Limnos, Ikaria–Samos and Kerkyra (about 3.5 points) and Irakleio (3.3), and smallest in Aitoloakarnania and Thessaloniki (2.3). The ranking is almost the same for a 2023-type year, because the same shock is applied everywhere and the differences reflect each region's economic structure rather than its climate. Because farming is a much larger part of the economy on the mainland (Figure 1), the loss weighs more on total regional income there. The smaller loss than the EU average fits the view of Spiteri et al. (2026) that Southern farming is partly irrigated and adapted to heat. That buffer, however, lasts only as long as the water does.

5.2 Volumes, prices and incomes

A fall in farm output could in principle be offset by higher prices, as the surge in olive-oil prices in 2023–2024 suggests. What matters for farm incomes and for tax revenue is value added in current prices. Table 2 therefore reports the main results in three ways, re-estimating the models with growth measured in real terms with the regional deflator used so far, in real terms with a national deflator for each sector, and in current prices.

The results change little. For agriculture, a 2022-type year lowers growth by 2.8 percentage points in the main estimate, 2.1 with the sector deflator and 2.3 in current prices; a 2023-type year by 3.0, 2.5 and 2.7. The loss in current prices is, if anything, slightly larger than the loss in volume measured with the sector deflator, so higher farm prices do not cushion farm incomes on average. The gap between these two measures and the main estimate reflects the regional deflator, which covers the whole economy, rather than farm prices. Tourism-related services show the same pattern after a fire: the cumulative loss is 0.63 points with the sector deflator and 0.69 points in current prices, both significant at the 5% level. In current prices, a 2022-type year would cost agriculture about 200 million euros of value added, and a 2023-type year about 240 million euros, compared with the 600 million euros set aside each year for all natural disasters (Section 6.2).[13]

Table 2: Main results in real and nominal terms

Result	Real, regional deflator (main)	Real, sector deflator	Nominal
Agriculture, 2022-type year	−2.82	−2.13	−2.27
Agriculture, 2023-type year	−3.02	−2.53	−2.70
Tourism-related services: cumulative effect per 1% of area burnt	−0.80	−0.63	−0.69

Notes: Percentage points of growth in GVA per capita. The first two rows are from the heat-wave and drought scenarios (Section 5.1); the last row is the cumulative effect from the fire year to two years after (Section 4.1). Tourism-related services are trade, transport, accommodation and food services (NACE G–I). The main estimate deflates regional GVA with the NUTS-2 GVA deflator; the sector-deflator column uses national deflators by sector; the nominal column uses GVA at current prices without deflation.

6 What It Means for the Public Finances

The results point to three different kinds of cost. Heat and drought cause a recurrent loss in agriculture; wildfires cause a loss in tourism-related services that peaks in the season after the fire; and floods destroy capital, with much of the bill landing on the state. Each reaches the budget through a different route and calls for a different instrument.

6.1 How much could disasters add to public debt?

To show what our estimates imply for the budget, we run a simple stress test in two steps. First, the output losses from Sections 4 and 5 are converted into budget effects with the European Commission's budget semi-elasticity of 0.5: when output falls by 1%, the budget balance worsens by 0.5% of GDP (Mourre et al., 2019). Second, the effect on public debt is traced against the path in the Medium-Term

[13] Computed as $2.27\% \times 8{,}867 \approx 200$ and $2.70\% \times 8{,}867 \approx 240$ million euros, applying the current-price effects in Table 2 to agricultural value added in 2025, 8,867 million euros at current prices (Eurostat, 2026, nama_10_a10). The calculation treats the average effect across regions as a national effect for a single year. With the main real estimate of 2.82%, the 2022 figure would be about 250 million euros.

Fiscal-Structural Plan 2025–2028, which projects debt, nominal growth and interest to 2038 (Ministry of National Economy and Finance, 2024b). Because tax revenue depends on value added in current prices, we use the current-price estimates of Section 5.2 (details in Appendix B).

We define a 2023-type disaster year as one that repeats three features of 2023: heat waves and drought as severe as in 2023, a fire season like that of 2023, and relief spending equal to the compensation paid after the 2023 fires and floods. Floods enter only through relief, because they leave no measurable trace in annual growth (Section 4.2). The heat waves, drought and fires lower GDP by about 0.32% over three years. Agriculture accounts for 0.12 percentage points in the year itself: an agricultural effect of 2.71 points times agriculture's 4.3% share of GVA in 2023. Tourism-related services account for 0.20 points over three years: the cumulative effect of 0.69 points per 1% of area burnt, times the average share of area burnt in 2023 weighted by the sector's value added (1.15%), times the sector's 24.8% share of GVA in 2023.[14] The budget balance therefore worsens by about 0.16% of GDP in total, approximately 400 million euros at 2025 prices. Relief paid after the fires and floods of 2023, about 0.3% of GDP or 745 million euros at 2025 prices (OECD, 2024), was about twice as large. Relief is therefore the larger gross cost, although the annual allocation already budgets for part of it. Part of the relief could also be met from the general reserve of the State Budget, which would reduce the effect on debt further, but the reserve covers all unforeseen expenditure in the year and is not set aside for disasters only.

Table 3 and Figure 8 show how far public debt would deviate from the projected debt trajectory under three scenarios, each starting in 2027. In S1, a heat-wave and drought year like 2023 hits agriculture. In S2, a 2023-type fire season and relief spending are added. In S3, the S2 year recurs every three years. Relief in a disaster year is set at 0.3% of GDP, the compensation paid in 2023, or about 800 million euros at 2027 prices. The projected debt trajectory already includes the 600 million euros budgeted each year for natural disasters, which pays for both compensation and prevention (Section 6.2). We therefore consider two cases. If the whole allocation goes to relief, only 200 million euros (0.08% of GDP) is new spending; if half goes to relief and half to prevention, 500 million euros (0.19% of GDP) is new spending. Each scenario is run twice, once with output recovering the following year and once with the loss of output persisting, which bound the result from below and above.[15]

A single disaster year leaves debt less than 1 percentage point of GDP higher by 2038 (0.25 to 0.80 points), and heat and drought alone add at most 0.23 points. Recurrence is what matters. As Figure 8 shows, debt rises with each disaster year and does not come back down in the years without disasters, so the gap with the projected debt trajectory widens every time a disaster recurs. If a 2023-type year occurs every three years, debt in 2038 is 1.0 to 3.0 points higher than projected. The upper end is comparable to the 2.6 to 2.8 points by 2032 that the European Commission's stress tests attribute to extreme weather under warming (Gagliardi et al., 2022). The result changes little with a semi-elasticity of 0.45 or 0.55.[16]

Disasters slow the anticipated decline in debt but do not reverse it. Even in the year of the shock, debt falls by about 4.6 to 4.7 percentage points of GDP, against 5.1 points on the projected debt trajectory.[17]

[14] We use 2023 shares because regional GVA, which the calculation needs to measure value added in the burnt areas, is available only until 2023.

[15] Losses are likely to persist, since Figure 5 shows no catch-up after a fire and droughts depress regional output for up to four years (Usman et al., 2025).

[16] The stress test is illustrative. It applies the sensitivity estimates of Section 5, which are not an expected loss, assumes that disasters of 2023 size recur at fixed intervals, and leaves out the cost of reconstructing public infrastructure, which European funds largely financed after Storm Daniel.

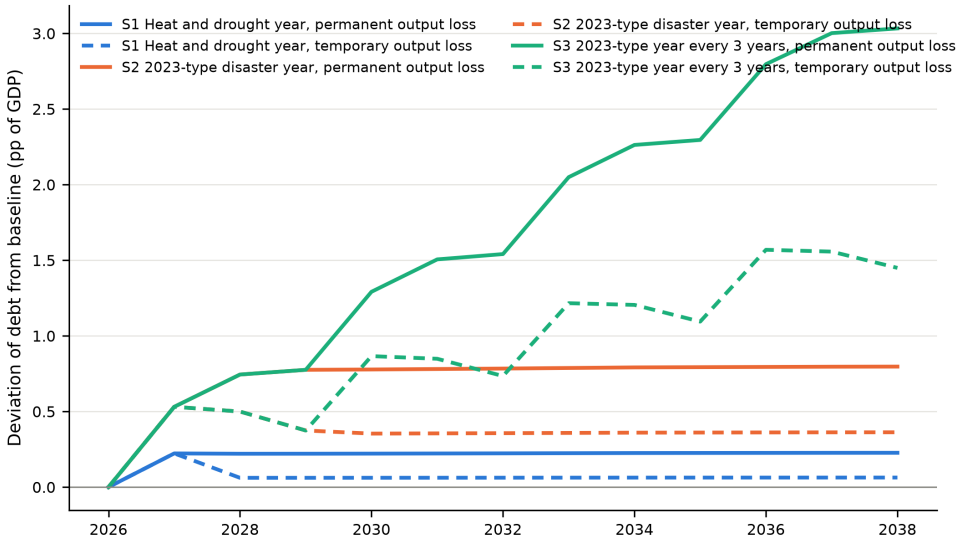
[17] On the projected debt trajectory, debt falls from 143.1% of GDP in 2026 to 138.0% in 2027 (Ministry of National Economy and Finance, 2024b, Table 7). In the scenarios with disasters, the fall in 2027 is 4.7 percentage points when the allocation is used fully for relief and 4.6 points when half of it is.

Table 3: Deviation of public debt from the projected debt trajectory

Scenario	**2030** **% of GDP**	**2035** **% of GDP**	**2038** **% of GDP**
S1 Heat and drought year (no relief)	0.06–0.22	0.06–0.23	0.06–0.23
S2 2023-type disaster year			
Allocation used fully for relief	0.24–0.67	0.25–0.68	0.25–0.68
Half of the allocation used for relief	0.35–0.78	0.36–0.79	0.36–0.80
S3 2023-type disaster year every three years			
Allocation used fully for relief	0.65–1.07	0.76–1.96	1.00–2.58
Half of the allocation used for relief	0.87–1.29	1.09–2.30	1.45–3.03

Notes: Percentage points of GDP, relative to the projected debt trajectory of the Medium-Term Fiscal-Structural Plan 2025–2028, which includes the 600 million euros budgeted each year for natural disasters (Ministry of National Economy and Finance, 2024b). Shocks start in 2027. The lower value assumes that output recovers the following year and the higher value that the loss of output persists. Relief in a disaster year is 0.3% of GDP, about 800 million euros in 2027 (OECD, 2024). When the allocation is used fully for relief, 200 million euros (0.08% of GDP) is new spending; when half of it is used for relief and half for prevention, 500 million euros (0.19% of GDP). Output losses use the current-price estimates of Section 5.2; budget semi-elasticity of 0.5 (Mourre et al., 2019). Source: authors' calculations.

Figure 8: Deviation of public debt from the projected debt trajectory, 2026–2038



Notes. Percentage points of GDP. Solid lines assume that the loss of output persists; dashed lines that output recovers the following year. Scenarios as in Table 3, with half of the annual allocation for natural disasters used for relief. Source: authors' calculations.

The Medium Term Fiscal Structural plan projects no one-off disaster spending after 2024 (Ministry of National Economy and Finance, 2024b, Table 7), so relief beyond the annual allocation is not budgeted. In a single 2023-type year the allocation covers part of the relief, but when disasters recur, or are larger than in 2023, the excess has to be met with new funds, as in 2023, when relief required a supplementary budget. Relief recorded as one-off spending is excluded from net expenditure, as in the plan's own accounts (Ministry of National Economy and Finance, 2024b, Table 5), so it does not breach the expenditure path, but it still adds to the deficit and to debt.

6.2 How Greece pays for climate-related disasters

Greece relies on a small number of national and European instruments to finance disaster relief. Until 2023, disaster costs were met through supplementary budgets, such as the 600 million euros voted after the fires and floods of that year (Ministry of National Economy and Finance, 2023). Since 2024, the Public Investment Budget has included 600 million euros a year of national resources for natural disasters, financed partly by a higher climate crisis resilience levy on tourist accommodation, which the plan expects to raise about 200 million euros a year from 2025 (Ministry of National Economy and Finance, 2023, 2024a,b, p. 18). Since 2026, a Special Programme for Natural Disasters 2026–2030, with a budget of 800 million euros over the period, finances restoration, more resilient infrastructure, prevention in affected areas and state aid to those affected, without allocating the budget across these purposes (Hellenic Republic, 2026). In the budget, the allocation is entered under a single account covering both "support for those affected by natural disasters" and "prevention, protection and restoration"; in 2024 its 600 million euros were spread across five ministries and redistributed during the year, so the published accounts do not show how much went to relief and how much to prevention (Ministry of National Economy and Finance, 2025). Emergency needs can also be met from the reserve of the State Budget, set at 1–2% of State Budget expenditure excluding debt service and used only for urgent expenditure that could not be foreseen when the budget was passed (Hellenic Republic, 2014, Article 59, paragraphs 1 and 2). Like the annual allocation in the Public Investment Budget, however, the reserve does not build up in years without disasters. National state aid (Κρατική Αρωγή) and the agricultural insurance agency ELGA make the first payments to households, firms and farmers; after Storm Daniel they paid 459 million euros.[18] European funds came later and mainly financed public infrastructure. The EU Solidarity Fund granted 101.5 million euros for Daniel (European Commission, 2024a), and 2.25 billion euros of unspent 2014–2020 cohesion funds were mobilised after the 2023 fires and floods (European Commission, 2023).

Two features of this system stand out in the light of our results. First, relief is concentrated in the year of the disaster, whereas the loss in tourism-related services peaks in the year after a wildfire. Second, the instruments compensate damage after the event, while the recurrent cost of heat and drought for agriculture calls for planned instruments such as insurance and investment in irrigation.

These costs arise when fiscal policy has little room for unplanned spending. Under the reformed EU fiscal rules, spending must stay within an agreed net expenditure path, so disaster costs must be absorbed within it unless they are recognised as one-offs or financed by EU funds. The Bank of Greece lists natural disasters among the main downside risks to the fiscal outlook and calls for fiscal buffers (Bank of Greece, 2026a), while the Recovery and Resilience funds that finance much of Greece's public investment end after 2026 (OECD, 2026a). High debt also makes disasters more costly, because sovereign yields rise

[18] This included 80 million euros of first aid to 28,517 recipients, most of them farmers and livestock breeders, 225 million euros of advance payments on assessed damage, 91 million euros for housing and household property, 34 million euros approved for damaged orchards and vines, and 13 million euros of targeted support for tourism, transport, accommodation and fishing businesses.

more after climate disasters in high-debt countries (Anyfantaki et al., 2025). Internationally, the average fiscal cost of 29 costed disasters was 1.6% of GDP, with a maximum of 6% (OECD/World Bank, 2019). Elsewhere in Southern Europe the bill is already large: in Spain, firefighting alone is expected to cost the state 1.7 to 3.3 billion euros in 2026 (Morningstar DBRS, 2026).

International practice favours a layered approach: annual allocations absorb frequent, moderate losses, reserve funds that accumulate in quiet years cover rarer and more severe events, and borrowing or risk transfer is kept for extreme ones (OECD/World Bank, 2019; OECD, 2022). Our results map onto these layers. The recurrent cost of heat, drought and wildfires fits the annual allocation, whereas the damage from a Daniel-type flood calls for a reserve. After the 2023 fires and floods, the Bank of Greece called for a dedicated "rainy day" fund and a greater role for private insurance (Bank of Greece, 2023a,b). An allocation that is spent every year does not build such a buffer. Pre-funding pays off in large events: Spain's Consorcio de Compensación de Seguros absorbed 4.9 billion euros of losses from the 2024 Valencia floods without new public funds, thanks to reserves built up beforehand (OECD, 2026b). Financing through a levy collected in advance, such as the climate crisis resilience levy, also avoids raising taxes after a disaster, which can deepen the downturn (Molnar-Tanaka and Sakamoto, 2025).

6.3 Who bears the cost: households, firms and insurance

Households are the least protected. Only about 14% of Greek households have property insurance against weather-related hazards and earthquakes, and less than 20% of Greece's economic losses from natural hazards since 2000 were insured, so most losses fall on households and the state (OECD, 2026b). This matters for the budget, because higher insurance cover is associated with lower government spending after disasters (OECD, 2026b). The gap is not specific to Greece: coverage of climate-related losses is low in many European countries (Bank of Greece, 2026b).

Greek firms respond to climate risk mainly by insuring rather than adapting (Appendix Table A2). In 2025, 58% of Greek firms bought or renewed climate insurance, against 25% in the EU, but only 28% had an adaptation strategy and 34% had invested to reduce their exposure, close to the EU averages (European Investment Bank, 2025). Compulsory insurance against floods, earthquakes and forest fires for larger firms, with uninsured firms excluded from state aid (OECD, 2026b), reduces but does not remove this fiscal risk. Grants and EIB-backed credit lines under the NSRF programmes, tied to adaptation plans, could help close the adaptation gap.

6.4 Matching instruments to hazards

The instruments needed to reduce losses from climate-related hazards already exist (Appendix Table A3). The task is to match each to the hazard and sector it fits, and to use it before disasters as well as after (Table 4).

Heat and drought in agriculture. The irrigation that helps explain why Greek farm losses are smaller than the EU average depends on water that droughts are depleting (Ceglar et al., 2025). Investment in water-efficient irrigation, reservoirs and groundwater management can be financed through the CAP Strategic Plan (EAFRD), the programme 'Environment and Climate Change 2021–2027' and EIB loans to water utilities, with priority for the most exposed island regions. Water pricing that reflects scarcity would complement these investments. Because heat and drought losses recur, farm incomes are better protected through planned CAP risk-management tools and ELGA insurance than through ad hoc state aid.

Table 4: Matching relief instruments to disasters and sectors

Type of disaster	Sector most affected (this note)	Emergency relief	Recovery	Prevention and adaptation
Heat wave and drought	Agriculture: −2.8 to −3.0 pp of growth in a 2022- or 2023-type year	ELGA; CAP emergency lump sums	CAP restoration of production potential; income stabilisation	CAP irrigation and water efficiency; Cohesion Fund and EIB water investment; LIFE
Floods	Public infrastructure and farmland; transport links (Daniel)	State aid first aid and advances; EU Solidarity Fund	ERDF and Cohesion Fund reconstruction (RESTORE); ELGA plant capital; housing grants	Cohesion Fund and EIB flood defences; Regional Adaptation Action Plans (LIFE)
Wildfires	Tourism-related services: −0.54 pp per 1% of area burnt, the year after	State aid; targeted business support	ERDF support for tourism SMEs in the following season; EAFRD forest restoration	EIB civil protection (AEGIS); CAP forest-fire prevention; LIFE

Notes: Sector effects from Sections 4.1 and 5.1. The assignment of instruments reflects their eligibility rules and the evidence in this note; it is indicative rather than exhaustive.

Floods. Prevention should come first: flood defences and drainage in the Regional Adaptation Action Plans can be funded by the Cohesion Fund and EIB loans. After a flood, state aid and ELGA pay households, firms and farmers quickly, while the EU Solidarity Fund and the RESTORE rules, which allow ERDF and Cohesion Fund money to be redirected to reconstruction at 95% EU co-financing, pay for public infrastructure. Preparing reprogramming plans in advance would shorten the months between national relief and European money. Flood costs are better tracked through damage registries, insured-loss data and satellite flood maps than through annual growth figures.

Wildfires and tourism. Relief after a fire is paid in the fire year, but the loss in tourism-related services comes mainly in the following season. Support for affected destinations, such as liquidity for tourism firms and destination marketing under the regional NSRF programmes, should therefore continue into the next season. In the longer term, climate projections to 2100 show beach and island seasons lengthening into spring and autumn but fewer comfortable days in peak summer (Lemesios et al., 2024; Appendix Table A1). With 80% of receipts earned in April–September, marketing, flight capacity and opening calendars can shift towards the shoulder months.

6.5 Policy recommendations

1. **A multi-year disaster fund.** The annual allocation for natural disasters in the Public Investment Budget could become a fund that accumulates in quiet years and is drawn down in disaster years, sized to estimates of expected annual losses (OECD, 2022; Bank of Greece, 2023b). Our stress test suggests that recurring disaster years could add 1.0 to 3.0 percentage points of GDP to debt (Section 6.1).
2. **Transparency on contingent liabilities.** The medium-term fiscal plan and associated Draft Budgetary Plans should quantify, to the extent possible, disaster-related contingent liabilities. The amended EU directive on budgetary frameworks now asks Member States to publish information on contingent liabilities and fiscal costs related to disasters and climate (Council of the European Union, 2024a). They could be estimated with stress tests such as the one in Section 6.1, and reported together with how the annual disaster allocation is actually spent (OECD, 2022).
3. **Wider household insurance.** Where natural hazards are automatically included in property policies,

55–63% of flood losses are insured, against 23–32% where no requirement exists (OECD, 2022). A public-private scheme with a capped and remunerated state guarantee and support for low-income households would broaden cover (OECD, 2026b).

4. **From relief to prevention.** Spending should shift from relief towards prevention, which the Bank of Greece notes costs less than repairing damage after the event (Bank of Greece, 2023a), starting with irrigation and water supplies, flood defences and fire prevention.
5. **Support for fire-hit destinations**. Continue support for fire-hit tourist destinations into the season after a fire, when the loss peaks.

7 Conclusions

Climate extremes already leave a measurable mark on Greece's regional economy. Large wildfires lower growth in tourism-related services, mainly in the season after the fire. A year of heat waves and drought like 2022 or 2023 lowers agricultural growth by about 3 percentage points in every region, and higher farm prices do not soften the blow. Floods do not show up in annual growth, but Storm Daniel's damage of more than 2 billion euros shows that their cost falls on the capital stock and the budget instead. Heat and drought have no clear effect on industry or manufacturing.

For the public finances, relief costs more than the revenue lost through lower output: a 2023-type disaster year lowers the budget balance by about 0.16% of GDP through lower output, about half the relief paid in 2023. The annual allocation of 600 million euros covers part of that relief, and a single disaster year leaves debt less than 1 percentage point of GDP above the level projected by the Medium Term Fiscal Structural plan. Recurrence is what matters: if such a year occurred every three years, public debt in 2038 would be between 1.0 to 3.0 percentage points of GDP higher than projected in the Medium-Term Fiscal-Structural Plan.

The response should therefore be well planned. The annual disaster allocation should build up into a multi-year fund, disaster risks should be reported in the budget, and insurance should cover far more households. Spending should move from relief to prevention, starting with irrigation and water supplies, and support for fire-hit destinations should last into the following season.

Several caveats apply. The heat and drought estimates come from a model built to predict growth rather than to identify causes, and they measure sensitivity to extreme conditions rather than an expected loss; only the agricultural result is robust enough to quote. All results rely on a short panel, and the regional accounts end in 2023, so the exceptionally hot summer of 2024 is not yet covered. Tourism cannot be separated from the wider trade, transport, accommodation and food sector. Finally, the stress test is illustrative and leaves out the cost of rebuilding public infrastructure.

Because the climate indicators used here are updated daily or every ten days, they can give early warning of which regions are likely to need support after a season of heat, drought or fire. For Greece, where climate extremes now recur almost every year, the question is no longer whether disaster will strike, but whether the budget will be ready when it does.

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Appendix

A Background tables

Table A1: Climatic suitability of Greek tourist destinations to 2100

Segment	Projected change to 2100	Most affected destinations
Beach and islands	"Excellent" season lengthens by about one month; up to about 34 extra very good days per season under RCP8.5; up to 4 fewer good days in peak summer	June and September gain most (Irakleio, Rhodes, Mykonos)
Cities and sightseeing	15–30 more good days a year under RCP8.5; summer comfort falls	Larisa, Serres and Thessaloniki drop below "excellent" in summer; Larissa, Trikala and Thessaloniki lose good days overall under moderate scenarios
Mountains and ski	General comfort improves except at Pelion; snow cover, not in the index, is expected to decline	Parnassos, Kaimaktsalan, Pelion, Seli

Notes: Based on five tourism climate indices for 22 Greek destinations under EURO-CORDEX projections. RCP8.5 is the high-emission scenario. Source: Lemesios et al. (2024).

Table A2: Climate risk and adaptation among Greek firms, 2025

Indicator	Greece	EU
Firms reporting physical climate risk	63%	68%
Any adaptation action	71%	53%
Bought or renewed climate insurance	58%	25%
Adaptation strategy in place	28%	26%
Invested to reduce exposure	34%	30%
Expect no impact from stricter climate rules	51%	37%
Invested in energy efficiency	38%	51%
Set emissions targets	33%	47%
Energy costs an obstacle to investment	92%	–
Finance-constrained firms	13.5%	6.1%

Notes: Telephone survey of 405 Greek firms, April–July 2025. Source: European Investment Bank (2025).

Table A3: Relief and recovery instruments available to Greece

Instrument	What it finances	Disasters	Main sectors	Greek example
National state aid (Κρατική Αρωγή) and ELGA	First aid and advance payments on assessed damage; housing restoration; ELGA compensation for insured crop, livestock and plant-capital losses	All	Households, agriculture, SMEs incl. tourism	459 million euros paid after Daniel, incl. 80 million euros first aid and 13 million euros for tourism, transport and fishing firms
NSRF (ΕΣΠΑ) / ERDF (ΕΤΠΑ)[19]	Regional programmes: SME support, infrastructure, risk prevention; reprogramming for reconstruction under RESTORE (95% EU co-financing, up to 10% of allocations, disasters of 2024–2025)	Floods, wildfires	SMEs, tourism, transport, local infrastructure	2.25 billion euros of unspent 2014–2020 cohesion funds mobilised after the 2023 fires and floods

[19] European Commission (2023), Statement by President von der Leyen with Greek Prime Minister Mitsotakis, 12 September

Instrument	What it finances	Disasters	Main sectors	Greek example
Cohesion Fund (Ταμείο Συνοχής)[20]	Large environmental and transport infrastructure: flood defences, water supply and waste water, climate adaptation	Floods, drought	Public infrastructure, water	Programme 'Environment and Climate Change 2021–2027' (ERDF and Cohesion Fund, 3.6 billion euros)
LIFE[21]	Adaptation planning, pilot projects, capacity building; not compensation	Floods, wildfires, drought, coastal	Public authorities, forests, water	LIFE-IP AdaptInGR (14.2 million euros, 2019–2026): National Adaptation Strategy and 13 Regional Adaptation Action Plans
CAP (ΚΑΠ) / EAFRD (ΕΓΤΑΑ)[22]	Restoration of farm and forest production potential; forest-fire prevention and restoration; irrigation infrastructure; since 2024, fully EU-financed emergency lump sums for farmers, foresters and rural SMEs	Drought, floods, wildfires, heat	Agriculture, forestry, rural SMEs	CAP Strategic Plan 2023–2027 interventions for forest prevention and restoration and irrigation works
EU Solidarity Fund (Ταμείο Αλληλεγγύης)[23]	Public emergency and recovery operations after major disasters: infrastructure, temporary housing, rescue, clean-up	Major floods, wildfires, earthquakes	Public sector	101.5 million euros for Storm Daniel (2024), including a 25 million euros advance
European Investment Bank (ΕΤΕπ)[24]	Long-term loans for civil protection, flood protection and water networks; co-financing of national contributions	Wildfires, floods, drought	Public sector, utilities	220 million euros (2024) for the AEGIS civil-protection programme; 250 million euros (2025) for Attica's water supply

Notes: RESTORE is the 2024 amendment to the cohesion-policy rules for disaster recovery. Sources are given in the footnotes to each instrument.

B Methods

Climate indicators: compounding and annual aggregation. Two further sets of variables capture the compounding of climate events. Geographic compounders measure the average of HCWI, SPI and LFI in neighbouring regions, reflecting the spatial spread of climate shocks; SMA and fAPAR are excluded, since agricultural drought shows limited cross-regional compounding in the short to medium term. Because several Greek regions are islands without land neighbours, each island region is assigned its three nearest regions within 250 km. Event compounding is captured by an indicator that interacts the scaled HCWI with the absolute value of the scaled SPI and is active only when a heat wave coincides

2023; Council of the European Union (2024b), Council gives final green light to package of measures to assist member states affected by natural disasters (RESTORE), press release, 18 December 2024.

[20] Ministry of Development (2022), approval of the programme «Περιβάλλον και Κλιματική Αλλαγή 2021-2027», budget 3.6 billion euros, co-financed by the ERDF and the Cohesion Fund, press release, August 2022.

[21] NECCA (2024), LIFE-IP AdaptInGR: Boosting the implementation of adaptation policy across Greece (LIFE17 IPC/GR/000006), National Environment and Climate Change Agency.

[22] Ministry of Rural Development and Food (2024), summary of the Greek CAP Strategic Plan 2023–2027; European Commission (2024b), Commission takes further steps to help Member States recover from climate disasters, Inforegio news, 21 October 2024.

[23] European Commission (2024a), Support from the EU Solidarity Fund helps Slovenia and Greece recover from climate-related disasters, Inforegio news, 12 October 2024.

[24] EIB (2024), Greece to bolster civil protection with new EIB loan of 220 million euros, press release, 12 April 2024; EIB (2026), Greece gets record-high EIB Group financing of 3.5 billion euros in 2025, press release.

with a meteorological drought, with the one-, six- and twelve-month horizons combined into a single measure. The monthly indicators are converted to annual frequency in three ways: as annual medians and standard deviations, as principal components, and through mixed-data sampling (MIDAS) weights.

Event studies. The growth responses to wildfires and floods are estimated with event studies, following the panel approach of the literature on natural disasters (Felbermayr and Gröschl, 2014; Meier et al., 2023). For each sector s, we estimate

$$\Delta y_{r,s,t} = \alpha_r + \delta_t + \sum_{k=-1}^{2} \beta_k x_{r,t-k} + \gamma w_{r,t} + \varepsilon_{r,s,t}, \tag{1}$$

where

$$\Delta y_{r,s,t} \equiv \frac{y_{r,s,t} - y_{r,s,t-1}}{y_{r,s,t-1}} \times 100$$

is the annual growth rate of real gross value added per inhabitant in sector s, region r and year t, and $y_{r,s,t}$ is nominal GVA deflated by the NUTS-2 GVA deflator and divided by population, as in Spiteri et al. (2026). The variable $x_{r,t-k}$ measures exposure to an event that occurred k years before year t; α_r are region fixed effects that absorb permanent differences between regions; and δ_t are year fixed effects that absorb national shocks such as COVID-19. Standard errors are clustered by region.

The coefficient β_k measures the change in growth k years after the event. Thus β_{-1} refers to growth in the year before the event and serves as a placebo, since an event cannot affect growth before it occurs; β_0 refers to the event year; and β_1 and β_2 to the two following years. The cumulative effect is $\beta_0 + \beta_1 + \beta_2$. For wildfires, $x_{r,t}$ is the share of the region's area burnt in year t, as in Meier et al. (2023). For floods, $x_{r,t}$ is an indicator equal to one when the region's wettest five days of the year, relative to the region's median, fall in the top 1% of all unit-years, so that floods are measured by their physical intensity rather than by reported damage (Felbermayr and Gröschl, 2014). The term $w_{r,t}$ is the year's total rainfall, standardised within each region, and enters only the flood regressions ($\gamma = 0$ for wildfires). It separates destructive floods from ordinary wet years, which in Greece tend to bring good harvests: a year one standard deviation wetter than the region's average raises agricultural growth by 2.23 percentage points ($p = 0.01$), while total rainfall has no significant effect in the other sectors.

Scenario model. As in Spiteri et al. (2026), the economic variables are last year's growth of the sector's real GVA per capita, the sector's employment-to-population ratio in the region, last year's national real GDP per capita growth, indicators for urban, rural, mountain and coastal regions (Eurostat, 2026, GISCO typologies), and an encoded regional identifier that captures each region's typical growth. The relationship between climate indicators and growth is estimated with XGBoost, a machine-learning model based on decision trees. Its hyperparameters are tuned on 2002–2017, and the model is then re-estimated on the full sample for 2002–2023 to produce the scenarios in Section 5.1. In the event scenario, each heat-wave and drought indicator is set to its extreme percentile across Greek regions in a reference year: the 99th percentile for the heat-wave, low-flow and event-compounding indicators and the 1st percentile for the precipitation, soil-moisture and vegetation indices. In the non-event scenario, all climate indicators are set to zero. Economic variables are held at their observed values, and the simulated effect is the difference between the two predictions, averaged over 2002–2023. As a robustness check, the percentiles are also taken from the pooled distribution over all years. The main reference year of Spiteri et al. (2026) is 2022, when Europe was severely affected by concurrent heat waves and droughts.

Fiscal stress test. Public debt as a share of GDP evolves as $d_t = d_{t-1}(1 + i_t)/(1 + g_t) - pb_t$, where i_t is the implicit interest rate, g_t nominal GDP growth and pb_t the primary balance including stock-

flow adjustments. The baseline takes d_t, g_t and i_t for 2024–2038 from Table 7 of the Medium-Term Fiscal-Structural Plan (Ministry of National Economy and Finance, 2024b) and backs out pb_t so that the projected debt path is reproduced exactly. The output loss in each scenario is built from the note's own estimates, using 2023 gross value added by region at current prices. For heat and drought, the 2023-type agricultural effect in current prices is averaged across regions with weights equal to their agricultural value added (-2.71 percentage points) and multiplied by agriculture's share of gross value added in 2023 (4.3%). For wildfires, the event-study coefficients for tourism-related services in current prices (-0.22, -0.41 and -0.06 in the fire year and the two following years) are multiplied by the share of the region's area burnt in 2023, averaged with weights equal to each region's value added in the sector (1.15%), and by the sector's share of gross value added in 2023 (24.8%). The budget balance falls by $\varepsilon = 0.5$ times the annual output shortfall (Mourre et al., 2019); with a persistent loss, the lower level of GDP also raises the debt ratio in later years. Relief of 0.3% of GDP is assumed in each disaster year, of which the part not met by the annual allocation of 600 million euros already in the plan is added to the primary deficit: 0.08% of GDP when the whole allocation goes to relief and 0.19% when half of it does (OECD, 2024).

C Additional results

Table C1: Largest burnt areas by region, 2016–2026

Region	Year	Burnt area (ha)	Share of region's area (%)	Farmland burnt (ha)
Evros	2023	94,578	22.3	16,621
Evia	2021	52,668	12.6	17,844
Dodecanese (incl. Rhodes)	2023	18,687	6.9	3,796
Dytiki Attiki	2021	15,463	15.4	1,532
Lakonia–Messinia	2021	14,665	2.2	5,377
Dytiki Attiki	2023	14,395	14.3	1,009
Chios	2025	14,280	15.7	3,176
Voiotia	2023	13,811	4.7	1,894
Ileia	2021	12,672	4.8	7,962

Notes: Fires are matched to the NUTS-3 regions they crossed. Source: Copernicus (2026, EFFIS burnt areas database); authors' calculations.

Table C2: Event study: growth response to area burnt, 2018–2023

Sector	Year before (placebo)	Fire year	Year after	Two years after	Cumulative, fire year to +2
Agriculture (A)	−0.57 (0.19)	−0.75 (0.08)	−0.24 (0.70)	−0.21 (0.69)	−1.20 (0.28)
Industry (B–E)	0.02 (0.95)	−0.11 (0.48)	−0.79 (0.10)	−0.43 (0.05)	−1.33 (0.05)
Manufacturing (C)	−0.13 (0.08)	−0.22 (0.01)	−0.18 (0.45)	−0.04 (0.75)	−0.43 (0.04)
Trade, transport, accommodation, food (G–I)	0.07 (0.57)	−0.21 (0.08)	−0.54 (0.00)	−0.05 (0.79)	−0.80 (0.00)

Notes: Coefficients in percentage points of real GVA per capita growth per 1% of the region's area burnt; p-values in parentheses. Region and year fixed effects; standard errors clustered by region. 52 regions, 312 observations.

Table C3: Event study: growth response to a major flood, 2003–2023

Sector	Year before (placebo)	Flood year	Year after	Two years after	Cumulative, flood year to +2
Panel A. Extreme five-day rainfall (top 1% relative to the region's median)					
Agriculture (A)	−13.46 (0.09)	−5.76 (0.15)	+5.03 (0.40)	−6.17 (0.13)	−6.90 (0.20)
Industry (B–E)	+4.07 (0.09)	+2.97 (0.29)	−0.97 (0.85)	+4.50 (0.05)	+6.50 (0.41)
Manufacturing (C)	−0.35 (0.73)	+2.58 (0.15)	+1.62 (0.67)	+1.21 (0.62)	+5.41 (0.32)
Trade, transport, accommodation, food (G–I)	+0.86 (0.55)	−0.38 (0.77)	+0.81 (0.49)	+2.55 (0.14)	+2.98 (0.36)
Panel B. At least 150 mm in one day in any grid cell of the region					
Agriculture (A)	−13.85 (0.04)	−4.58 (0.47)	+2.35 (0.53)	−3.18 (0.18)	−5.41 (0.39)
Industry (B–E)	+3.57 (0.19)	+6.14 (0.00)	+0.13 (0.96)	+6.04 (0.10)	+12.31 (0.00)
Manufacturing (C)	−0.48 (0.71)	+1.36 (0.10)	+1.76 (0.16)	+2.37 (0.00)	+5.49 (0.01)
Trade, transport, accommodation, food (G–I)	−0.44 (0.69)	−0.02 (0.99)	+1.33 (0.01)	+2.55 (0.05)	+3.87 (0.00)

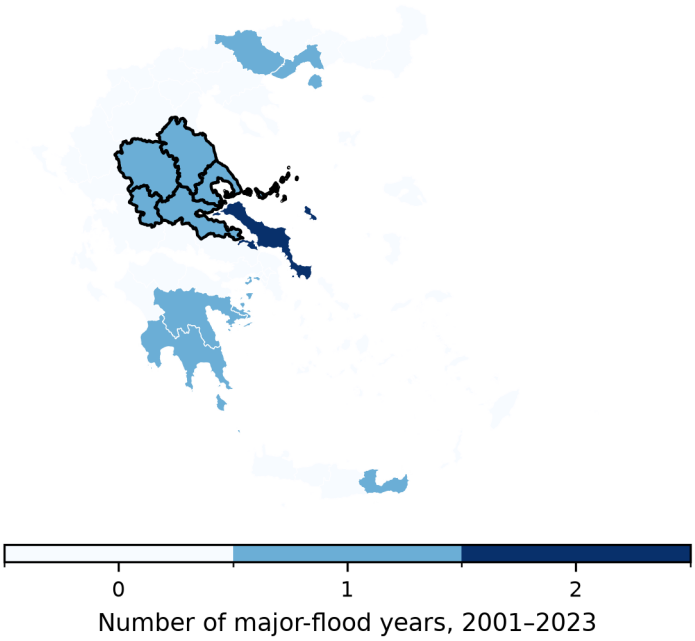
Notes: Coefficients are in percentage points of growth in real GVA per capita for a region hit by a flood; p-values are in parentheses. Rainfall data are from ERA5-Land. Panel A flags a unit-year when its wettest five days, relative to the region's median, fall in the top 1% of all unit-years: 13 unit-years over 2001–2023, of which 11 fall within the 2003–2023 estimation period. Panel B flags a unit-year when any grid cell of the region records at least 150 mm in one day (9 flood unit-years, of which only Magnisia, Larisa and Evia in 2017 have years after the flood in the sample). With Panel B, the three non-agricultural sectors grow faster in the two years after a flood, a pattern consistent with reconstruction spending but to be read with caution: with so few affected regions, clustered standard errors tend to overstate precision, and Storm Daniel enters only in its flood year because the regional accounts end in 2023. The total rainfall control is the year's total rainfall, standardised within each region; its coefficient in agriculture is +2.23 (0.01) in Panel A and +2.18 (0.01) in Panel B, and it is not significant in the other sectors. Standard errors are clustered by region. 52 regions, 1,092 observations.

Table C4: Simulated effect of a heat-wave and drought year on growth, all sectors

Sector	2022-type year: mean	2022-type year: range	2023-type year: mean	2023-type year: range	Extremes over all years
Agriculture (A)	−2.82	−3.50 to −2.25	−3.02	−3.73 to −2.40	−3.08
Industry (B–E)	−0.68	−0.94 to −0.63	−0.47	−0.73 to −0.42	+3.53
Manufacturing (C)	−0.35	−0.68 to +0.04	+0.83	+0.53 to +1.17	+5.51
Trade, transport, accommodation, food (G–I)	+0.87	+0.63 to +1.20	+1.36	+1.08 to +1.57	+0.69

Notes: Percentage points of real GVA per capita growth, XGBoost. The event scenario sets each heat-wave and drought indicator to its extreme percentile across Greek regions in the reference year; the non-event scenario sets all climate indicators to zero. Effects are averaged over the economic conditions of 2002–2023. Ranges are across the 52 regions. The last column takes the extremes from the 2002–2023 distribution.

Figure C1: Major floods by region, 2001–2023



Notes. Number of years in which the region's wettest five days, relative to its median, fall in the top 1% of all unit-years. Regions outlined in black were hit in September 2023 (Storm Daniel). Evia is the only region with two major floods, in 2001 and 2018. The remaining events, in Argolida–Arkadia, Lakonia–Messinia and Piraeus and the Islands in 2005, and in Thasos–Kavala, Serres and Lasithi, each affected a single region once. With a grid of about 9 km, ERA5-Land does not flag Storm Ianos in 2020 or the Mandra flash flood of 2017. Source: Copernicus (2026, ERA5-Land, Climate Data Store); authors' calculations.



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