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Beyond the floods: the economic case for adaptation and insurance in Brazil

Isabel Lara Miranda, Juan Pablo Martínez, Alia Yusuf, Fernanda Gimenes, Eduardo Gonçalves and Swenja Surminski

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About the authors

Isabel Lara Miranda is an Economic and Fiscal Policy Fellow, Juan Pablo Martínez is a Policy Analyst, Alia Yusuf is a Policy Analyst and Fernanda Gimenes is a Senior Research Lead on Private Capital Mobilisation, all based at CETEx. Eduardo Gonçalves is a Climate Adaptation Specialist at the Institute for Climate and Society (iCS). Swenja Surminski is a Professor in Practice – Adaptation Research at the Grantham Research Institute on Climate Change and the Environment at LSE.

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Contents

Summary

In the context of intensifying climate change impacts, this report quantifies average annual fluvial flood losses for eight Brazilian cities under three climate scenarios covering 2025 to 2100. It highlights the economic case for adaptation, insurance and better financial planning for flooding, and by implication, other climate-related physical risks. The analysis is informed by stakeholder interviews including with Brazilian policymakers, international actors and the insurance sector.

Growing climate change risk and impacts in Brazil

Brazil is experiencing growing impacts from climate change, including storms, floods, hail, heatwaves and wildfires. Flooding is a particular concern: it is the fastest-growing climate hazard in the country and its impacts are especially felt in cities, where most Brazilians live. The 2024 Rio Grande do Sul flood alone cost nearly US$17.8 billion, displaced over 580,000 people and required a federal emergency package, as local and regional authorities were overwhelmed. Brazil still has a window of opportunity to get ahead of these risks. But it must act now by investing in adaptation, closing its insurance protection gap and building a financial architecture that can absorb sudden and severe climate impacts – or 'shocks' – that are already locked in and unavoidable.

Brazil's risk landscape is being transformed by climate change, with deep fiscal consequences. Historically, the country's geographical characteristics have shielded it from primary perils, such as earthquakes and hurricanes. But this protection is being eroded as climate change intensifies secondary perils, such as floods, droughts, wildfire and landslides. In this way, Brazil is moving from being a country with limited exposure to catastrophes to one confronting rapidly escalating, large-scale disaster risk. The fiscal consequences are severe: when private insurance is absent, governments become not only insurers of last resort, but also the main financiers of disaster recovery, absorbing losses that overwhelm subnational budgets and ultimately fall on the federal government. Calculations based on the Rio Grande do Sul flood show that Brazil's insurance protection gap stands at around 90-94%, far above the global average of 51%.

Key findings

Economic losses caused by fluvial flooding in Brazilian cities are large and growing, with major fiscal implications for municipalities, states and the federal government. The most exposed cities, Manaus and Porto Alegre, face average annual flood losses equivalent to around 2–5% of city gross domestic product (GDP), depending on the climate scenario. Losses of this scale cannot be absorbed by municipal budgets alone. They trigger surges in expenditure, erode local tax bases, damage sovereign credit ratings and increase borrowing costs. This creates a vicious cycle in which the cost of inaction rises over time.

The insurance protection gap is a direct source of fiscal instability. When losses, including those from flooding, are uninsured, they fall on public balance sheets. Brazil's low insurance penetration means that, in practice, the federal government has repeatedly absorbed costs that market-based risk transfer could have partly covered. Without a pre-arranged disaster risk financing strategy responses to disasters remain reactive, fragmented and more expensive than they need to be.

Investment in adaptation measures reduces the expected cost of disasters, and increases resilience to them, and floods are no exception. Modelling shows that upgrading flood protection in the most exposed cities, Manaus and Porto Alegre, could reduce average annual losses by around 50–80%. Every Brazilian real that is not spent on disaster recovery is available for investment, supporting growth and development. Adaptation should be seen not as a cost, but as an immediate, effective form of risk management.

Brazil's insurance sector has the foundations to play a greater role in managing climate-related risks such as floods: it is large, sophisticated and regulated by Superintendência de Seguros Privados (SUSEP). But currently climate catastrophe cover remains a relatively small and underdeveloped segment of the market and insurance penetration for climate-related hazards is limited. Parametric insurance, which triggers payouts based on a predefined threshold (e.g. wind speed or level of rainfall) rather than assessed damage, is drawing growing attention, as it can enable faster payouts and lower claims-adjustment costs, where timely liquidity is critical.

The risks from flooding disproportionately affect the most vulnerable. Informal settlements or favelas, home to low-income communities across Brazil's cities, are disproportionately located in risk areas: as of 2022 3% of urban land in Brazil sits in risk zones, rising to 18% of favela land. Climate change will deepen existing inequalities unless adaptation investment is directed towards these communities.

Policy recommendations

1. **Create a Disaster Risk Financing Strategy, to be led by the Ministry of Finance, complementing the new National Civil Protection and Defence Plan.** Brazil's 2025 national disaster plan lacks a financing architecture. The Ministry of Finance should lead the development of a layered disaster risk financing strategy. This should define how risk is retained, transferred and shared across levels of government, households and firms, matching financial instruments to the frequency and severity of different hazards, including floods. Brazil can learn from countries such as Mexico, Colombia and Indonesia who are leading by example on this front.

2. **Expand the Brazilian development bank's (BNDES) toolkit for disaster risk financing and climate resilience.** With central fiscal space constrained, BNDES could play a key role in reducing the fiscal risks from disasters, including floods, given its mandate and operational capacity. The toolkit could include: i) a catastrophe contingency credit line for states and municipalities (conditional on progress against adaptation and resilience benchmarks); ii) technical assistance to support the development of risk atlases (already mandatory in Brazilian law) and preferential financing for municipalities that submit and regularly update their risk atlases; and iii) demand-side incentives that reward borrowers for holding climate insurance. Other public financial institutions could play complementary roles in scaling up these approaches across different market segments.

3. **Increase the uptake of parametric insurance at state level and explore an inter-state risk pool.** Brazil's size and geographical diversity mean that not all places will be hit with the same types of disasters at once, with weather events and other perils in one region not correlating with those in another. This makes a pooled mechanism financially efficient. Rapid, pre-agreed payouts would enable governments to respond faster and plan ahead, reducing the humanitarian cost of delays.

4. **The Ministry of Finance should scale up adaptation investment, starting in the cities (such as Manaus and Porto Alegre) and communities most exposed to flooding (as revealed by our analysis).** Investment in adaptation, including nature-based solutions, flood defences, better land-use planning and early warning systems, is the most cost-effective way to reduce the underlying risk that insurance and fiscal buffers must absorb. The principle of 'resilience by design' should be embedded in public procurement, especially for infrastructure, led by the Ministry of Finance.

5. **The Ministry of Finance should harness Brazil's digital public infrastructure to strengthen adaptation and insurance markets.** Satellite data, geospatial information and digital risk mapping could help identify vulnerable populations living in disaster prone areas, including those exposed to flooding, and exposed assets, improving risk atlases and the pricing of parametric instruments. Brazil's instant payment system Pix, digital identity systems and other payment technologies could speed up post-disaster payments and insurance payouts, ease premium collection and expand financial inclusion, reducing transaction costs and other barriers to implementing disaster-risk financing.

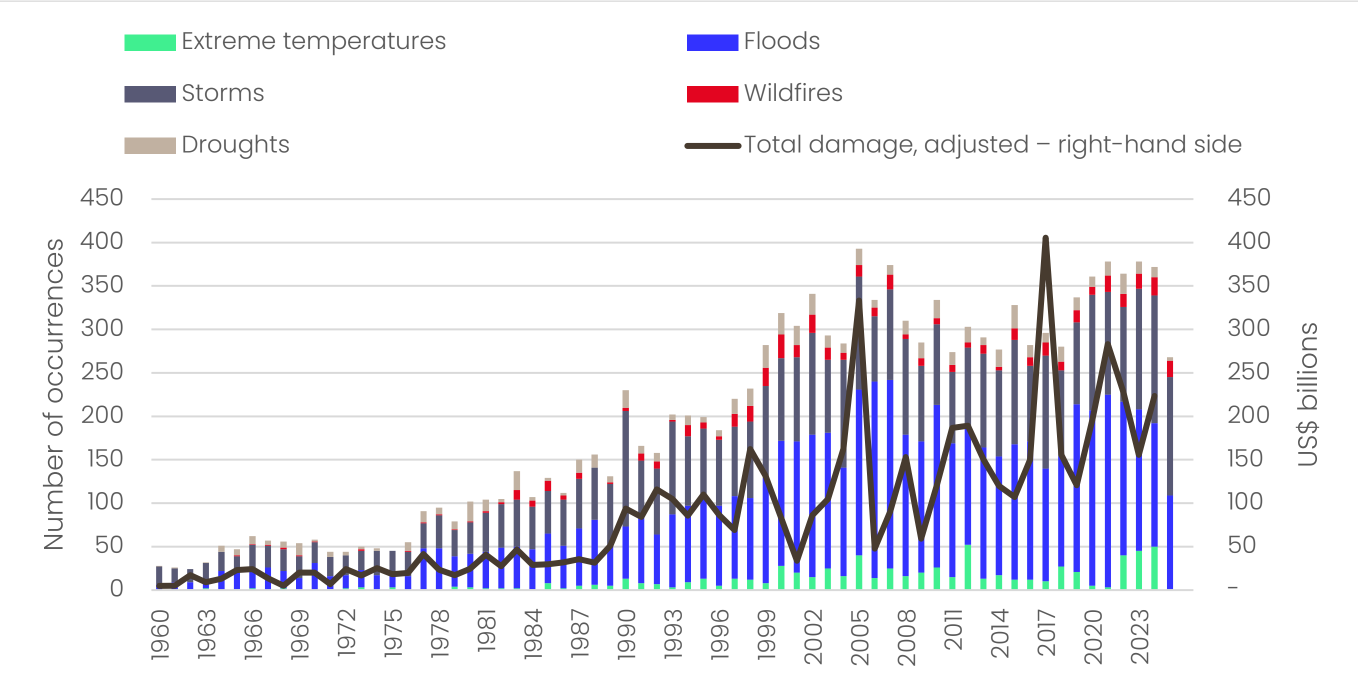
The successful implementation of these recommendations to minimise the fiscal risks from urban flooding, as well as other climate-related physical hazards in Brazil, will depend on institutional and political economy factors that fall beyond the scope of this report. Future research and the development of institutional capacity should focus on implementation pathways and roadmaps, including institutional responsibilities, regulatory requirements and coordination mechanisms.

1. Introduction and context

Climate-induced disasters are an increasing threat for economies, societies and public finances, underscoring the need to scale up investment in adaptation, and design and implement risk financing strategies and tools. This report quantifies the economic cost of flood risk on installed capital[1] in eight Brazilian cities under different climate scenarios, highlighting the economic case for adaptation. It explores policy tools such as disaster risk financing strategies, parametric insurance, adaptation investment and digital technologies to minimise the fiscal implications of disasters.

Climate change is increasing the frequency and intensity of natural catastrophes such as floods, extreme temperature and wildfires, and their associated costs (see Figure 1.1) (Battiston et al., 2025), imposing vast and growing financial burdens on governments, businesses and households. Estimates of total economic losses from natural disasters vary: according to Swiss Re Sigma (2025), in 2024 alone, losses reached an estimated US$318 billion worldwide, with 57% of these uninsured. Meanwhile, according to the international disaster database (EM-DAT), total losses reached more than US$200 billion in 2024. However, these global data points obscure significant regional and country-level variation: in emerging economies typically between 80% and 90% of losses are not covered by insurance (Swiss Re Sigma, 2026).

Figure 1.1. Selected natural catastrophes worldwide by peril, 1960-2025



Source: elaborated by the authors with data from EM-DAT data. The adjusted damage data uses 2015 as a base year. For natural disaster events that were reported in another currency, they were first converted to US dollars before being adjusted for inflation. The dataset includes hydrological, meteorological and climatological events, and excludes geological disasters (volcanic activity and earthquakes).

[1] We take the data from the World Bank's wealth accounts, who define installed capital as the value of machinery, buildings, equipment and urban land.

Physical risks, particularly flooding, pose significant threats to infrastructure, economic stability, fiscal sustainability and social wellbeing, especially in urban areas (Intergovernmental Panel on Climate Change [IPCC], 2022). In addition, this type of peril represents the fastest-growing natural disaster category globally (see Figure 1.1). The vast economic and social costs of floods have manifested in countries around the world, including Brazil. In April and May 2024, Brazil experienced unprecedented flooding in Rio Grande do Sul. This was one of the most severe climate-related disasters in recent history: around 2.3 million people were affected, with 640,000 homes damaged, and critical infrastructure including highways, airports and energy and water systems severely disrupted (Clarke et al., 2024). The flood had significant fiscal consequences: emergency relief and the costs of reconstruction raised public expenditure, while simultaneously compressing fiscal revenues, with the federal government mobilising an aid package of R$50.9 billion Brazilian Real (BRL) (equivalent to US$10 billion) (Clarke et al., 2024) to support an already fiscally constrained state (Comisión Económica para América Latina y el Caribe [CEPAL], 2024). This illustrates how national governments are becoming not only the insurer of last resort, but also the main financier of disaster recovery (Monasterolo et al., 2025).

In Brazil, our interviews with practitioners on the front line of disaster response, including civil defence specialists, underwriters and government officials, confirm an unmistakable acceleration of flood events. A civil servant noted that in the North Region of Brazil major fluvial floods which historically occurred every six to seven years have become near-annual events since 2021. Flash floods (*alagamentos*), which did not occur over a 17-year period from 2004 to 2021, are now happening multiple times per year (interview [INT]-D).[2] In the insurance sector, a major insurer estimated a 30% increase in the frequency of climate-related claims in recent years; this figure excludes 2025, which is expected to significantly worsen the trend (INT-B).

These mounting climate-related losses highlight the importance of mechanisms that can help societies manage risk and recovery more effectively. Insurance is one such tool, as it contributes to distributing the cost of an event and recovering more effectively after a disaster strikes (Monasterolo, et al., 2025; European Central Bank [ECB]/European Insurance and Occupational Pensions Authority [EIOPA] 2023; Jarzabkowski et al., 2018). Yet insurance is not a panacea: while it distributes risk, it does not necessarily reduce it. Effective responses to climate-induced disasters therefore require adaptation policies and risk management strategies that go beyond insurance coverage.

Two widening and interconnected gaps sit at the core of this report: the insurance protection gap, which is the difference between total economic losses and insured losses, and the adaptation finance gap, which is the difference between the investment needed to build climate resilience and the capital currently allocated for that purpose. Both are especially pronounced in emerging market and developing economies, where insurance markets tend to be less developed, penetration rates remain low and fiscal challenges persist, harming investment in adaptation.

The increasing frequency and severity of extreme weather events is contributing to widening the insurance protection gap through escalating economic losses (G20, 2025). This is a source of fiscal instability: when households, businesses and subnational governments lack insurance coverage, the costs of disaster response, emergency relief and reconstruction default to the central government. Effectively, uninsured losses are transferred onto public balance sheets, posing challenges for ministries of finance managing post-disaster expenditure. The 2024 Rio Grande do Sul floods highlighted the scale of Brazil's insurance protection gap: 90-94% of losses were uninsured, far exceeding the global average of 51% of losses (CNSeg, 2024; Gallagher Re, 2025; Swiss Re Sigma, 2026).

At the same time, adaptation measures, such as nature-based solutions and flood defences, remain systematically underfinanced. It is estimated that developing economies need US$365 billion in adaptation finance annually until 2035 (UN Environment Programme [UNEP], 2025). In 2023, international adaptation finance flows stood at US$30 billion, mainly driven by public sources (US$26 billion). This leaves an adaptation finance gap of around US$335 billion annually, based on countries' own nationally determined contribution (NDC) and national adaptation plan (NAP) submissions (UNEP, 2025). Private finance for adaptation reached US$4 billion in 2023 (UNEP, 2025), a share which must increase significantly if adaptation finance goals are to be met (Bhattacharya et al., 2024) as public budgets alone cannot mobilise the necessary resources to maintain basic services, foster

[2] See Appendix for a description of the interviewees and below for further explanation of our methodology.

development and combat climate change (UN Trade and Development [UNCTAD], 2014). This shortfall in adaptation finance is even more pronounced in urban areas, where most of the world's population live. Only around 1.2% of climate finance targeting urban environments was for adaptation (Cities Climate Finance Leadership Alliance [CCFLA], 2024), suggesting cities are especially exposed to underinvestment relative to their share of climate risk. In Brazil, these constraints are particularly pronounced, with central government budget allocations from 2003 to 2021 to "environmental management" amounting to just 0.13% of total expenditure (World Bank, 2024; Salanié et al., 2025),[3] reinforcing the structural underinvestment in adaptation measures that leaves both households and public finances highly exposed to escalating physical climate risks.

Beyond the direct fiscal costs already outlined, physical risks also generate broader and compounding economic and social damage. Extreme climate-related events negatively impact the real economy, erode livelihoods, set back development and deepen inequality (World Bank, 2014). As the frequency and severity of such events increases, so does the structural vulnerability of countries that lack adequate risk-management frameworks.

Objective, methods and structure of this report

The objective of this report is to:

1. Assess the exposure of infrastructure assets to fluvial flood events in eight cities[4] in Brazil, covering different geographical characteristics, including coastal cities, cities in the interior and cities in the Amazon rainforest region

2. Estimate and quantify the economic losses that are likely to result from this exposure from 2025 to 2100

3. Propose policy recommendations on how these risks can be managed through innovative insurance solutions and promoting adaptation investments and risk management practices.

The analysis in the report combines quantitative scenario-based risk modelling with qualitative insights from semi-structured interviews with government officials, civil defence practitioners, insurance sector representatives and development finance specialists (detailed in the Appendix). The interviews were used to contextualise the modelling results, validate key findings and identify implementation challenges and policy opportunities that are not readily captured in the existing literature. For the quantitative analysis, we applied an open-source, globally consistent framework to estimate city-level fluvial flood losses for eight Brazilian cities under future climate scenarios. Flood hazard projections are taken from the ISIMIP2b CaMa-Flood (Catchment-based Macro-scale Floodplain) ensemble, which integrates multiple global hydrological and climate models to simulate annual maximum flood depths from 2025 to 2100 under three emissions pathways (Representative Concentration Pathways (RCP) 2.6, RCP 6.0 and RCP 8.5). We approximated the exposure of assets using the LitPop methodology, which downscales nationally produced capital totals for each city using population density and satellite-derived night-time light activity. Impacts are quantified using a function that translates flood depth into expected monetary losses.

These components are integrated via CLIMADA (CLIMate ADAptation), an open-source framework to compute expected annual impacts (average annual losses), expressed relative to 2022 municipal real gross domestic product (GDP), taken from the Brazilian Institute for Geography and Statistics (IBGE), to assess fiscal materiality and enable cross-city comparison. The report also explores how the implementation of higher flood protection standards (using documented flood protections as a baseline, and a 100-year standard as a benchmark) could reduce expected losses, while noting that the hazard type in our analysis is limited to fluvial flooding.

[3] Salanié et al., 2025 explain that because the responsibility for preventing climate disasters in Brazil is split across the federal government, state governments and municipalities, it is difficult to pinpoint total prevention spending. To work around this, the authors use central government budget allocations to environmental management as a proxy for prevention.
[4] The selection includes the coastal cities of (1) Fortaleza (Northeast region); (2) Rio de Janeiro (Southeast region); (3) São Paulo (Southeast region); (4) Florianópolis (South); (5) Porto Alegre (South); the interior cities of (6) Brasília (Centre East region); and the Amazon rainforest cities of (7) Manaus (North region); and (8) Belém (North region).

The discussions that formed the interviews with the actors mentioned above focused mainly on: how perceptions of flood and climate risk have evolved over time; how physical risks transmit into fiscal pressures and institutional mandates; supply and demand-side barriers behind Brazil's large insurance protection gap; adequacy and pricing of existing insurance products; scope for instruments such as parametric insurance, catastrophe bonds and risk pools; and, regulatory and public–private coordination reforms needed to strengthen disaster risk financing and climate-risk management.

Brazil's geography has historically shielded it from primary perils,[5] such as earthquakes and cyclones. This means that the country has had comparatively little reason to develop the institutional knowledge, administrative capacity and insurance infrastructure that high-risk nations, such as Mexico, have built over decades. This does not mean that Brazil has been free from climate hazards: hydrological and climatological events have long affected all regions of the country (Ministry of the Environment and Climate Change, 2025). As climate change amplifies the frequency and severity of secondary perils,[6] such as floods, droughts and fires, Brazil's risk landscape is undergoing a fundamental transformation. As a private actor said: "*O Brasil entrou na rota de catástrofe*" ("Brazil has entered the catastrophe route"), a phrase that captures the structural shift from a market historically considered 'free of catastrophe risk' to one facing recurring, high-severity events (INT-E). This shift in perception has profound implications for the pricing, availability and design of risk-transfer instruments in the country.

Without adequate risk management financing solutions, future natural catastrophes could potentially translate into growing fiscal volatility, weakened investment capacity and deepening social inequality (see Section 3). The opportunity, however, may be equally significant: a well-designed protection system would not only reduce risk exposure, but also support the development of a deeper reinsurance market, reduce contingent public liabilities, improve sovereign resilience, avoid climate-induced debt dynamics and free up fiscal resources to support national development priorities. Realising these benefits, however, would require coordinated action across regulatory, fiscal and market actors. Brazil still has a window of opportunity to build fiscal resilience in a world where the climate is rapidly changing. This report aims to contribute to that effort.

The remainder of the report is structured as follows:

- Section 2 examines Brazil's evolving physical risk landscape, exploring how the increasing frequency and intensity of extreme weather events intersects with existing vulnerabilities, leading to uneven and growing economic and social costs across the country.

- Section 3 explores how climate-related disasters transmit into macroeconomic and fiscal frameworks, focusing on government expenditure, fiscal revenue and sovereign credit ratings. It then explores the role of insurance markets in managing climate-related losses, analysing Brazil's insurance protection gap and the structural barriers to greater insurance penetration.

- Section 4 estimates average annual flood losses for eight Brazilian cities under three climate scenarios. To assess fiscal relevance, it compares the losses to city-level GDP and examines how investing in flood protection could reduce damages. The findings are intended to inform the design of insurance instruments, the allocation of adaptation finance and the integration of physical climate risks into fiscal planning at federal, state and municipal levels.

- Section 5 outlines five policy recommendations to reduce the fiscal implications of the estimated losses presented in section 4.

[5] The term primary peril is used in the insurance sector and refers to those events that cause severe and widespread damage, leading to substantial financial losses, mainly earthquakes and tropical cyclones.
[6] Secondary perils are events that typically generate smaller to medium-seized losses and occur more frequently, such as hail, floods, wildfires and winter storms.

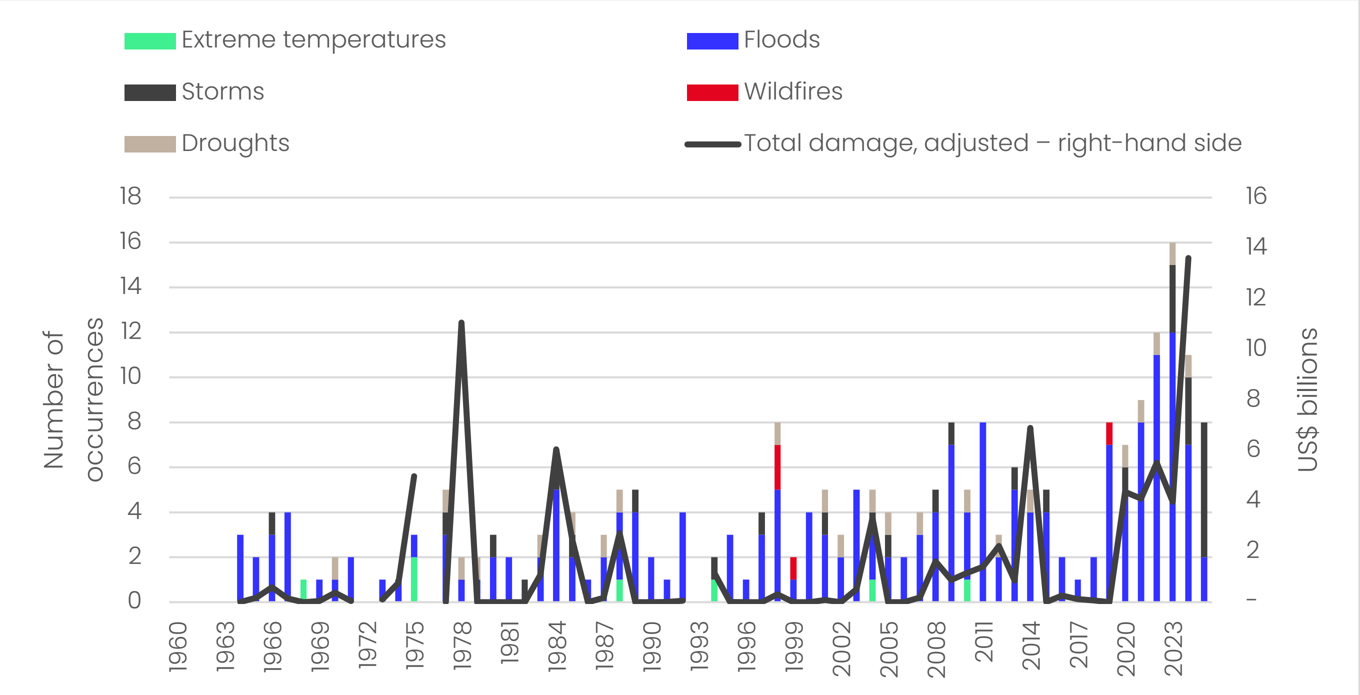
2. Physical risks and socioeconomic vulnerability in Brazil

In this section, we examine Brazil's evolving physical risk landscape, exploring how the increasing frequency and intensity of extreme weather events intersects with existing vulnerabilities, producing uneven and growing economic and social costs across the country's cities.

Physical risks trends

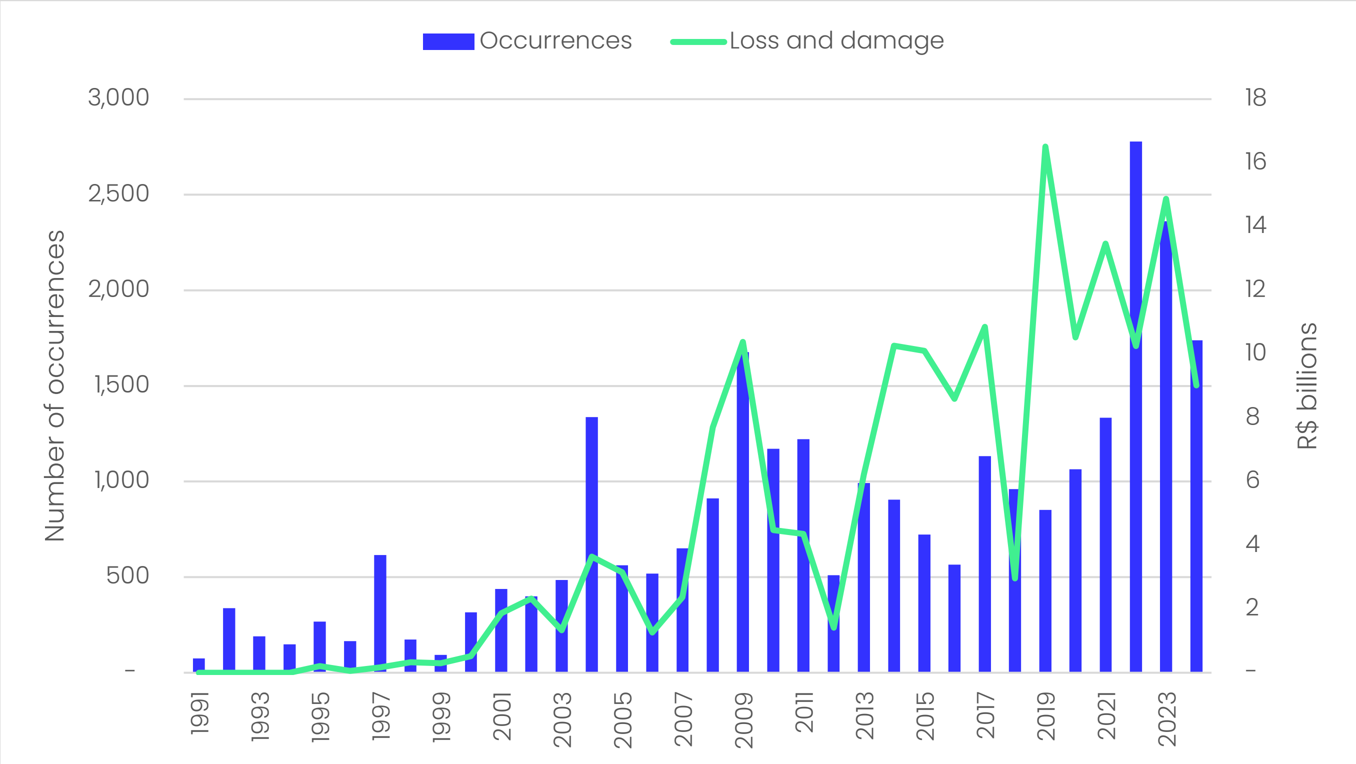
Climate change is exacerbating the frequency and intensity of extreme weather events in Brazil, especially in relation to precipitation patterns (Figure 2.1). In addition, the costs associated with these events is increasing. Brazil's average annual insured losses surged from US$175 million between 2000-19 to US$908 million between 2020-24 – a fivefold increase, driven primarily by the severe droughts and floods of recent years. Flood-related losses, damages and occurrence have followed an upward trend (Figure 2.2), compounding a longstanding structural feature of Brazil's risk landscape: floods and droughts have accounted for 94% of insured catastrophe (CAT) losses since 2000 (Gallagher Re, 2025).

Figure 2.1. Selected natural catastrophes in Brazil by peril, 1960-2025



Source: Authors' analysis based on EM-DAT (2025). The adjusted damage data uses 2015 as a base year. Natural disaster events reported in another currency are first converted to US dollars, before being adjusted for inflation. The dataset includes hydrological, meteorological and climatological events, and excludes geological disasters (volcanic activity and earthquakes).

Figure 2.2. Losses and damage associated with hydrological disasters and occurrences in Brazil, 1991-2024



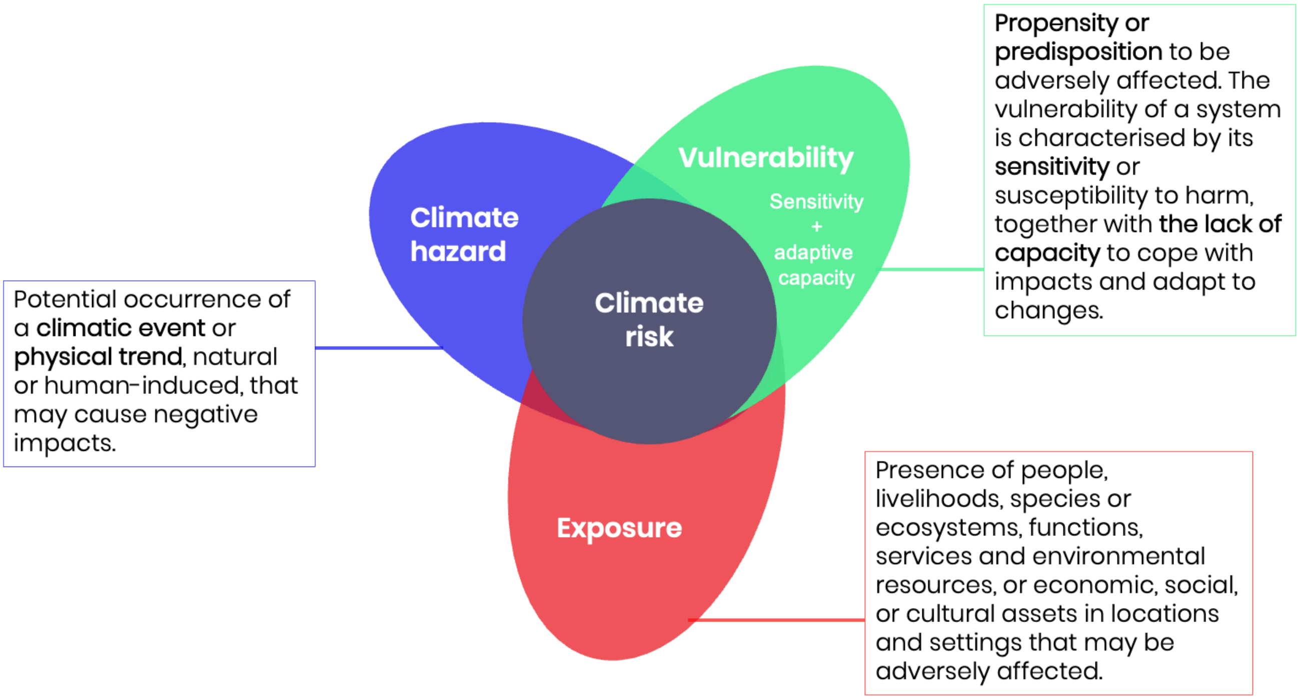
Source: Authors' analysis based on Atlas Digital de Desastres no Brazil (2026).

Brazil's risk landscape is undergoing a significant transformation driven by the increased intensity and frequency of extreme weather events. Despite having strong institutions for risk management, Brazil has not developed a robust disaster risk financing strategy. Rather than taking a proactive approach on fiscal planning, prevention and financial preparedness, the country's response has remained predominantly reactive, mobilising resources only after disaster strikes (World Bank, 2026). This pattern is also reflected in recent federal climate expenditure: between 2019 and 2024, spending on disaster response and reconstruction totalled R$23.3 billion, compared with just R$2.4 billion for disaster prevention and preparedness, suggesting that public resources have remained heavily concentrated on after-the-event responses rather than anticipatory resilience building (Centro Internacional Celso Furtado de Políticas para o Desenvolvimento [CICEF], 2026). Brazil's limited historical exposure to primary perils also means

the country has had little incentive to build a national risk management financing framework comparable to those of regional peers, such as Mexico's FONDEN. However, recent natural disasters and the anticipated rise of secondary perils, including floods, droughts and fires, are fundamentally reshaping this reality. In the words of one market participant interviewed, Brazil is moving from a "CAT free market" - one reinsurers have historically treated as a low-risk and largely free of catastrophe exposure – to a "CAT market", where catastrophe risk is now increasing and must be actively priced, modelled and backed by capital (INT-H).

Natural disasters are highly localised phenomena that affect communities heterogeneously, with impacts shaped not only by the nature of the hazard itself, but also by the exposure and vulnerability of the areas affected. Physical risks emerge from the interaction of three key factors: hazards, exposure and vulnerability, each of which is deeply context-specific (Figure 2.3) (IPCC, 2012; UN Office for Disaster Risk Reduction [UNDRR], 2015; IPCC, 2022; Network for Greening the Financial System [NGFS], 2024; Ministro of the Environment and Climate Change, 2025). Beyond these physical dimensions, socioeconomic conditions play a decisive role in determining who bears the greatest burden when disasters strike, producing significant distributional consequences across populations. Climate change is expected to deepen these inequalities further: an estimated 32 million people are projected to fall into poverty by 2030 due to intensifying climate impacts, reflecting the human cost of chronic underinvestment in adaptation (NGFS, 2024).

Figure 2.3. Risk analysis considering the combination of information on climate-related hazards, exposure and vulnerability



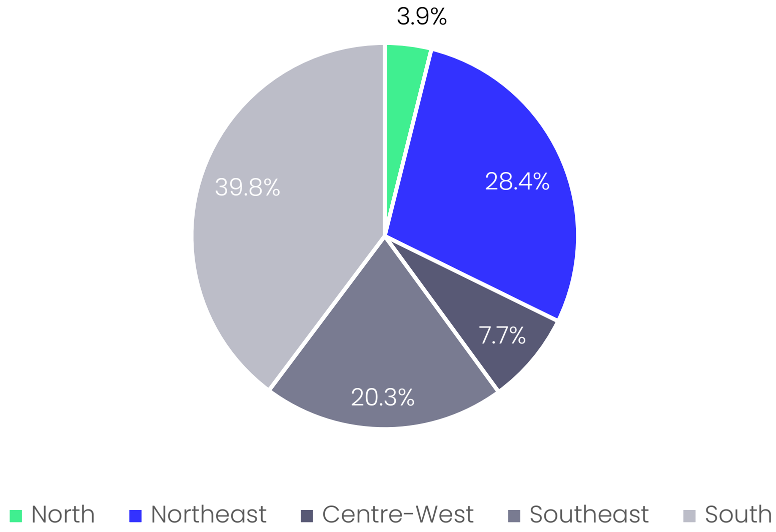
Source: Adapted from the Brazilian Climate Adaptation Plan – National Adaptation Strategy, published by the Brazilian Ministry of the Environment and Climate Change (2025).

Urban hazard, exposure and vulnerability

Brazil's extensive and varied geography, covering more than 8.5 million square kilometres, means that physical climate risks vary significantly across its territory (Ministry of the Environment and Climate Change, 2025). The North and Centre-West face increasing drought frequency and duration, with the Amazon basin experiencing severe droughts in 2023–24 that isolated communities, disrupted agricultural production and drove widespread wildfires across the Amazon, Pantanal and Cerrado (Ministry of the Environment and Climate Change, 2025). The Centre-West is particularly exposed given its role as the country's primary agricultural region, producing almost 50% of Brazil's grain output (Companhia Nacional de Abastecimiento, 2026). The Northeast is the most climate-exposed region in human terms, facing intensifying drought, shifting rainfall patterns, rising temperatures and cascading hazards, such as wildfires and water shortages (Ministry of the Environment and Climate Change, 2025). Meanwhile, the South and Southeast are increasingly threatened by extreme rainfall events that trigger fluvial flooding, flash floods and landslides. These hazard types account for 87% of disaster-related deaths in Southern Brazil, with heavy precipitation projected to intensify further, particularly in coastal zones (World Bank, 2021; Ministry of the Environment and Climate Change, 2025).

These climatological differences, together with local exposure and vulnerability, impact Brazilian states differently, as reflected in the uneven distribution of material damage and losses from 2015-24 across regions (Figure 2.4). The South bears the greatest share of disaster-related economic losses, accounting for nearly 40% of total material damage nationally, followed by the Northeast with 28.4% and the Southeast with 20.3%. The Centre-West and North regions account for smaller, but still significant shares of 7.7% and 3.9%, respectively.

Figure 2.4. Distribution of material damage and losses caused by natural disasters by Brazilian region, 2015-24



Source: Adapted from Ministry of the Environment and Climate Change (2025).

It is also important to acknowledge that the regional distribution of recorded losses (Figure 2.4) partly reflects differences in asset value and visibility, rather than the severity of the hazard itself. Several disasters of comparable or greater human impact have occurred in lower-income regions, yet generated smaller recorded material losses and, often, less national attention. In 2015, the Acre River reached a historic high of 18.40 metres in Rio Branco (North), affecting more than 100,000 people and displacing tens of thousands in a city where most of the population lives in conditions of social vulnerability (Governo do Acre, 2016). In May 2022, intense rainfall triggered floods and landslides across the Recife metropolitan region (Northeast), killing 133 people, most of them in precarious hillside settlements (Secretaria de Defesa Social de Pernambuco, 2022). That same year, the floods and landslides in Petrópolis (Southeast) left 241 dead, the worst disaster in the city's history (Departamento de Recursos Minerais do Estado do Rio de Janeiro, 2022). These cases show that the burden of climate-related disasters falls heavily on the most socially vulnerable populations, whose losses may be underrepresented in aggregate economic figures precisely because of their lower asset base – this is a distributional dimension that the regional loss data alone does not fully capture.

This uneven hazard landscape makes local and regional approaches to adaptation essential. Hazard profiles, exposure and vulnerability differ substantially across and within municipalities, and effective adaptation planning must reflect these local realities. Brazil's National Adaptation Plan recognises this, setting a target for at least 35% of Brazil's 5,570 municipalities to have adopted a local adaptation plan by 2035. Progress has been limited: so far, only 22 municipalities have developed plans. The AdaptaCidades programme, in partnership with the German Corporation for International Cooperation (GIZ), aims to close this gap, reaching 500 municipalities by 2027 (De Castro Soares et al., 2026).

Against this backdrop of diverse and intensifying climate hazards, this report focuses on fluvial flood events in cities. EM-DAT data show that flood hazard (covering both riverine and pluvial) represents the fastest-growing climate risk in Brazil (Figure 2.1), with the highest average annual growth rate since 2000. This carries deep economic and social consequences for urban areas (IPCC, 2022). The 2024 Rio Grande do Sul floods illustrate the economic dimension of this as 82% of the affected assets were located in urban areas, compared to just 18% in rural areas (CEPAL, 2024). The social dimension is equally significant, given that 87% of Brazil's population lives in cities (IBGE, 2022), making urban flood risk a challenge that affects the majority of citizens. The remainder of this section narrows its focus to the urban context and examines how hazards manifest across Brazilian cities, and how exposure and vulnerability shape the unequal distribution of risk among urban populations.

Urban hazard profiles

Understanding the hazards that different cities face is crucial to directing investment, strengthening preparedness and building resilience across Brazil's regions and cities. Using the ThinkHazard platform – an open-source tool developed by the Global Facility for Disaster Reduction and Recovery (GFDRR) – we identified the three most significant natural hazards for eight cities spanning Brazil's geographic regions. ThinkHazard draws on the best available global datasets to classify hazard severity across a range of threats, including floods, landslides, extreme heat, cyclones and earthquakes. The map below presents these findings spatially, enabling a quick comparative assessment of how risk profiles differ from city to city. This evidence base is intended to support informed, place-based decision-making – ensuring that disaster risk reduction strategies and resource allocation reflect the distinct hazard realities faced by communities in different parts of the country.[7]

Figure 2.5. Selected top three hazards for each of the eight cities examined, based on ThinkHazard tool

Source: authors, based on ThinkHazard data.

Urban exposure and vulnerability

The impact of extreme weather events in cities is not only determined by the hazard itself, but by who and what is exposed to it within the urban environment, and how vulnerable they are. Exposure and vulnerability are not randomly distributed; they reflect patterns of urbanisation, inequality and governance that concentrate risk among the most marginalised populations. In Brazil, rapid and often unplanned urban growth has pushed low-income communities into hazard-prone areas, while structural gaps in infrastructure and public services leave them with fewer resources to prepare for and recover from disasters.

Rapid urbanisation and population growth are significant drivers of increased disaster exposure and vulnerability. Urban development patterns are outpacing risk management, with settlements expanding into hazard-prone areas faster than protective measures can offset this (Rentschler et al.,

[7] For more information, visit: ThinkHazard

2022). Rapid urbanisation and population growth increases exposure to hazards by expanding construction into coastal areas, low-lying areas, floodplains and unstable or steep slopes. This is compounded by the replacement of permeable land with hard surfaces, such as asphalt or concrete. It also deepens vulnerability by creating dense informal settlements that are poorly constructed and altering natural drainage patterns, degrading natural protection systems, such as wetlands and forest (IPCC, 2022; UNDRR, 2022). These dynamics are clearly visible in Brazil: since 1985, population density in areas exposed to climate disasters has increased significantly. By 2022, approximately 123,000 hectares of urban land were situated in zones susceptible to floods, landslides, droughts and other climate hazards. This produces deeply unequal outcomes. Wealthier residents tend to live on higher, safer ground, in better quality buildings and can recover from damages faster. Lower income residents, by contrast, are disproportionately concentrated in hazard-prone areas and have fewer resources to prepare for, absorb or recover from disaster losses. Informal settlements, which are a direct product of urbanisation without adequate planning, are particularly exposed and are expected to suffer the worst impacts from natural catastrophes. Compounding this, informal settlements frequently lack basic infrastructure, such as drainage systems, solid waste collection and sanitation, which amplifies the destructive impact of extreme weather events such as flooding (IPCC, 2022).

The pace of expansion into disaster-prone terrain has outpaced overall urban growth. Between 1985 and 2022, urban areas in Brazil tripled in size. Over the same period, occupation of hazard-prone areas such as riverbeds quadrupled and high-slope terrain quintupled: the most dangerous land is being settled at a faster rate than urban expansion overall (MapBiomas, 2023). In addition, evidence obtained through interviews suggests that exposure dynamics may be outpacing the increase in hazard intensity itself. A civil servant reported that in the North Region, the state capital's urban footprint has expanded into flood-prone *igarapé* margins, where informal settlements lack drainage or insurance (INT-D). At the federal level, officials acknowledged that risk data is typically available only at the municipal level, making it difficult to assess project-level exposure: "We know which municipalities are more at risk, but we lack precision at the project or asset level" (INT-A).

Favela growth has been especially significant, further concentrating vulnerable populations in at-risk areas. The area occupied by favelas doubled roughly every 20 years between 1985 and 2022, accounting for 5% of all urban expansion nationally. In 12 municipalities, favelas represented more than half of all urban expansion, and capital cities such as Manaus and Belém are among those where favela growth dominates. In Manaus alone, 14,000 new hectares of favela settlement emerged during this period, further concentrating vulnerable populations in climate-exposed locations (MapBiomas, 2023). This expansion has left favelas disproportionately exposed to hazards: by 2022, just 3% of Brazil's total urban area was located in risk zones, compared to 18% of favela area (MapBiomas, 2023).

Vulnerability to disaster risk is further compounded by structural gaps across other interconnected dimensions. For example, inadequate access to public services and infrastructure, such as drainage systems, road networks, early warning systems and emergency response capacity, leaves communities disproportionately exposed when extreme events strike (IPCC, 2022). Beyond community-level services, much of Brazil's critical infrastructure is already exposed to present-day hazards due to poor efficiency and maintenance. This includes water supply, food production and distribution, electricity generation and transmission, and transport networks, including roads and ports (Instituto Internacional para a Sustentabilidade [IIS], 2019).

In addition, existing governance and institutional constraints mean that sub-national governments often lack the technical and financial resources to implement land use regulations, building codes or adaptation investments. Brazil's 1988 Federal Constitution decentralised urban policy to municipalities, but without equalising their technical and financial capacity to implement it. The vulnerability of local institutions is particularly acute. In Acre, for example, 80% of municipalities had no formal civil defence structure as recently as five years ago (INT-D). Even where capacity exists, political interference delays disaster response. For instance, politically appointed civil defence coordinators may lack technical qualifications, and inter-governmental coordination during emergencies is described as "practically non-existent" (INT-D). The result has been growing territorial inequality, with inadequate infrastructure and the concentration of poverty disproportionately burdening peripheral urban communities (Paz, Menezes, Branco et al., 2022). Furthermore, characteristics such as age, gender and race all play a part in how vulnerable a community is to a disaster's impact and its capacity to recover (Ministry of the

Environment and Climate Change (2025); Monteiro Dos Santos et al., 2024; Yang, et al., 2023; Erman et al., 2021).

The hazard trends, exposure dynamics and structural vulnerabilities outlined above do not manifest in isolation; they translate directly into fiscal and macroeconomic consequences for the Brazilian state. As extreme weather events intensify in frequency and severity, the costs of disaster response, infrastructure repair, agricultural losses and social protection demands will place growing pressure on public finances. These pressures are compounded by Brazil's highly unequal exposure landscape, where the concentration of vulnerable populations in hazard-prone areas amplifies both the human and the economic cost of each event.

3. Policy and market challenges

The intensification of physical climate risks poses mounting challenges not only for communities and ecosystems, but for the fiscal and financial systems that underpin economic stability and development. In this section, we examine how climate-related disasters transmit into macroeconomic and fiscal frameworks, with a focus on government expenditure, fiscal revenue and sovereign credit ratings. We then turn to the role of insurance markets in managing climate-related losses, analysing Brazil's protection gap and the structural barriers to greater insurance penetration.

Macro-fiscal implications of physical climate risks

The fiscal risks associated with extreme weather events caused by climate change are now an important and, in many cases, critical issue for governments around the world (Coalition of Finance Ministers for Climate Action [CFMCA], 2025). Climate change is expected to result in more frequent and severe physical hazards, creating multiple transmission channels into national macroeconomic and fiscal frameworks (Calcaterra et al., 2025; Organisation for Economic Co-operation and Development [OECD], 2024; Klusak et al., 2023; Mallucci, 2022; Volz et al., 2020). The flooding in Rio Grande do Sul in 2024 is a clear illustration of how extreme weather events can impact public budgets.

The three transmission channels examined in this section – government expenditure, fiscal revenues and sovereign credit ratings – compound one another. Expenditure pressures and reductions in revenue occurring simultaneously constrain the fiscal space needed for recovery, while rising debt levels and potential rating downgrades further increase the cost of financing both adaptation and reconstruction. Understanding these dynamics is essential for ministries of finance seeking to build climate-resilient fiscal frameworks.

Government expenditure

Climate-related disasters have direct fiscal implications by increasing government expenditure in the short and medium term. In the immediate aftermath of a disaster, governments face pressure to fund emergency relief, including food and water assistance, temporary shelter and population reallocation. In the medium term, fiscal pressure shifts to reconstruction and recovery, which typically entails rebuilding public infrastructure such as roads, bridges, ports, schools and hospitals, as well as restoring utility networks. Some governments also extend support to specific economic sectors impacted by disasters through subsidies, credit lines and temporary tax relief.

These fiscal impacts are heterogeneous across income groups and institutional contexts. Melecky and Raddatz (2011), drawing on data from high- and middle-income countries, show that climate-related disasters lead to an average increase in public expenditure of around 15%, alongside a decline in revenues of approximately 10%, over the five years following an event. Constrained fiscal space in emerging market and developing economies often prevents adequate government responses, highlighting the trade-off between absorbing shocks and scarcity of financial resources (International Monetary Fund [IMF], 2023). In these contexts, ministries of finance face an escalating need for public expenditure to deal with extreme climate events, while economic development strategies and investments in the green transition remain under threat from these impacts (CFMCA, 2025).

Brazil's underinvestment in disaster prevention reflects not only a fiscal imbalance, but a deeper political economy problem. The Brazilian government consistently spends around 10 times more on disaster response than on prevention, a pattern that has persisted annually since at least 2022 (INT-F; CICEF, 2026). Actual disaster response expenditure consistently exceeds budgeted allocations, indicating that Brazil's fiscal planning systematically underestimates climate risk. As one official observed, there is a deep "cultural barrier" in Brazilian public administration: "it is much harder to secure approval for prevention spending than for emergency response after a disaster has already occurred" (INT-A).

A further dimension amplifying public expenditures is the low insurance penetration in Brazil. Where private risk transfer mechanisms are underdeveloped, the financial burden of post-disaster reconstruction falls almost entirely on governments and taxpayers (Akyapi et al., 2025; G20, 2025). This leaves the government to effectively function not only as the insurer of last resort, but also as the main financier of disasters (Monasterolo et al., 2025), absorbing losses that would otherwise be partially offset by the private sector, an approach that may become fiscally unsustainable due to rising physical risks. Moreover, extensive public compensation can also create moral hazard: when losses are largely guaranteed by the state, incentives for households, firms and subnational authorities to invest in ex-ante risk reduction are weakened (UNDRR, 2025). These dynamics demand a fundamental reorientation of fiscal planning, from reactive post-disaster expenditure management toward ex-ante preparedness frameworks that build contingency buffers and mobilise public and private financing before extreme events happen. Instruments such as catastrophe bonds and parametric insurance, which provide governments with rapid pre-agreed payouts at the moment of crisis, rather than requiring lengthy damage assessments, are one such tool (Clarke et al., 2016; Talbot et al., 2017). The role of insurance markets in absorbing these losses is examined in depth in the following sub-section.

Fiscal revenues

Physical climate-related risks generate fiscal pressure through the erosion of government revenues. In the aftermath of natural disasters, businesses and professionals are frequently forced to suspend operations, causing a sharp contraction in economic activity that can persist well beyond the immediate recovery period, especially where productive capacity has been destroyed (Nguyen and Noy, 2020). Reduced business activity translates directly into lower tax revenues and worsening fiscal imbalances at precisely the moment when public expenditure on emergency response, reconstruction and social support is at its highest (Avgousti et al., 2023; Dabus, 2026).

These revenue effects have significant regional implications. In federal systems such as Brazil, subnational governments that depend on revenue streams closely tied to local economic activity can experience acute fiscal deterioration following a localised disaster, even when aggregate national indicators appear relatively stable. The 2024 Rio Grande do Sul floods illustrate this: revenue from the Tax on the Circulation of Goods and Services (ICMS), a key subnational tax, fell by 17.3% in May 2024 relative to pre-disaster projections (CEPAL, 2024). In addition, as shown in our analysis in Section 4, an average annual loss equivalent to 2.2% of Manaus's GDP under the RCP 2.6 scenario barely registers at the national level, yet has profound implications for the local economy. This shows we need to better understand how local climate-related events connect to larger trends, a question with direct policy implications for intergovernmental fiscal architecture, especially as extreme weather events become more frequent and intense.

Box 3.1. Case study: Rio Grande do Sul floods in 2024

Overview. In April and May 2024, Rio Grande do Sul, Brazil's southernmost state – which contributes 12.6% to the country's agricultural GDP and 5.9% of its total GDP – registered its worst floods on record. The disaster affected 478 of 497 municipalities, displaced over 580,000 people, caused 182 deaths and impacted 2.3 million people directly (Caleffi et al., 2024). The event cost nearly US$17.8 billion, equivalent to 0.76% of Brazil's GDP (World Bank, 2026) and around 13% of the state's total GDP (calculated by the authors using the latest IBGE data (2023)).

Regional fiscal stress. Rio Grande do Sul was already under fiscal stress before the disaster. Its debt stood at 224% of net current revenue: above the 200% legal ceiling set by Brazil's Fiscal Responsibility Law. The disaster caused ICMS revenue to fall 17.3% in May 2024, relative to pre-disaster projections, followed by a further 8.9% in June (CEPAL, 2024).

State response. A range of domestic actors contributed to assistance during the Rio Grande do Sul floods. Some of the programmes include:

- The federal government mobilised an initial aid package of R$50.9 billion (US$10 billion), combining direct expenditure, social protection, subsidised credit, guarantees, and tax and debt relief. It suspended the state's debt payments for 36 months (Clarke et al., 2024; CEPAL, 2024). Through the **Auxilio Reconstrução** programme, the federal government disbursed one-off payments to displaced households. Other measures include tax deferrals and an earlier disbursement of Bolsa Família, the country's social assistance programme.
- At the state level, the local government leveraged **Programa Volta Por Cima**, established following the 2023 floods, which provides cash transfers to affected families. During the 2024 floods, this programme disbursed around R$250 million to around 100,000 families (Government of Rio Grande do Sul, 2025).
- The Central Bank of Brazil (BCB) implemented complementary prudential and liquidity support – they temporarily lowered compulsory reserve requirements for banks with significant lending exposure in the region and allowed certain flood-related loans to be restructured to avoid their reclassification into problem assets (BCB, 2024).

International support was also mobilised by reallocating resources from existing projects as well as through new contracts, particularly from the World Bank, the Inter-American Development Bank (IDB) and the Development Bank of Latin America and the Caribbean (CAF). When combined with funds from the New Development Bank (NDB), BNDES, Banco do Brasil and the Regional Development Bank of the Far South (BRDE), the total assistance offered by these institutions reached around R$15.6 billion (US$2.99 billion). These packages included emergency assistance and credit lines for affected households and small and medium-sized enterprises, reconstruction, as well as financing to help improve longer-term resilience, such as water and agricultural infrastructure (Government of Brazil, 2024).

Insurance protection gap. With an insurance protection gap estimated at 90-94% for this event (Gallagher Re, 2025; CNSeg, 2024), the majority of losses fell directly on public finances. Private-sector losses reached R$80 billion, with only a small share of it covered by insurance (INT-C). After the event, insurers withdrew flood risk coverage from the market entirely. In response, the state is now structuring three innovative instruments with IDB and World Bank support: a state-level climate risk fund, a comprehensive state government insurance programme and a parametric contingent credit line triggered by rainfall thresholds (INT-C). The state is also exploring the issuance of a catastrophe bond and planning Brazil's first climate-tagged budget (LOA climática) for fiscal year 2027.

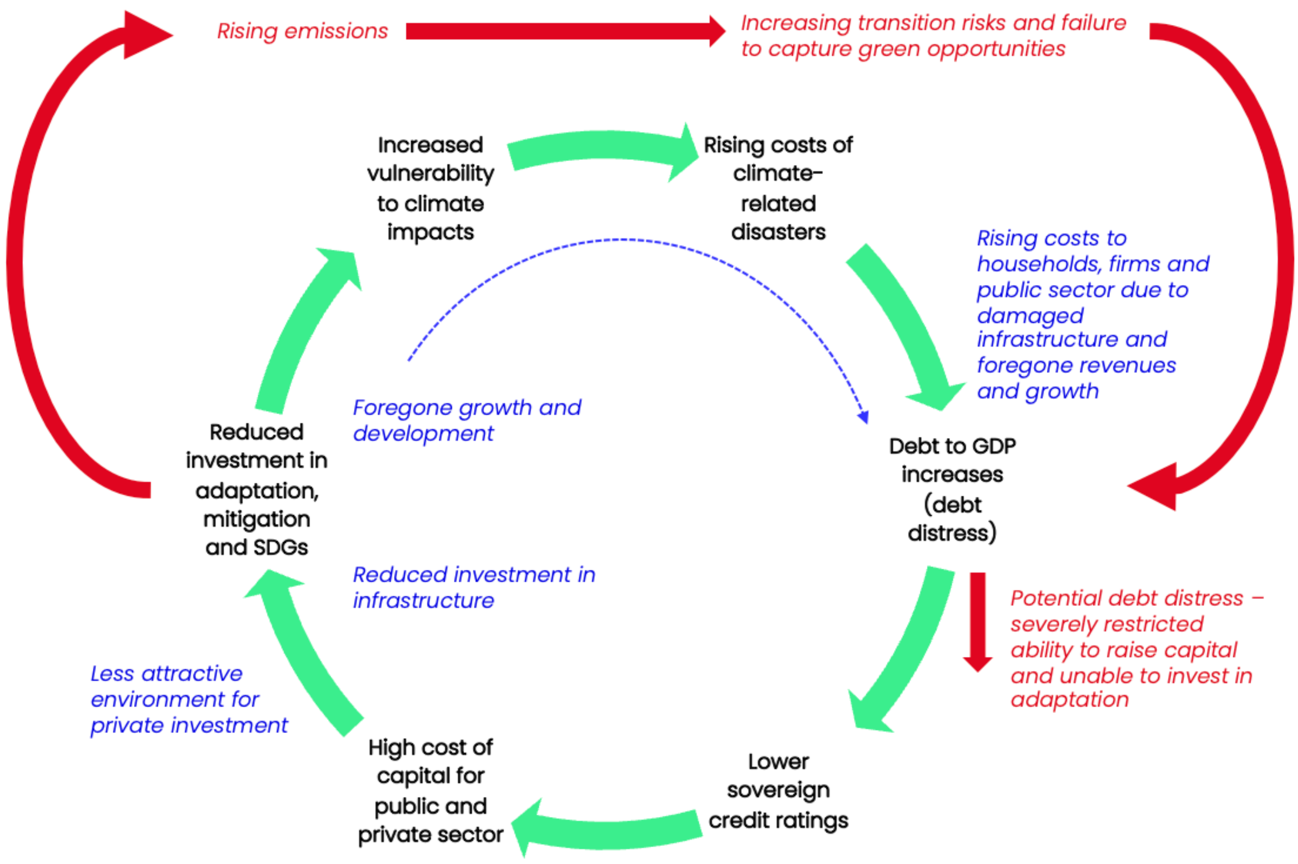
Sovereign credit ratings and borrowing costs

Physical climate-related risks can adversely affect sovereign credit ratings, with important implications for a country's ability to attract capital and its borrowing costs. Climate risks may enter rating assessments through forward-looking adjustments that account for structural exposure to climate hazards, and through post-disaster reassessments following a disaster, as illustrated by Fitch's downgrade of Pakistan following floods in 2022 (Bernhofen et al., 2024; Fitch Ratings, 2022). Klusak et al., (2023) project that 63 countries will experience rating downgrades by 2030, while Duffy (2025) further documents how climate change translates into higher sovereign borrowing costs.

The 2024 Rio Grande do Sul floods illustrate how physical risk can transmit to creditworthiness below the sovereign level, a dynamic that is likely to intensify as climate change causes more frequent and severe weather events. Following the disaster, both Fitch and S&P took negative rating actions on Banrisul, the state-owned bank of Rio Grande do Sul, reflecting the bank's high regional concentration (over 90% of its credit originates from the southern region) and significant exposure to flood-affected areas (Fitch Ratings, 2024a; S&P Global Rating, 2024a). Both agencies ultimately removed their negative watches within months – S&P in July 2024 and Fitch in October 2024 – affirming the bank's ratings with a 'stable outlook', as the impact on asset quality and profitability proved more contained than initially anticipated (Fitch Ratings, 2024b; S&P Global Rating, 2024b).

Taken together, the three channels examined above create a self-reinforcing cycle of fiscal vulnerability. Increased post-disaster expenditure and reduced revenues translate into higher public debt and rising borrowing costs; credit rating pressures compound this further by increasing the cost of financing both adaptation and reconstruction (Melecky and Raddatz, 2011; Monasterolo et al., 2025). This dynamic is captured by Bernhofen et al., (2024) in their "climate investment trap for adaptation" (Figure 3.1). Addressing this trap requires moving from reactive spending towards proactive risk financing strategies, including insurance.

Figure 3.1. The climate investment trap for adaptation B



Source: Adapted from Bernhofen et al., 2024

Overview of the insurance market in Brazil

Brazil has a large and well-developed insurance sector, supported by substantial technical reserves, a consolidated regulatory framework and strong institutional capacity. The sector, which is regulated by the Superintendence of Private Insurance (SUSEP), responsible for overseeing insurance, open private pension and capitalisation products, collected R$415.09 billion in revenues in 2025. By December 2025, the sector held approximately R$2.06 trillion in technical reserves, set aside to meet obligations to policyholders and beneficiaries. This is equivalent to 16.15% of Brazil's GDP (SUSEP, 2026). Despite the scale of the sector, however, insurance coverage against climate-related catastrophe risks remains relatively low, contributing to a significant insurance protection gap for climate-related losses.

The composition of the Brazilian insurance market helps explain this protection gap. Up until October 2025, motor insurance accounted for 42% of premiums within the property and casualty market segment, according to SUSEP data (2025b). While products covering certain climate-related risks do exist, families, companies and the government remain largely uninsured against them. For example, only 0.14% of existing home insurance covers flood risks, and only 20% of homes are insured at all (SUSEP, 2025). In the case of public infrastructure, climate-related risks are often considered 'force majeur', falling within exclusions in coverage, or at least being a subject of dispute between insurer and policyholder (Institute for Climate and Society [iCS] and Radar PPP, 2025). This creates a mismatch between the growing materiality of physical climate-related risks and the types of risks currently insured at scale. As climate-related losses increase, this mismatch creates growing pressure on households, businesses and public finances.

The cost structure of insurance in Brazil also constrains market expansion. It is estimated that 40–50% of insurance premiums are absorbed by intermediary costs (brokers, commissions and administrative expenses), leaving a relatively small share to cover expected losses (INT-C). Pricing climate-related risks presents an additional challenge: actuarial models remain backwards-looking, relying on historical loss data that may no longer reflect the changing climate risk profile. As one insurer noted: "We price based on the past, but the past is no longer a good predictor of the future" (INT-B). At the same time, the limited number and small size of climate-related insurance products in Brazil make it difficult to generate reliable pricing: there is simply insufficient loss data to assess whether premiums are adequate (INT-E).

The insurance protection gap is already visible in recent disaster losses. Globally, natural catastrophe losses reached US$235 billion in 2025, while insured losses amounted to US$120 billion, meaning that approximately 51% of losses were uninsured (Swiss Re Sigma, 2026). In Brazil, the 2024 Rio Grande do Sul floods exposed an even wider gap. Gallagher Re (2025) estimates economic losses of approximately US$15 billion. Of these losses, only US$1.5 billion were insured by the private insurance market, implying a protection gap close to 90%. In addition, CNSeg (2024) estimated the insurance protection gap to be around 94%. This means that the overwhelming majority of losses were ultimately absorbed by households, businesses and governments.

Another structural constraint in Brazil lies in the design of standard insurance products. In Brazil, the mandatory minimum coverage for residential insurance until 2021 covered only fire, lightning and explosion, excluding flood damage. After 2021, insurers were given greater flexibility to design their products, but the old structure remained a legacy (INT-F). Even when flood coverage is available as an optional add-on, uptake is minimal: at one major insurer, only 5–8% of residential policyholders opted for it when offered (INT-B). In the Rio Grande do Sul floods, this meant that many insured households received no indemnification whatsoever: they held valid insurance policies that simply did not cover the peril that destroyed their homes (INT-F).

The insurance protection gap is becoming particularly important as Brazil's climate risk profile changes. Historically, Brazil has not been seen as a major catastrophe insurance market, unlike countries exposed to primary perils, such as earthquakes and hurricanes. However, climate change is amplifying secondary perils in Brazil, particularly floods, droughts, extreme rainfall, wildfires and landslides. Gallagher Re (2025) estimates that Brazil's average annual insured losses from natural catastrophes increased from US$175 million from 2000–19 to US$908 million between 2020-24, representing a 20-fold increase every five years largely associated with recent severe droughts and floods. This reflects a broader global trend in which climate change is increasing the frequency and severity of weather-related losses (IPCC, 2022; NGFS, 2024).

Climate-related catastrophe risks present particular challenges for insurance markets because losses tend to occur simultaneously across a geographic area. Unlike risks such as car accidents or household theft, floods and droughts can generate simultaneous claims across entire regions, reducing insurers' ability to diversify risk efficiently and increasing capital requirements. Climate change further complicates underwriting because historical loss data may no longer accurately predict future hazards and return periods (Monasterolo et al., 2025; OECD, 2023). As the relationship between past and future losses becomes less predictable, insurers face greater uncertainty when pricing risk and setting reserves. The result is growing pressure on insurers to raise premiums, restrict coverage or, in some cases, withdraw from high-risk areas, as has happened in wildfire-prone regions in California (Congressional Research Service, 2025).

Low insurance penetration in Brazil also reflects demand-side barriers. Affordability constraints, low levels of risk awareness, income inequality and limited familiarity with financial products all reduce demand for coverage, particularly among lower-income households and small businesses. These barriers are especially significant in informal settlements and urban peripheries, with high exposure to climate-related floods and landslides, and low levels of financial resilience (OECD, 2023; World Bank, 2025). As a result, those most exposed to climate risks are often the least financially protected.

Interview data provides a more granular picture of insurance penetration than published statistics alone. Residential insurance covers approximately 17–20% of Brazilian households, with penetration higher in the South due to both cultural factors and more frequent weather events (INT-B, INT-E, INT-F). Automobile insurance covers roughly 30% of Brazil's vehicle fleet, while rural insurance has collapsed to around 3% of cultivated areas following reductions in the government subsidy programme (at its peak, rural insurance was 14%) (INT-F). Insurance for infrastructure directly managed by the government is negligible: security sector specialists estimate it is below 2% (INT-F, INT-E).

The broader economic burden of disasters in Brazil is already substantial. According to the Confederação Nacional de Municípios, disasters generated R$639.45 billion in reported losses between 2013 and 2023. Agriculture accounted for R$271 billion, equivalent to 42.4% of total losses; water supply accounted for R$45.3 billion; infrastructure works for R$38.9 billion; housing for R$36.2 billion; and transport systems for R$23 billion (Confederação Nacional de Municípios, 2024). These are likely to be underestimates because less than half of the municipalities that declared disasters reported monetary losses through the federal reporting system.

The Rio Grande do Sul floods illustrate why this matters not only for insurers, but also for public finance and economic resilience more broadly. Attribution research suggests that the disaster resulted not only from extreme rainfall, but also from the interaction between hazard exposure, uneven flood protection infrastructure, insufficient maintenance and the expansion of developments into flood-prone areas (Simoes-Sousa et al., 2025). This reinforces a central finding of the climate risk literature: insurance can distribute losses financially, but it does not directly reduce the underlying hazard, exposure or vulnerability that generate those losses (Seifert-Dähnn, 2018; Surminski, Bouwer and Linnerooth-Bayer, 2016). Effective climate resilience therefore depends on combining insurance with broader adaptation and disaster risk reduction strategies, including nature-based solutions, resilient infrastructure, land-use planning, drainage systems or other adaptation measures.

The insurance sector should therefore be understood as one component of a broader climate risk management architecture rather than as a standalone solution. The disaster risk financing literature typically distinguishes between three complementary layers of climate risk management: risk reduction, risk retention and risk transfer (Clarke, 2016; World Bank, 2025). In this context, risk reduction aims to lower expected losses through adaptation investments such as nature-based solutions, resilient infrastructure, flood defences and land-use planning. Risk retention involves absorbing smaller and more frequent losses through reserve funds, budget reallocations or contingency mechanisms. Risk transfer, by contrast, shifts part of the financial burden of severe disasters to insurers, reinsurers or capital markets through instruments such as insurance, reinsurance, catastrophe bonds or parametric products. Effective resilience strategies require all three layers simultaneously (Clarke et al., 2017).

Brazilian insurers also play an important role as institutional investors. According to our interview data, the sector holds approximately 26% of Brazil's public debt (INT-F). However, Brazilian insurers allocation to infrastructure investment is minimal, typically up to 3% of portfolios, compared to roughly 20% in Peru, a notable exception in the world (INT-F; OECD, 2025). The implementation of Solvency II-style capital requirements in Brazil, mostly through the National Monetary Council (CMN) Resolution No. 4,993 of 2022, has further reduced insurers' appetite for long-duration, illiquid infrastructure assets (INT-F). However, unlocking even a modest reallocation of insurer portfolios towards climate-resilient infrastructure could create a virtuous cycle: better infrastructure reduces insured losses, which improves the sector's risk profile, which in turn supports further infrastructure investment.

Brazil's federal system adds another layer of complexity, as responsibility for disaster risk management is distributed across municipalities, states and the federal government. Municipalities are primarily responsible for drainage systems, urban planning and local disaster prevention, yet many lack the fiscal and technical capacity to implement adequate risk reduction measures. When disaster strikes, many municipalities are also unable to bear the costs of disaster response and reconstruction. Consequently, localised climate-related disasters frequently escalate into state and federal fiscal shocks, requiring emergency transfers, reconstruction spending and debt relief measures. In practice, the federal government often assumes a risk-absorbing role, bearing a significant share of reconstruction costs when subnational resources prove insufficient.

The literature suggests that higher levels of insurance penetration can support faster and more stable post-disaster recovery by spreading losses over time and across larger pools of capital, reducing liquidity constraints and limiting the need for ad hoc public compensation (Melecky and Raddatz, 2011; OECD, 2018; Cambridge Centre for Risk Studies and AXA XL, 2020). However, expanding insurance coverage alone will not be sufficient. It must be accompanied by stronger climate risk data, improved local risk assessment, resilient infrastructure investment, adaptation finance and incentives for prevention. This challenge is likely to become more acute as climate change may increase both the physical and financial risks associated with insurance. While rising climate-related risks may increase the need for insurance, higher premiums, affordability constraints and tighter public and household budgets could also limit demand and reduce the availability of coverage.

Regulatory framework

Brazil has a well-established institutional framework for insurance supervision. However, the broader framework for financing climate-related disaster risks remains fragmented and needs to evolve into a fully integrated architecture for climate-related catastrophes. SUSEP supervises the insurance, open private pension, capitalisation and reinsurance markets, while the National Council of Private Insurance (CNSP) establishes policy guidelines and regulatory standards for the private insurance system; both are linked to the Ministry of Finance.

The regulatory environment has also become more supportive of innovation. Governmental supervisory agencies are described by market participants as increasingly receptive to innovation, particularly in parametric products and technology-driven distribution (INT-B). However, regulatory openness has not yet translated into market adoption. For example, although parametric insurance for property has been discussed in the industry for the past few years, no commercial products have reached the Brazilian market to date (INT-B). There is a bill currently under congressional debate that proposes a catastrophe protection framework that could provide the legislative foundation for several innovations, though its timeline and final form remain uncertain (INT-B).

Recent reforms have modernised important aspects of the regulatory framework. Law No. 15,040/2024 established a new legal regime for private insurance contracts, aiming to improve legal certainty and contractual predictability. Complementary Law[8] No. 213/2025 expanded the framework governing insurance cooperatives and mutual protection arrangements, while also strengthening SUSEP's supervisory powers. In parallel, SUSEP Circular No. 666/2022 introduced sustainability-related requirements for insurers, pension entities and reinsurers, reflecting the growing relevance of climate-related physical and transition risks for underwriting, solvency and investment management.

While these reforms represent important progress, they do not create a comprehensive disaster risk financing framework capable of managing climate-related losses. Brazil still lacks a clearly layered system defining how climate-related risks should be managed across municipalities, states and the federal government. This includes how risks should be monitored, communicated and reduced, as well as transferred across households, firms, insurers, government agencies and public financial institutions.

The regulatory and policy challenge for Brazil therefore extends beyond expanding private insurance penetration. It also involves strengthening fiscal resilience by integrating disaster risk financing into broader fiscal, infrastructure and investment strategies (Pereira da Silva et al., 2026), including designing an enabling framework for climate-related disaster risk financing across all levels of government. Areas for policy development could include clearer rules for subnational risk transfer, improved fiscal treatment of insurance premiums and payouts, public procurement frameworks for parametric insurance products, integration of climate risk into public asset management and incentives for critical infrastructure operators to assess, disclose and reduce physical climate risks.

Strengthening a framework for disaster risk financing will require improvements in the information and payment infrastructure that underpin insurance markets. Advances in satellite imagery, geospatial

[8] In the Brazilian legislation, a Complementary Law regulates matters for which the Federal Constitution expressly requires this type of legislation. It ranks above ordinary laws and below the Constitution.

data, remote sensing and digital risk mapping can improve the identification of exposed assets, strengthen risk pricing and support the development of products such as parametric insurance. At the same time, Brazil's digital public infrastructure, including PIX and digital identity systems, could facilitate faster post-disaster payments, improve premium collection and expand access to insurance, particularly among underserved populations. These technologies cannot be a substitute for regulatory reform, but they can reduce transaction costs and help overcome some of the practical barriers to implementation. Their effectiveness will depend on complementary investments in climate data and modelling, stronger knowledge transfer between scientists and insurance professionals, and regulatory and market incentives that encourage innovation and wider adoption.

Compulsory insurance is unlikely to provide a solution, as its political feasibility in Brazil is low. The political debate in this area continues to be shaped by the precedent of DPVAT, a mandatory vehicle insurance that was abolished after controversies. Multiple interviewees independently raised DPVAT as a cautionary tale (INT-C, INT-F) and suggested that compulsory insurance was currently politically unfeasible in Brazil (INT-C). This suggests that strengthening Brazil's disaster risk financing architecture is likely to depend on voluntary market uptake supported by well-designed public incentives such as subsidies, tax benefits or conditional credit. To avoid reinforcing existing exposure or creating moral hazard, these incentives should be linked, where possible, to measurable risk reduction and resilience outcomes, rewarding investments that reduce underlying climate-related risks (Brown et al., 2026).

4. Analysis

In this section, we present quantitative analysis estimating average annual flood losses for eight Brazilian municipalities under three climate scenarios. To assess the fiscal relevance of these flood losses, we compare them to city-level GDP and examine how investing in flood protection could reduce damages. The findings are intended to inform the design of insurance instruments, the allocation of adaptation finance and the integration of physical climate risk into fiscal planning across Brazil.

Framing and objectives

Quantifying the economic cost of flooding for cities in Brazil is necessary to inform the design of effective policy that can mitigate these costs. Ministries of Finance, financial regulators and development banks need estimates of where losses are likely to be, how large they could be under different climate trajectories and how much of that exposure could be reduced through investment in adaptation. In the previous section, we set out the transmission channels through which physical risks translate into fiscal pressure, for instance, through sudden demands on expenditure, reduction in government revenues, pressure on credit ratings and the 'climate investment trap for adaptation' (Figure 3.1). This section outlines the scale of these risks by means of average annual flood losses.

Our analysis uses open-source, globally consistent data and tools to produce estimates that are comparable across cities and scenarios. Fluvial flood hazard projections come from the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP2b) CaMa-Flood simulation ensemble (Zimmer et al., 2023; Yamazaki et al., 2011), which combines six global hydrological models with four global climate models to generate annual maximum flood depths across each city. These estimates are available under three RCPs (RCP 2.6, RCP 6.0 and RCP 8.5).[9] We estimate the exposure of assets to flood risk using the LitPop methodology (Eberenz et al., 2020), which disaggregates national installed-capital totals across each city using satellite images of night-time lights and gridded population data. Hazard and exposure data are combined using the CLIMADA platform (Bresch and Aznar-Siguan, 2021) to produce average annual loss for each city. This is then expressed as a share of city GDP, drawn from the IBGE municipal GDP series (pooled from Ipeadata, 2025). The average annual loss should be understood as the loss that could be expected in any given year, averaged across the full range of possible flood outcomes, rather than an amount lost every year. In practice, most years bring little or no flood damage, while a minority of severe years account for the bulk of the long-run average.

Our chosen methodology aims to balance precision and policy relevance, while ensuring the analysis can also be done by policymakers. Open-source global flood datasets cannot capture every dimension of urban flood risk in Brazil.[10] Instead, the analysis provides an internally consistent, cross-city estimates that distinguish cities most exposed to fluvial flood losses from those that are not. This framework enables us to identify where the losses are large enough to matter for subnational fiscal stability and to quantify how much of the exposure can be removed with stronger flood protections. These results provide clear and useable information that can inform the design of a Disaster Financing Risk Strategy for Brazil and for prioritising adaptation investment across Brazilian cities.

[9] RCP 8.5 was originally designed as a scenario of comparatively high greenhouse gas emissions, implying, for example, a substantial expansion of coal use (Riahi et al., 2011) and a scenario which has not followed historical trends (Ritchie and Dowlatabadi, 2017). It is now more commonly understood as a 'tail-risk' pathway, partly because observed emissions have tracked closer to intermediate scenarios than to RCP 8.5 (Hausfather and Peters, 2020; McSweeney et al., 2026). Although the IPCC has since moved to the Shared Socioeconomic Pathway scenarios and de-emphasised the older RCPs, the ISIMIP2b hazard simulations used here are based on the RCPs. Thus, RCP 8.5 is treated in this report as a high-risk, but increasingly implausible upper bound. RCP 6.0 central estimates, which are more consistent with the historical record, are our preferred estimates.
[10] Coastal storm surge and pluvial flooding driven by overwhelmed urban drainage remains outside the modelled hazard layer. The rapid pace of informal urban expansion in cities such as Manaus and Belém all remain outside the modelled exposure layer. A more detailed description of the methodology is discussed below and in the technical Annex.

Leveraging CLIMADA to estimate expected losses

Our analysis is built on three metrics that are key to estimating the economic exposure of cities:

- A representation of the assets at risk in each city (exposure)
- A representation of where and how often flooding occurs (hazard)
- A function that links flood depth to monetary damage (impact).

The three metrics are integrated within the CLIMADA platform (Bresch and Aznar-Siguan, 2021) to produce a single comparable metric for each city: the average annual loss. All monetary values in the analysis are expressed in constant 2019 US dollars (US$).

Exposure: where the assets are

Detailed maps of the locations of physical assets in cities and their value are rare. But we can approximate this information using satellite images of night-time light data and population maps. LitPop combines these to distribute city-specific total capital across grid cells of around 1km^2 (Eberenz et al., 2020). Brightly lit and densely populated cells receive a larger share of the national total of assets, which comprises machinery, buildings, equipment and urban land reported in real chained 2019 US dollars (World Bank, 2024), than dark or sparsely populated areas. This produces a spatial pattern that approximates where physical assets are located. The exposure measure is each city's installed capital: the stock of built private and public assets. Rather than splitting the national total of assets across cities by lit and populated land alone, our analysis first allocates it across municipalities in proportion to their observed share of national GDP (Ipeadata, 2025). We then distribute each municipality's share within the city using the night-time lights and population pattern data.

Hazard: where and how often flooding occurs

Our flood projections come from ISIMIP2b ensemble of fluvial flood simulations (Zimmer et al., 2023), an international scientific initiative that coordinates climate impact modelling under standardised inputs. Our analysis uses simulated annual maximum flood depth at a resolution of around five kilometres (at the equator), which is applied consistently for each city, over the period 2025–2100.

Rather than relying on a single projection, our analysis uses an ensemble of six hydrological models combined with four global climate models, repeated under three emissions pathways (RCP 2.6, RCP 6.0 and RCP 8.5). The model ensemble approach was chosen because there is substantial uncertainty. Different hydrological and climate models yield different rainfall and river flow patterns under the same emissions scenario (Beck et al., 2017; Mester et al., 2021), hence a central estimate alongside the spread across model combinations provides both a headline number and a sense of how modelling choices drive the main results. A small number of model combinations are excluded on a city-by-city basis where they produce inconsistent results with respect to the rest of the ensemble. More specifically, these models yield much higher estimates of losses, a flaw partially documented in the hydrological literature. Given that the excluded combinations sit at the high-loss end of the distribution, removing them makes the reported estimates lower and more conservative. [11]

Impact: from flood depth to monetary loss

Simply combing hazard and exposure does not produce a damage estimate. A damage function translates flood depth at a given location into the fraction of asset value destroyed. Our analysis uses a depth-damage function for South America recommended for the region in the Joint Research Centre's (JRC) global flood damage database (Huizinga et al., 2017). This function captures the fact that deeper flooding causes more damage, up to a ceiling that reflects full destruction of the asset. CLIMADA sometimes call this 'the vulnerability function'. This report uses vulnerability in the broader IPCC sense (2022), which also reflects the social and institutional capacity to anticipate, cope with and recover from hazards. We refer to it as the 'impact' or 'damage' function: a purely mathematical

[11] A more detailed discussion of the exclusions is in the technical Annex.

relationship between flood depth and the share of asset value lost. By combining the three layers for each year in each simulation, we can produce an expected monetary loss for each city.

Average annual flood losses across cities and scenarios

There is wide divergence in expected flood losses across Brazil's largest cities. Expressed as a share of city GDP, the eight municipalities fall into three broad tiers of exposure (Figure 4.1). First, Manaus and Porto Alegre face the highest expected losses. Their central estimates are 2.2% and 1.6% of city GDP, respectively, even under the most ambitious mitigation scenario, and rising further under higher emissions. The second tier of exposure is made up of Belém, São Paulo, Rio de Janeiro and Florianópolis, with central estimates ranging from around 0.1 % to 0.6 % of GDP across scenarios. At the low end, expected losses in Brasília and Fortaleza sit below 0.01 % of GDP across all scenarios.

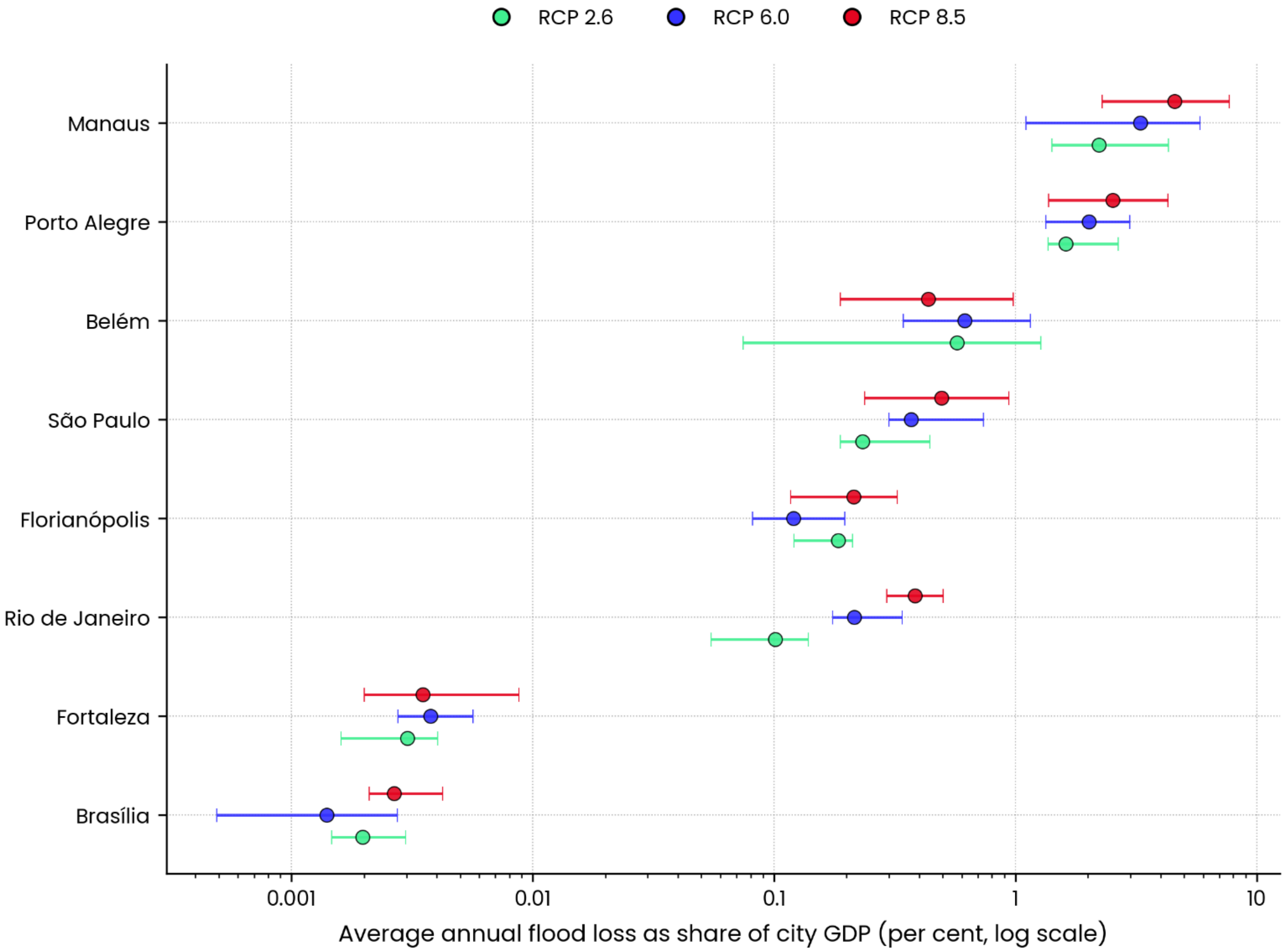
For the mid- and lower-tier cities, these averages are of a similar order to the contingency reserves that municipalities typically hold. In other words, in most years the losses would be absorbable within existing budgets. However, the figures are long-run averages, and much of the loss is concentrated in a small number of severe years in which damages can far exceed the average. It is this concentration in rare, severe years, rather than the average itself, that strains municipal finances and underpins the case for risk transfer, alongside investment in adaptation measures.

High-exposure cities face high fiscal risk

Manaus and Porto Alegre stand apart in terms of fiscal risk. Under RCP 2.6, central estimates place average annual loss at 2.2% of city GDP for the former and 1.6% for the latter. Under RCP 8.5, the central estimates rise to 4.6% for Manaus and 2.5% for Porto Alegre, with the upper end of the ensemble reaching 7.7% and 4.3%, respectively.

Losses on this scale could not be absorbed annually from municipal budgets alone. As seen in Section 3, physical risks become sudden and unexpected liabilities for public finances through three channels: surges in emergency expenditure, the erosion of revenues from damaged tax bases, and pressure on sovereign and subnational credit ratings. The 2024 floods in Rio Grande do Sul, for example, caused economic losses of US$17.8 billion, equivalent to around 0.76% of Brazil's GDP that year (World Bank, 2026), a sizeable share of national output. The floods required a federal emergency package of around US$10 billion, an illustration of the economic demands a single extreme flood event can impose.

Figure 4.1. Average annual flood loss as a share of 2022 GDP for each city



Note: point estimates correspond to the median of the estimated average annual loss across the model ensemble for each city under a given RCP. The bands represent the 25th and 75th percentiles of the ensemble distribution.

Source: Authors' calculations using Zimmer et al. (2023) and Bresch and Aznar-Siguan (2021).

Mid-exposure cities face significant losses

Belém, São Paulo, Rio de Janeiro and Florianópolis form a middle tier of fiscal risk. Under RCP 6.0, central average annual loss estimates range from 0.6% of city GDP for Belém, 0.4% for São Paulo, 0.2% for Rio de Janeiro and 0.1% for Florianópolis. In absolute terms, however, São Paulo's exposure is the largest of any city in the analysis: central RCP 6.0 losses approach US$700 million per year (relative to a GDP of US$190 billion).

For these cities, expected losses are large enough to compete with material lines of public investment. Losses of this magnitude would meaningfully tighten the climate investment trap: resources committed to post-disaster recovery are resources that will not be used to finance adaptation, public services or other activities with high multiplier effects. Importantly, the resulting drag on growth can feed back into a weaker fiscal position over time, even where the headline average annual loss share of GDP appears moderate.

Low-exposure cities are not riskless

Fortaleza and Brasília show average annual losses well below 0.01% of GDP under all central estimates. Neither city is heavily exposed to fluvial flooding in the ISIMIP2b simulations, reflecting their inland geography and the absence of major floodplains in their urban footprints. However, our analysis only covers fluvial flooding, and these cities could be exposed to pluvial flooding from extreme rainfall.

Higher emissions, higher losses with higher uncertainty

In general, fiscal losses from flooding increase under higher emissions pathways: across most cities, central estimates under RCP 8.5 exceed those under RCP 6.0, which in turn, exceed those under RCP 2.6. The picture is not uniform, however. For Belém, the central estimate under RCP 8.5 (0.44% of GDP) is below the estimate under RCP 2.6 (0.57%) and RCP 6.0 (0.62%). For Florianópolis, the central estimate under RCP 6.0 is below that under RCP 2.6, though RCP 8.5 remains the highest of the three. This does not mean higher emissions reduce flood damages. Instead, it highlights two sources of uncertainty in our modelling:

- First, the model ensemble yields a relatively high spread of estimated annual expected losses, which results from the fact that different combinations of hydrological and climate models respond to the same climate forcing[12] in different ways. This can therefore impact the ordering of central estimates across scenarios (Beck et al., 2017; Mester et al., 2021).

- Second, there is a resolution gap when using open-source datasets: the global flood models employed operate at a scale of roughly five kilometres, which captures large floodplains well, but can miss the finer hydrological features that matter at the municipal level.

Both effects compound at higher emissions, where the climate system moves further from the historical conditions used to calibrate the underlying models, and uncertainty grows accordingly. Relatedly, because these estimates are averaged over the full century, they smooth over changes within it: for several cities and scenarios the underlying losses grow towards the later decades as cumulative warming increases, a pattern set out in the technical Annex.

The role of adaptation in mitigating expected losses

Figure 4.2 shows how average annual flood losses, as a share of city GDP, decline as flood protection standards rise. In each panel the dark curve approximates the median estimate across the full ensemble of climate and hydrological models, and the darker shaded band captures the spread between the 25th and 75th percentiles. Two markers anchor the policy comparison: the red square shows where each city sits today under the FLOPROS standard, a global database of existing flood protection (Scussolini et al., 2016), and the green diamond shows what a 1-in-100-year standard would deliver (flood defences designed to withstand a major flood event that has a 1% change of occurring any single year). The vertical distance between the two markers is the avoided average annual loss from upgrading the protection standard. The markers are the modelled losses at each standard, while the curve is an approximation built from auxiliary data, so the markers are not expected to fall exactly on it. Given that both markers summarise each city across the full ensemble of models and scenarios, they do not necessarily correspond to any single point in Figure 4.1.

The six cities shown in Figure 4.2 are those with the largest exposure to fluvial flood in our analysis. Brasília and Fortaleza are not included as their fluvial flood losses are small. This does not mean that they do not face risks from flood (pluvial flooding from extreme rainfall is not modelled in our analysis and may affect both cities), but it does suggest that fiscal resources directed specifically at fluvial flood defences in Brasília and Fortaleza would deliver limited returns relative to alternatives.

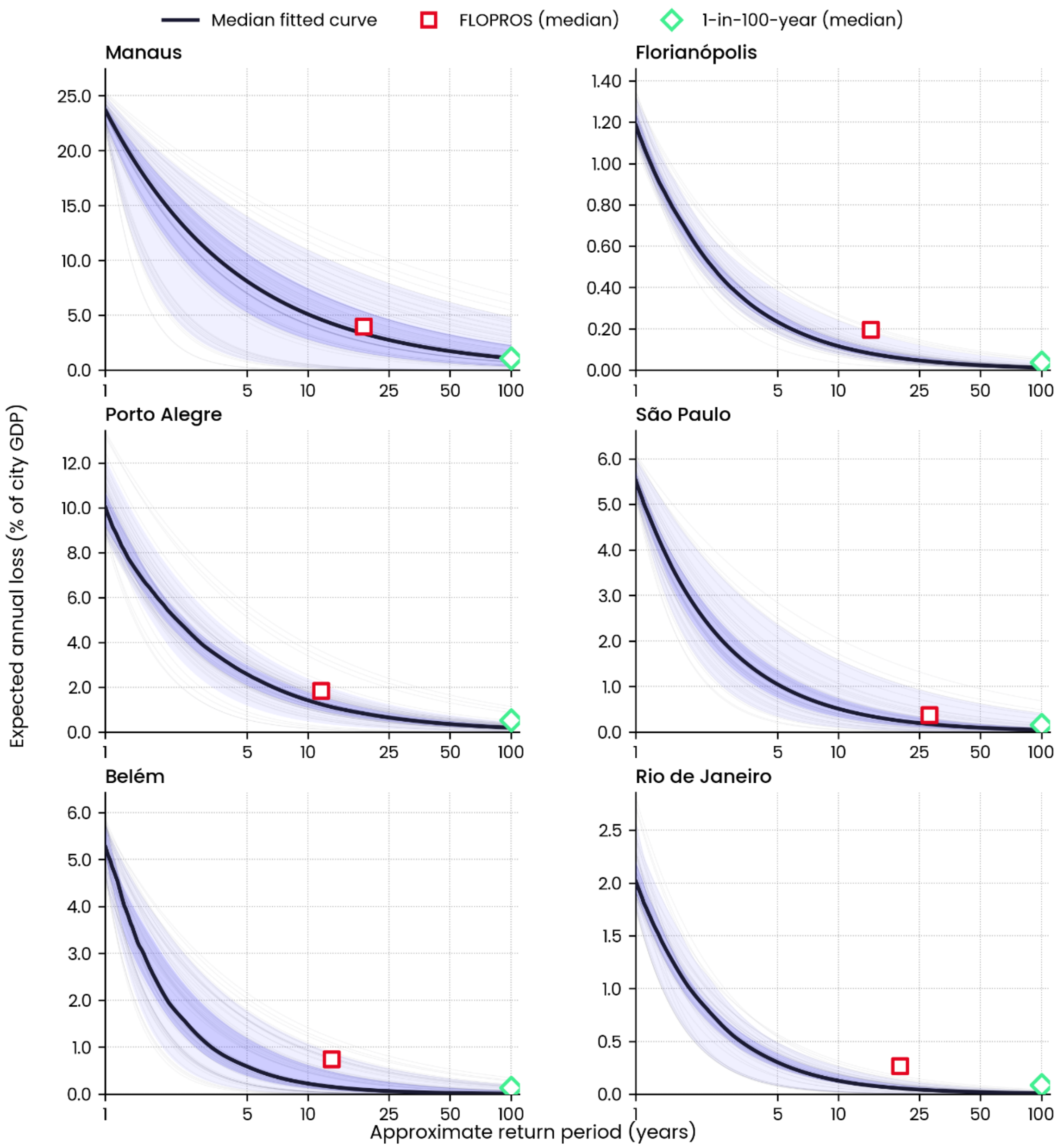
High-exposure cities: adaptation translates into high returns

For the two cities most exposed to fluvial flood, Manaus and Porto Alegre, the gap between current protection and a 1-in-100-year protection standard is large. For example, in Manaus the difference between current protection and a 1-in-100-year standard could reduce average annual losses from 4% to under 1.1%, a reduction in expected losses of about US$650 million. In Porto Alegre, the comparable reduction is from 1.8% to under 0.5% of GDP, or around US$230 million. Across the cities, moving to a 1-in-

[12] Climate forcing refers to the change in net radiative balance at the top of the atmosphere driven by greenhouse gas concentrations.

100-year standard prevents average annual flood losses by between 50% and 80%. In a few model-scenario combinations, these adaptation measures prevent expected losses completely. Reductions of this magnitude have direct implications for the fiscal channels set out in Section 3: avoided losses are resources that can be committed to other purposes, such as national development priorities.

Figure 4.2. Average annual flood loss as a share of city GDP under different flood protection standards



Note: The dark blue line is the median estimate across the ensemble of climate and hydrological models, and the shaded bands represent the inter-quartile range (25th to 75th percentiles, darker band) and the 5th to 95th percentile range (lighter band). The red square marks each city's median average annual loss at the FLOPROS standard (capturing existing flood protection); the green diamond marks the median loss at a 1-in-100-year return period standard. The markers are the modelled losses at each standard, while the curve is fitted separately from auxiliary data using a power law, so the two need not coincide. The technical Annex sets out how the curves are fitted. Source: Authors' calculations using Zimmer et al. (2023), Bresch and Aznar-Siguan (2021), Scussolini et al. (2016) and IBGE Produto Interno Bruto (PIB) Municipal (2023).

Mid-exposure cities: smaller reductions, yet material in absolute terms

For Belém, São Paulo, Rio de Janeiro and Florianópolis, the headline percentage-point reductions are smaller: in the range of 0.1 to 0.4 percentage points of GDP. This does not imply that adaptation is unimportant. In fact, the absolute fiscal benefit can still be substantial when applied to a large economic base. For São Paulo, a reduction of approximately 0.2 percentage point of GDP corresponds to avoided expected losses of around US$360 million a year. For Rio de Janeiro, the same logic yields a reduction in expected losses in the order of US$120 million a year.

Two further details are worth highlighting: first, the analysis only contemplates fluvial flooding. Pluvial flooding from overwhelmed urban drainage, which is, for example, more relevant in the case of São Paulo, is not included. Thus, the avoided-loss figures should be read as a lower bound on the broader benefits of investment in urban flood resilience. Second, for Rio de Janeiro and Florianópolis, coastal storm surge is a separate hazard that is not captured by the simulations used in our analysis.

The avoided losses estimated here capture only direct, modelled damage to installed capital. Investment in adaptation also shapes the broader risk outcome. It lowers recurrent damage, eases pressure on emergency expenditure, protects revenue bases, and weakens the borrowing-cost and credit-rating channels through which physical risk becomes fiscal risk, as set out in Section 3. The wider literature frames these gains as a triple dividend of adaptation: avoided losses, induced economic activity and broader social and environmental co-benefits, with median benefit-cost ratios on the order of four to one (Rising et al., 2026). For Latin America and the Caribbean, the adaptation gap remains wide; closing it through integrated, well-targeted investment becomes more urgent as climate impacts intensify (Inter-American Development Bank, 2025).

Residual risk and the case for risk-transfer instruments

Even at a 1-in-100-year protection standard, average annual losses do not fall to zero. Across the six cities, residual losses range from around 0.04% of GDP in Florianópolis to about 1.1% of GDP in Manaus. These residual losses arise from events that exceed even high engineering standards; they are precisely the low-probability, high-severity tail risks for which insurance and other risk-transfer instruments are designed.

Our results therefore make a strong case for investment in adaptation, particularly in the most exposed cities, and the widespread adoption of insurance and risk-transfer solutions, both public as well as private, capable of transferring the residual risk that adaptation cannot eliminate. These two pillars are complements, not substitutes. Adaptation lowers the expected size of flood losses, while insurance and other risk-transfer instruments distribute any remaining losses, thereby smoothing their fiscal impact and protecting public and private finances from unexpected and sudden demands. A coherent policy package must therefore advance both: ex-ante adaptation measures to reduce the underlying exposure, alongside a risk financing strategy, which includes risk retention and risk transfer instruments, such as insurance products, to manage the salient flooding risks that persist.

Neither pillar removes the need for mitigation. Rapid reductions in emissions are essential to limit how far flood risk ultimately increases. But because past emissions have already locked in further warming, more frequent and severe flooding will continue to materialise regardless of the mitigation pursued today. This is precisely what makes adaptation and risk transfer indispensable, even as adaptation itself cannot engineer away all exposure to risk. Investment in adaptation and the expansion of insurance are therefore necessary alongside continued mitigation, not as a substitute for it.

This combined approach becomes more relevant under a more volatile climate. The wide ensemble spread around the central estimates reflects deep uncertainty about how flood hazard will evolve under higher emissions, and that uncertainty itself argues for a robust policy mix. Brazil's 90%-94% insurance protection gap for natural disasters (estimated from the Rio Grande do Sul flood in 2024 [Gallagher Re, 2025; CNSeg, 2024]) indicates that the insurance pillar of this package is, at present, substantially underdeveloped. Section 5 sets out the policy framework for advancing both pillars.

Limitations and data gaps

The estimates presented in this section are designed to support policymakers with judgements around the fiscal scale of flood risk in Brazilian cities and the case for investment in adaptation and insurance. They are not designed to produce a point estimate of expected losses for any single city under any single scenario. There are six limitations that are particularly relevant for how the results should be read, each introducing a potential source of bias whose direction is not always obvious. This is why the analysis is best read as an order-of-magnitude assessment, rather than a precise quantification.

First, the exposure layer captures installed capital only and is built by disaggregating national capital stock totals using satellite images of night-time lights and gridded population data (LitPop). The methodology assigns more capital to grid cells that are brightly lit and densely populated, and less to dark or sparsely populated cells. While this is a useful approximation at the city scale, it is not the same as a direct measurement of where physical assets are located. Eberenz et al. (2020) acknowledge that LitPop may fail to reproduce the spatial distribution of assets within metropolitan areas in some cases. They also note that the accuracy of the methodology has been evaluated against subnational GDP shares (which serve as a proxy for capital because direct subnational capital stock data are unavailable), rather than against capital stock measurements directly. For cities such as Manaus and Belém, where informal settlements are expanding rapidly, this introduces a two-sided potential bias: night-time lights may underrepresent capital accumulation in newer or informal areas, while overrepresenting capital installed in long-established commercial districts. The headline numbers should therefore be read with this spatial uncertainty in mind.

Second, the exposure layer is a snapshot from 2022. The night-time lights and gridded population inputs are both from 2022, so they are contemporaneous with one another and with the exposure reference year, but they predate the 2025-2100 period over which the hazard is simulated, and the exposure is held fixed. Where urban footprints expand after 2022, particularly in fast-growing cities with informal settlements, the analysis will understate the concentration of assets in newer neighbourhoods. The estimates should therefore be read as reflecting the 2022 distribution of exposure, rather than its future evolution.

Third, the hazard layer captures fluvial (river) flooding only. This reflects the data available at the scale of the analysis: the ISIMIP2b ensemble simulates river flooding consistently across all cities, whereas pluvial flooding depends on local rainfall intensity and urban drainage capacity, for which, to our knowledge, no comparable, globally consistent hazard dataset exists at the resolution required. Pluvial flooding from overwhelmed urban drainage is a major risk for São Paulo and Fortaleza, and it likely contributes to flood losses in most of the cities in the analysis. Coastal storm surges are relevant for Rio de Janeiro, Florianópolis and Belém. Because these omitted mechanisms add to rather than scale the fluvial picture, the fluvial estimates are best read as a partial lower bound on total flood risk rather than a proxy for it: they capture one driver consistently across cities, but the gap between fluvial and total risk is widest precisely where pluvial or coastal flooding dominates. For the same reason, the limited fluvial exposure of Brasília and Fortaleza should not be read as an indication of low flood risk overall.

Fourth, the hazard layer is coarse. The ISIMIP2b flood simulations are produced at roughly five kilometre resolution, well below the scale at which flood risk varies within a city. Because inundation depends closely on local elevation, flood impacts can be highly localised: the depths that matter for one neighbourhood can differ sharply from those a short distance away. Applying a single coarse depth value across a much finer pattern of assets can therefore either overstate losses, where floodplain depths are extended to ground that would, in reality, stay dry; or it can understate them, where a deep but spatially concentrated flood is averaged out. The direction of this bias is not fixed and varies from city to city. This is a central reason why the estimates are best read as an order-of-magnitude assessment, rather than a precise quantification of any single city's losses.

Fifth, the analysis does not model cascading or indirect effects. Disruption to supply chains, long-term productivity losses, interruption of businesses, migration and displacement, and second-round fiscal effects through credit rating downgrades are all outside the scope of our estimates. These channels can either amplify or compound the direct damages, but they are not captured here.

Sixth, the results at current protection levels rely on the FLOPROS database (Scussolini et al., 2016) to represent the flood defences each city has in place today. FLOPROS is the protection standard applied throughout the analysis, including the current-protection markers in Figure 4.2. Two features of this data warrant caution. On the one hand, Mester et al. (2021) conclude that FLOPROS tends to overstate the protection in place, which would push the modelled losses at current protection downward and, on that count, understate present-day flood risk. On the other hand, and more consequential for Brazil, the FLOPROS values used here contain no empirically observed protection standards for any Brazilian state. The current-protection results should therefore be read as an indicative benchmark, rather than a measurement of the protection Brazilian cities have.

Beyond the modelling limitations, the analysis is also constrained by the quality and granularity of the underlying data, a gap that emerged clearly in stakeholder interviews. At a public bank, officials noted that risk information is available at the municipal level but often lacks the granularity needed for project-level assessment (INT-A). In the insurance sector, the absence of a shared, reliable catastrophe loss database was cited as one of the most important barriers to adequate pricing and product development: one reinsurance executive placed it first among three priorities for market development (INT-E). Specialists in the security sector have proposed creating a unified climate-risk database linked to the government's Adapta Brasil platform, which could serve both insurance pricing and public policy needs (INT-F). The development of Brazil's agricultural climate resilience zoning (ZARQ) offers a potential template for linking geospatial risk assessment to insurance pricing (INT-F).

Taken together, these limitations mean the estimates carry substantial uncertainty, stemming both from the quality of the underlying data and from the modelling assumptions needed to work with it. The model ensemble captures part of that uncertainty, through the spread across hydrological and climate models, but not all of it: the resolution, exposure and protection-standard assumptions discussed above can shift the central estimates in ways the ensemble spread does not fully reflect. The results are therefore not intended, and are not precise enough, to underpin a formal cost–benefit analysis of any specific investment in protection. What they do show, across the great majority of model runs, is that six of the eight cities studied face average annual flood losses that are sizeable relative to their economies, and that the risks of this scale make a compelling case for combining adaptation with insurance and other risk-transfer solutions against looming flood risk. The technical Annex sets out the methodology and these modelling considerations in full.

5. Policy recommendations

In a rapidly changing climate, Brazil has significant opportunities to build a more climate-resilient economy. However, this will require targeted policy action. This section outlines five recommendations to support that objective.

1. Create a Disaster Risk Financing Strategy complementing the new National Civil Protection and Defence Plan (2025-2035)

The National Civil Protection and Defence Plan (PN-PDC, 2025-2030), formalised by Presidential Decree No. 12,652 of 7 October 2025, is the first fully integrated national disaster risk reduction strategy, aligned with the Sendai Framework for Disaster Risk Reduction, the Paris Agreement and the Sustainable Development Goals (SDGs). It is an important step forward. It establishes a framework for coordinated disaster risk governance across the federal, state and municipal levels, and includes expanding risk mapping, integrating disaster-risk information systems, strengthening early warning systems and mainstreaming disaster risk reduction across sectoral policies. However, disaster risk financing is not yet systematically integrated, leaving a critical structural gap. Financing remains largely reactive, relying on emergency budget reallocations, extraordinary credit lines and post-disaster federal transfers, with limited use of pre-arranged instruments, such as contingent credit or risk transfer tools. This leaves the federal government not only as an insurer of last resort, but also as the primary financier of disaster recovery (especially given the high insurance protection gap previously discussed), a role that is becoming fiscally unsustainable as the frequency and severity of climate disasters increases.

To address this, the Ministry of Finance should lead the development of a dedicated Disaster Risk Financing Strategy, designed to respond to the escalating fiscal risks posed by climate change, following other emerging market and developing economies, including Mexico, Colombia and Indonesia. The strategy should: i) allocate financial responsibility clearly across risk layers, levels of government, households and firms; ii) match financial instruments to the frequency and severity of extreme weather events, covering both risk retention and transfer; and iii) clearly differentiate ex-ante prevention responsibilities from ex-post response and reconstruction, ensuring that prevention incentives and financing arrangements are aligned. Integrating this framework into budgetary planning would enable Brazil to move from a reactive framework (mobilising resources after disaster strikes) to a proactive one that reduces both the human and fiscal cost of each event.

A stronger risk financing architecture also requires better information about where risks sit. It is important to acknowledge that our analysis focuses on eight cities in Brazil. Developing an effective disaster risk financing strategy requires risk assessments at a more granular scale than this sample can provide. Brazil should therefore conduct its own risk assessments using local asset-level data, both to refine this policy strategy and to better capture impacts on local economies. These assessments should not focus exclusively on fluvial flooding but should also include pluvial flooding and other hazards. Law 12608/2012 already requires municipalities to identify and map disaster risk, and states to coordinate and supervise the mapping. Yet many regions still lack up-to-date and technically robust risk atlases, weakening ex-ante prevention efforts and increasing fiscal exposure when disasters occur. The federal government could strengthen compliance by linking adaption and resilience funding to the submission and regular updating of state and municipal risk atlases. This would move beyond traditional unconditional transfers towards a system that rewards ex-ante preparation. Given Brazil's constrained fiscal position, however, the central government budget alone should not carry this. The next recommendation addresses how BNDES can contribute to fill the gap.

2. Expand the Brazilian development bank's (BNDES) tools in disaster risk financing and climate resilience

Brazil's fiscal space is limited, with a debt-to-GDP ratio of 80.1% and a fiscal deficit of 9.41% (BCB, 2026). This means the central government's capacity to fund adaptation and disaster risk financing through the national budget alone is constrained. Across multiple interviews and recommendations, BNDES consistently emerges as a key institutional actor for both disaster risk financing and climate adaptation investment. Given its existing mandate to support subnational governments, as well as its extensive operational reach and technical capacity, BNDES is well positioned to play a central role in the implementation of a national Disaster Risk Financing Strategy.

BNDES could integrate disaster risk financing instruments directly into its policy toolkit. A catastrophe contingency credit line, such as the World Bank's Catastrophe Deferred Drawdown Option (Cat DDO), adapted to subnational borrowers would provide states and municipalities with rapid, pre-arranged liquidity in the aftermath of a natural disaster, without requiring lengthy damage assessments or political negotiation. A potential pathway exists through the Fundo Clima, an existing BNDES vehicle for climate mitigation and adaptation financing, which could be restructured to include a contingent-credit component. Crucially, access to this credit instrument should be conditional on progress against disaster risk management benchmarks, creating a direct incentive for states and municipalities to invest in preparedness, rather than waiting for post-disaster transfers. This conditionality addresses a recurring weakness in Brazil's current approach: the absence of ex-ante incentives for subnational governments to build their own resilience.

BNDES could play a direct role in supporting the development of risk atlases (see recommendation 1). Many capacity-constrained municipalities lack the technical and financial resources to produce and maintain robust risk maps, which are key to developing targeted adaptation investments and risk transfer instruments. BNDES could provide both technical assistance and preferential financing conditions to municipalities that submit and regularly update their risk atlases, effectively using its balance sheet to build the information infrastructure that the broader disaster risk financing system depends on. Efforts could be concentrated in high-risk municipalities such as Manaus and Porto Alegre, followed by the mid-exposure cities identified in our analysis.

BNDES could create a demand-side insurance incentive. One potential approach would be to offer preferential financing conditions, such as lower interest rates or longer repayment tenors, to borrowers who maintain qualifying climate insurance. This approach would leverage the bank's existing client base and help to expand the insured pool through a market-based mechanism rather than regulations. If implemented across BNDES's lending portfolio, this instrument could meaningfully increase demand for climate-related insurance products, particularly in key sectors analysed in this report, such as urban infrastructure. Other public financial institutions could play complementary roles. Caixa Econômica Federal, given its strong engagement with municipalities, and Banco do Brasil, through its extensive relationships with businesses and the agricultural sector, could adopt similar incentive mechanisms tailored to their respective client bases, helping to broaden insurance uptake across different segments of the economy.

3. Increase uptake of parametric insurance at state level and explore an inter-state risk pool

Climate-induced disasters are highly localised but are overwhelming in their fiscal consequences for regional governments. As our analysis shows, average annual flood losses in cities such as Manaus reach around 2.2% of city GDP under RCP 2.6 and 4.6% under RCP 8.5, with the upper bound of the ensemble approaching 8%, amounts that no municipal or regional budget can absorb alone. While the federal government has stepped in following major events, as the Rio Grande do Sul case illustrates, emergency transfers are rarely fast, unconditional or free of political friction. Waiting for central government support after a disaster strike is not a strategy; it is a vulnerability. States and municipalities should step up efforts and develop their own tools to minimise this risk, such as parametric insurance.

Within the National Disaster Risk Management Frameworks, the combination of mandatory insurance, parametric instruments and catastrophe bonds have delivered measurable reductions in fiscal uncertainty and enabled faster, more predictable post-disaster recovery – as seen, for example, in Peru's sovereign disaster risk financing strategy (World Bank, 2026). The advantage of parametric insurance is speed: payouts triggered by predefined indicators rather than by assessed damage reach governments at the moment of crisis. This budget certainty allows governments to plan ahead for disaster scenarios, while speed of payment at the moment of crisis reduces the disaster's longer-term humanitarian consequences (Clarke et al., 2016; Talbot et al., 2017).

Effective risk transfer, however, requires deliberate prioritisation. States do not need to insure all assets, as over-coverage can create moral hazard, weakening incentives for ex-ante risk reduction (UNDRR, 2025) that the previous two recommendations are designed to build. Instead, parametric mechanisms should be applied selectively, targeting critical public assets, such as water, food and energy infrastructure, and the most vulnerable populations. We recommend that the initial scope focus on public assets and essential services, with a clear review mechanism to extend coverage as the market matures and risk data improves.

Current insurance in Brazil mainly covers individual properties rather than whole urban areas, even though climate impacts typically affect entire neighbourhoods, cities or states. Brazil's municipalities and states present a compelling case for the pooled approach. The country's geographical diversity means municipal- and state-level risk profiles are largely uncorrelated across regions, making risk pooling financially cost-effective. Pooling lowers costs by spreading risk across members with different profiles, builds shared reserves, unlocks access to reinsurance and capital markets, splits operational costs and improves the foundations for risk information (World Bank, 2017). Critically, it would also ensure that risk transfer coverage extends beyond wealthier states. Over time, this mechanism could be extended to other Latin American countries, though that would require a separate and lengthier negotiation process.

One of the biggest weaknesses of parametric insurance is around basis risk: the difference between what the policyholder receives after the event and the actual losses. This means that the payout can fall short of, or be entirely absent from, the support that is needed, even where real damage has occurred. This was the case, for example, with Hurricane Maria in 2017 and the Caribbean Catastrophe Risk Insurance Facility. Basis risk cannot be eliminated altogether in any parametric scheme, including any developed in Brazil, but a range of tools, can help to reduce it. For example, diversifying the triggers the policy relies on contributes to reducing the chance that a single imperfect metric determines the outcome. In addition, layering parametric cover with traditional indemnity-based insurance also offers a practical solution. Technological solutions can also contribute significantly to minimise this risk (see recommendation 5, which focuses on technology).

It is important to be clear about what insurance can and cannot do. Risk distribution instruments, such as parametric insurance, distribute the financial cost of disasters across a broad pool of policyholders and contribute to timely reconstruction and smoothing sudden and unexpected fiscal demands, but they do not necessarily reduce the underlying hazard, exposure or vulnerability driving those losses (Jarzabkowski et al., 2018). Rapid mitigation, principally through CO_2 emission reductions, remains essential to curb climate risks. However, the lock-in effect of existing greenhouse gases means that climate-induced disasters will continue to materialise with increasing frequency and severity in the short and medium term, irrespective of mitigation actions taken today. This reality is compounded by the current state of the global agenda: the pace of the energy transition has fallen well short of internationally agreed targets, and growing geopolitical tensions have slowed collective climate action, emphasising the need for robust adaptation measures. This leads to the next recommendation, which reframes adaptation as a core risk-management tool rather than solely as a climate objective.

4. Increase investment on adaptation and resilient infrastructure

The ministry of finance should increase budget allocations on adaptation and resilience infrastructure. The adaptation finance gap for developing economies is enormous, standing at around US$335 billion annually by 2035, with adaptation finance driven mainly by public sources (UNEP, 2025). This gap is highly relevant in urban areas, where most people live and where most assets are located, with only 1.2% of urban climate finance targeted towards investment in adaptation (CCFLA, 2024). Brazil reflects this pattern: the central government allocates just 0.13% of total expenditure to "environmental management" (World Bank, 2024; Salanié et al., 2025[13]). At this level of investment, the country is not building resilience near the pace that a rapidly changing risk landscape demands, and the gap between what is being spent what is needed will widen with every year of inaction.

This underinvestment in adaptation and resilient infrastructure is not simply an environmental concern. As Section 4 makes clear, the less resilience there is to climate-related risks, the greater the losses that insurance and fiscal buffers must absorb, and the more expensive and difficult those insurance instruments become to maintain. Investment in adaptation should therefore be understood as a form of risk management, not a discretionary expenditure (UNDRR, 2025). Nature-based solutions, resilient infrastructure, improved land-use planning, early warning systems and community resilience programmes all work by reducing the vulnerability of exposed assets before a disaster strikes. This directly lowers expected losses, reduces the underlying risk that insurers must price (making coverage more affordable) and shortens recovery times when events do occur (Monasterolo et al., 2025). In a world where some degree of climate risk is now unavoidable, risk reduction is both the most immediate line of defence and the most cost-effective response available (NGFS, 2024).

Brazil's cities illustrate both the urgency and the opportunity of investing in adaptation. Our modelling shows that in the most exposed cities, Manaus and Porto Alegre, central estimates place average annual flood losses at around 2.2% and 1.6% of city GDP respectively under RCP 2.6. Under higher emissions, central losses rise to 4.6% in Manaus and 2.5% in Porto Alegre under RCP 8.5, with the upper end of the ensemble reaching around 7.7% and 4.3% respectively. These losses cannot be absorbed annually by municipalities or states without damaging their fiscal positions, public services and development. However, these figures are not fixed and can be reduced by investing in adaptation. Upgrading flood protection in the most exposed cities to a 100-year standard could reduce average annual losses by up to seven percentage points of GDP. Every percentage point avoided is a point not committed to emergency response or foregone investment in other areas. This makes the economic case for adaptation an imperative for development and growth, and for humanitarian reasons.

Climate-related risks are highly localised, shaped by each city's geography, infrastructure, informal settlement patterns and socioeconomic vulnerabilities; therefore, investments in adaptation must be designed from the bottom up. A nature-based solution that works in Porto Alegre may be poorly suited to Manaus; an early warning system that reaches residents in Rio de Janeiro may fail entirely in a city with lower digital connectivity. Embedding community voices into the planning and implementation of adaptation measures improves their technical fit, and ensures that the populations most exposed to climate risk have a say in how resilience is built in their neighbourhoods, supporting a just transition in which the burden of climate change does not fall disproportionately on those least able to bear it.

At the same time, bottom-up actions need to be supported by national standards that make resilience the default rather than the exception. The 'resilience by design' principle should be embedded into public procurement standards, requiring that climate risk criteria are incorporated into project evaluation and contractor selection processes. This shifts the incentive structure for developers and infrastructure operators, making resilience a condition of winning public contracts rather than an optional upgrade, and reduces the far greater cost of retrofitting resilience into infrastructure that was not designed for a changing climate. Doing so would directly operationalise the National Adaptation Plan target requiring that 100% of federally supported infrastructure projects by 2035 consider climate risks, translating a policy commitment into a practical and enforceable delivery mechanism.

5. Harness Brazil's digital public infrastructure to strengthen adaptation and insurance markets

The ministry of finance should harness Brazil's digital public infrastructure to strengthen adaptation and insurance markets. Better use of satellite data, geospatial information, AI and digital risk mapping could improve the identification of vulnerable populations, exposed assets and measurable risks. This

[13] Salanié et al. (2025) explain that because the responsibility for preventing climate disasters in Brazil is split across the federal government, state governments and municipalities, it is difficult to pinpoint total prevention spending. To work around this, they use central government budget allocations to 'environmental management' as a proxy for prevention.

would strengthen both risk atlases (recommendation 1) and the pricing of parametric insurance instruments (recommendation 3). These technologies could also improve risk pricing, targeting and monitoring, more broadly.

These same tools are central to containing the basis risk discussed in recommendation 3. For example, high-resolution satellite imagery and Internet of Things (IoT) sensors, which detect physical changes, can sharpen the accuracy of the index and reduce the mismatch with actual losses. In addition, sophisticated models, including AI and machine learning techniques can contribute to recalibrating the thresholds over time and helping us to better understand the correlation between parametric triggers and actual losses (PwC, 2024).

Brazil's digital public infrastructure may become an important part of the solution. PIX, digital identity systems and other payment technologies could facilitate rapid post-disaster payments, including direct support to affected households, faster insurance payouts, easier collection of insurance premia and greater financial inclusion. In short, digital technologies could help reduce both the transaction costs and the implementation barriers that otherwise constrain disaster-risk financing.

Finally, while this report focuses on identifying policy priorities to strengthen Brazil's disaster risk financing architecture, translating these recommendations into practice will require a more detailed assessment of institutional responsibilities, regulatory frameworks and political economy constraints. Further work should therefore map the roles of key public and private actors (including the Ministry of Finance, National Treasury, SUSEP, BNDES, federal and subnational governments, regulators and the insurance industry) and identify the legislative, regulatory and coordination mechanisms needed to support implementation. Such an analysis would help distinguish measures that could be advanced through existing institutional arrangements from those requiring regulatory reform, new legislation or enhanced intergovernmental coordination.

6. Conclusion

Brazil still has time to increase resilience against physical climate risks, including floods, but that window is narrowing. The policy interventions set out in this report are achievable, but they require urgent and coordinated action from public and private actors at every level. The longer the action is delayed, the higher the cost of the flood losses will be for citizens, companies, municipalities, states and governments.

Brazil is increasingly exposed to the economic and fiscal consequences of climate change, with floods emerging as a defining risk for its cities, infrastructure and public finances. The increased frequency and severity of extreme weather events will increase flood-related losses, with significant implications for subnational fiscal stability, national budgets and long-term development objectives.

Our analysis highlights that Brazil's current risk architecture remains insufficiently equipped to manage this transition. A large insurance protection gap and low levels of investment in adaptation mean that the costs of disasters are disproportionately borne by public finances and the most vulnerable populations. In this context, the state continues to act as insurer of last resort, exposing fiscal frameworks to increasing volatility as climate risks materialise more frequently.

At the same time, Brazil has important structural strengths. Its financial and insurance sectors are well developed relative to many emerging markets, and there is growing recognition of the need to integrate physical climate risks into fiscal and financial decision-making. The evidence presented in this report shows that both adaptation and risk transfer can play a critical role in managing future losses. Investments in resilience can significantly reduce expected damages, while insurance and other financial instruments can help absorb risks and stabilise post-disaster recovery.

However, the current scale of action remains far below what is required. As climate impacts intensify, failure to close the adaptation and insurance gaps risks reinforcing a cycle of rising losses, fiscal strain and constrained investment capacity. Conversely, strengthening the links between adaptation, financial protection and fiscal planning can support a more resilient and sustainable growth trajectory.

In this sense, Brazil is at a pivotal moment. The choices made now in how climate risk is understood, financed and managed will shape not only the resilience of its cities and communities, but also the stability of its public finances and the foundations of its long-term economic development.

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Appendix: Key informant interviews

Interview	Date	Category of interviewee
INT-A	26 May 2026	Development finance institution representative working on climate resilience and disaster risk financing
INT-B	25 May 2026	Private insurance company representative with expertise in property and catastrophe insurance
INT-C	27 April 2026	State government official with responsibilities for fiscal policy and disaster recovery
INT-D	06 May 2026	Civil defence practitioner with experience in disaster preparedness and emergency response
INT-E	11 May 2026	Reinsurance specialist with expertise in catastrophe risk and capital markets
INT-F	29 May 2026	Insurance sector representative with expertise in regulation and market development
INT-G	28 May 2026	Municipal government official with experience in disaster risk management and resilience planning
INT-H	13 March 2026	Local underwriter in Brazil working in a private insurance company