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From invisible to investible: An investment taxonomy for climate adaptation

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Allianz Research

Content

Executive Summary

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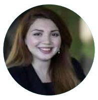

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- **Exposure to climate risk is rising sharply but unevenly across hazards and regions.** Global warming continues to accelerate, with 2025 the third-warmest year on record, reinforcing warnings that the +1.5°C threshold could be reached as early as 2030. As a consequence, global natural catastrophe losses have risen roughly fourteen-fold since 1970, reflecting intensifying hazards and rising exposure as urbanization, asset concentration and populations expand in risk-prone areas. Risk is increasing unevenly across hazards and regions: flood exposure is rising fastest in Southeast Asia, the Middle East and North Africa; wildfire exposure has grown markedly in North America; heat stress is expanding across Africa and Asia and drought risk remains concentrated in already water-stressed regions.

- **The sharp increase in uninsured losses poses a growing risk to public finances and adaptation spending should triple to be commensurate with the needs.** While the share of uninsured losses has remained broadly stable, their absolute scale has increased sharply as climate damages rise, leaving a growing volume of losses unprotected and hundreds of millions without effective financial coverage. Protection gaps exceed 80% in several major economies, including Mexico, South Africa, Italy, India and China. Governments often absorb part of these losses through ad hoc support, but reliance on such measures risks shifting rising climate liabilities onto public balance sheets and increasing fiscal pressures. Large extreme-weather events have been found to worsen fiscal balances by between 0.2% and 1.1% of GDP, though average impacts on EU and OECD economies have been more limited due to stronger institutions and broader insurance coverage. At the same time, insurers are transferring climate risk to capital markets through catastrophe bonds, with issuance reaching record levels in 2025 and supported by strong investor demand, raising questions about the financialization of climate risk in the absence of scaled adaptation and public risk-sharing. Adaptation expenditure represents a form of preventive fiscal policy. However, current combined public and private sector spending in Europe stands at approximately 0.3% of GDP, well below the estimated requirement. Projections indicate that investment would need to triple to 0.9% of GDP to adequately address adaptation needs across the EU-27 and the UK, corresponding to an additional EUR67.5bn in annual expenditure.

- **Mobilizing capital for climate adaptation at the required scale remains constrained by a set of deep structural barriers.** Fiscal space in many European economies is limited, restricting the public co-investment needed to crowd in private finance. Policy frameworks remain fragmented across jurisdictions, creating regulatory uncertainty that discourages long-term private commitments. Investment cases for adaptation are underdeveloped: projects often lack bankable structures, established track records and the financial modelling that institutional investors require. Compounding this, physical climate-risk disclosure remains inconsistent, data on adaptation outcomes is scarce and, unlike mitigation, the benefits of adaptation are context-specific and difficult to measure and verify. Together, these frictions make adaptation an opaque and commercially challenging asset class for private investors. Addressing these barriers requires action across multiple fronts: agile and coordinated policy frameworks, stronger project pipelines, improved risk-sharing mechanisms, better data infrastructure and more robust investment cases. Within this broader agenda, classification and transparency are foundational – investors and governments cannot coordinate effectively around an asset class they cannot clearly define or track.

- **A shared taxonomy of climate adaptation would provide a critical first step by establishing a common language, reducing ambiguity and making adaptation spending more visible in financial markets.** This would help the private sector identify investment opportunities, support the development of new financial instruments and limit greenwashing and "adaptation-washing". We develop a taxonomy of 61 adaptation measures, drawing on and consolidating existing frameworks, and classify them according to their underlying economic and financial characteristics – particularly the extent to which benefits can be monetized and captured by private actors. This yields a differentiated mapping of financing modalities: 38% of measures are primarily public, notably large-scale infrastructure and system-level resilience; 23% are primarily private, concentrated in scalable, innovation-driven segments such as cooling technologies and climate analytics and 39% fall into public–private territory, highlighting the central role of risk-sharing mechanisms. Importantly, these shares reflect the distribution of adaptation measures, not the allocation of investment volumes, which vary significantly across activities and remain difficult to quantify consistently. Rather than providing a capital split, the taxonomy offers a structural framework to understand investability and guide the respective roles of public, private and blended finance.

Current climate losses, protection gaps and rising future exposure

The year 2025 has been confirmed as the third-warmest on record, following the record-breaking years of 2023 and 2024 and a decade of unprecedented temperature highs. This trend reinforces scientific warnings that the Earth system is approaching the +1.5°C threshold, potentially as early as 2030, nearly a decade sooner than previously projected[1]. This acceleration of climate change is manifesting through profound and persistent disruptions to weather patterns, hazard intensities and the stability of natural systems. These physical shifts are increasingly translating into economic damages, as reflected in the evolution of global natural catastrophe losses. An analysis of historical loss data (Figure 1a) shows that total losses worldwide have increased by approximately fourteen-fold between 1970 and 2024. This surge is driven by the combined effects of more frequent and severe climate-related hazards and a structural rise in exposure due to rapid urbanization, asset concentration and population growth in risk-prone areas.

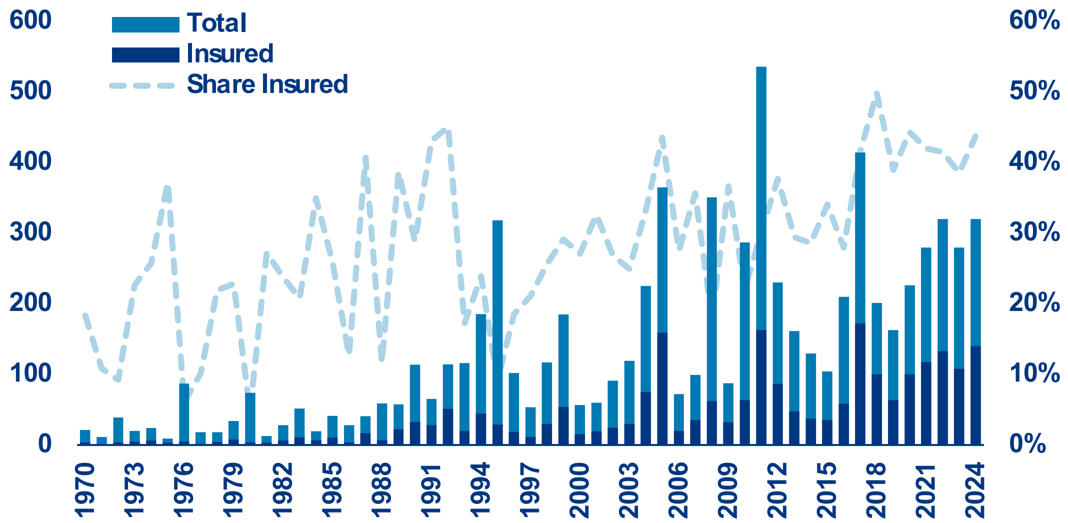
While the share of uninsured losses has remained broadly stable over time, their absolute volume has increased sharply as total climate-related losses continue to rise. As a result, a growing amount of economic damage remains unprotected, leaving hundreds of millions of people without effective financial coverage against climate shocks. Figure 1b highlights stark cross-country disparities in insurance coverage, with protection gaps exceeding 80% in several major economies, including Mexico (81%), South Africa (81%), Italy (83%), India (93%) and China (98%). In many cases, these gaps are partially absorbed through ad hoc state-based mechanisms, which can provide short-term relief and social stabilization. However, in the absence of a coherent risk-financing and adaptation strategy, this approach risks transferring mounting climate liabilities onto public balance sheets, thereby amplifying fiscal pressures and long-term debt vulnerabilities.

[1] Earth to breach 1.5C warming a decade early, scientists say

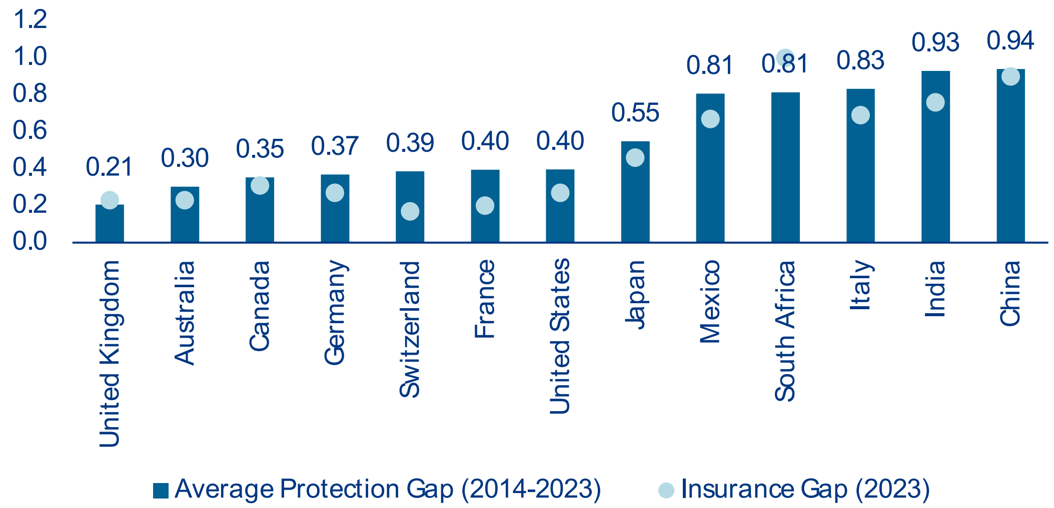
This dynamic is increasingly translating into material macro-financial risks, particularly for insurance markets that play a foundational role in economic and financial stability. One prominent response to the increasing climate risks has been the rapid expansion of catastrophe bonds, through which climate risks are increasingly shifted from insurance balance sheets to capital markets, with issuance reaching record levels in 2025[2]. Strong investor demand has been supported by attractive risk-adjusted returns, with a Swiss Re industry index of catastrophe bonds delivering a 14% return over the past year and cumulative gains exceeding 50% over the past five years. While this trend enhances insurers' short-term resilience, it also raises critical policy questions regarding the growing financialization and redistribution of climate risk, particularly in the absence of sufficiently scaled mitigation, adaptation and public risk-sharing frameworks.

Figure 1: Global development in NatCat losses

a) NatCat losses (2023 USD bn)



b) Average protection gap



Sources: national, Allianz Research

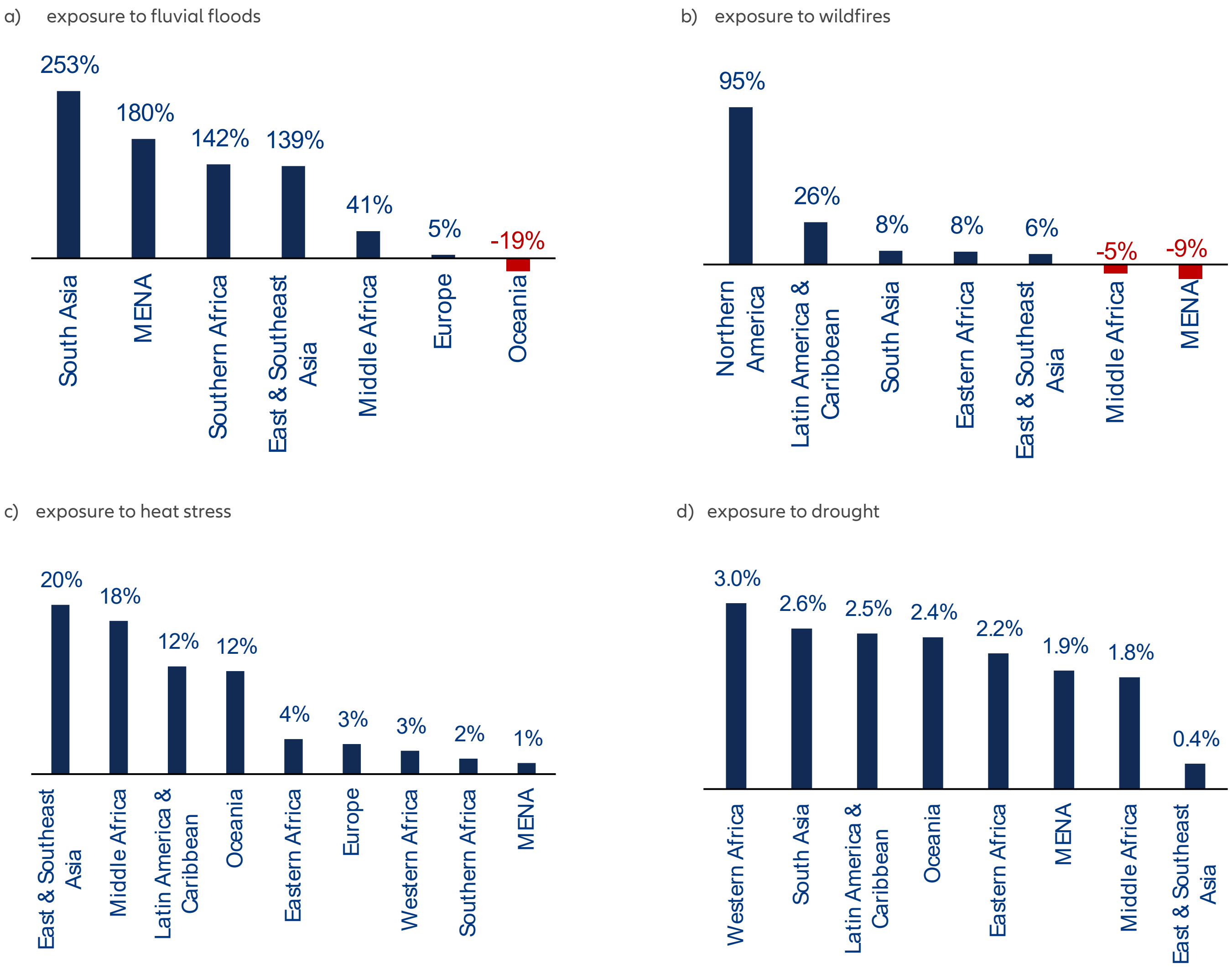
[2] Catastrophe bond sales hit record as insurers offload climate risks

This widening protection gap has a direct fiscal counterpart. Climate disasters do not only generate uninsured losses, they also have an adverse impact on sovereign balance sheets through higher emergency and reconstruction expenditure, damage to public infrastructure and weaker tax revenues as output production is disrupted. Cross-country evidence from the ECB[3] finds that large extreme-weather events worsen fiscal balances by between 0.23% and 1.1% of GDP, although historical average effects for EU and OECD economies were more muted, largely because stronger institutions, deeper financial systems and broader insurance penetration partially cushioned the shock. Yet recent evidence indicates that such protection should not be overstated in the European case: The IMF[4] finds that climate-related human and economic costs are already significant across Europe and especially acute in Central and Eastern Europe, where disaster shocks are more likely to translate into persistent macroeconomic damage. Moreover, recent empirical work for EU countries shows that climate shocks can materially weaken fiscal balances and worsen debt-sustainability indicators, particularly in countries with limited fiscal space (Gagliardi et al., 2022)[5]. Under these conditions, adaptation is preventive fiscal policy. Climate-resilient infrastructure lowers disaster losses, limits medium-term scarring and supports stronger debt dynamics than post-disaster repair. IMF simulations suggest that highly exposed European economies may need to allocate 2–2.5% of GDP annually to adaptation in the near term, which is a significant fiscal commitment. However, early and sustained investment reduces the climate exposure by 2040, lowering the required spending over time and limiting the cumulative economic impact of climate damages. The simulations further indicate that debt sustainability is better preserved when adaptation spending is paired with concessional funding and improvements in public investment efficiency, making the upfront cost a more favorable proposition than delayed action.

Looking ahead, climate exposure will be rising fast – and unevenly – dramatically expanding the populations and economies at risk from floods, fires, heat and drought (Figure 2). To capture the future exposure, we develop a methodology that quantifies the evolution of exposure of population to major climate hazards, fluvial floods, wildfires, heat stress and drought, using geospatial weighted aggregation over the 2030–2050 horizon (see Appendix A1 for methodological details). Fluvial flood exposure rises most dramatically in Southeast Asia and the MENA region, where the exposed population is projected to increase by 253% and 180%, respectively, between 2030 and 2050. This surge reflects the combined effects of rapid economic expansion, accelerating urbanization in flood-prone zones, and intensifying precipitation extremes. Wildfire exposure also expands markedly, particularly in Northern America, where the number of people exposed is expected to double. In contrast, heat-stress exposure grows more moderately in relative terms but affects a far broader geographic base. The Middle Africa and East and Southeast Asia are projected to see population exposure increases of around 18–20%, reinforcing projections that link rising heat extremes to mounting labor productivity losses and adverse health outcomes. Drought exposure, while showing more modest aggregate growth rates, exhibits persistent increases across Africa, the Middle East and parts of Latin America, regions already characterized by structural water scarcity and limited adaptive capacity.

[3] The impact of extreme weather events on budget balances and implications for fiscal policy
[4] Weathering Tomorrow: Climate Analogues and Adaptation Gaps in Europe, WP/24/109, May 2024
[5] The Fiscal Impact of Extreme Weather Events: Stress Tests for EU Countries

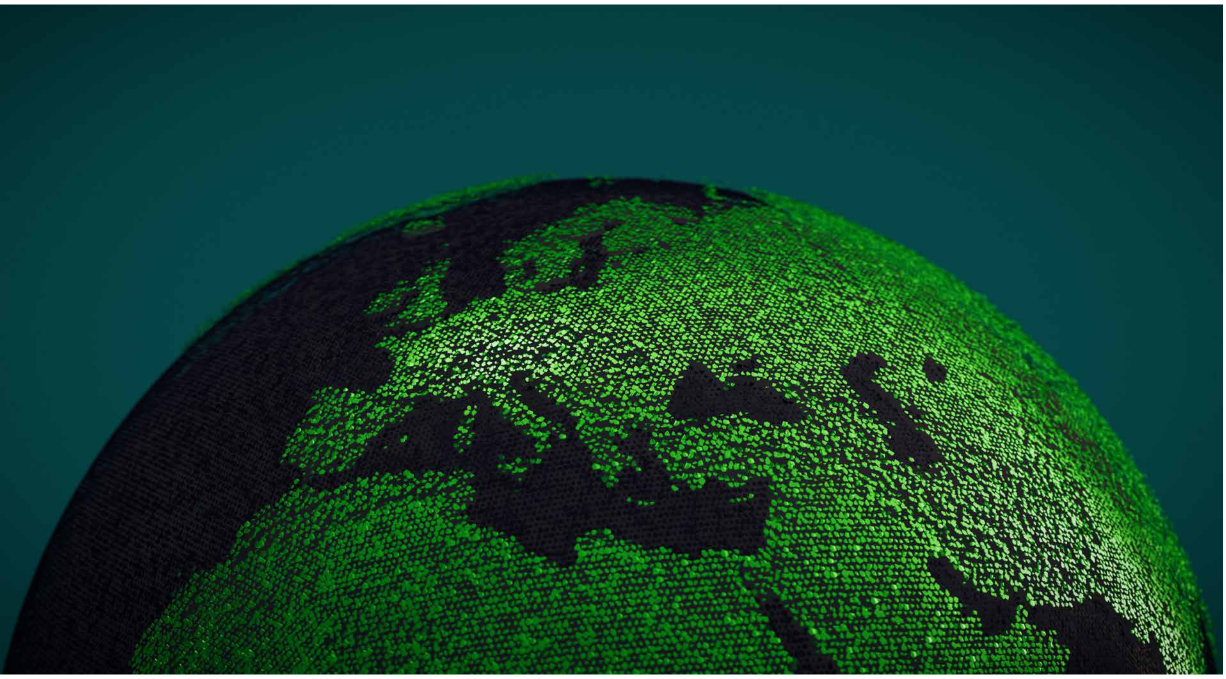
Figure 2: Increasing need for climate adaptation driven by higher exposure between 2030 and 2050



Sources: Copernicus, ISIMIP, Allianz Research

As climate exposure continues to rise, both from past warming and projected future changes, climate adaptation is increasingly becoming a central pillar of climate policy. Adaptation needs are expanding rapidly, requiring substantial mobilization of both public and private capital. This growing investment demand is driven not only by rising policy ambition but also by the accelerating increase in climate-related risks and exposure. Recent estimates suggest that global climate adaptation investment needs could grow from approximately USD0.5trn in 2025 to more than USD1.3trn by 2050[6], reflecting rising demand for protection of populations, infrastructure, and economic activity against intensifying climate hazards. This growth is partially exposure-driven showing how the scale of assets and people at risk is increasing sharply as climate hazards intensify and economic development continues in exposed regions.

[6] Investment Opportunities in the Climate A&R Market | BCG

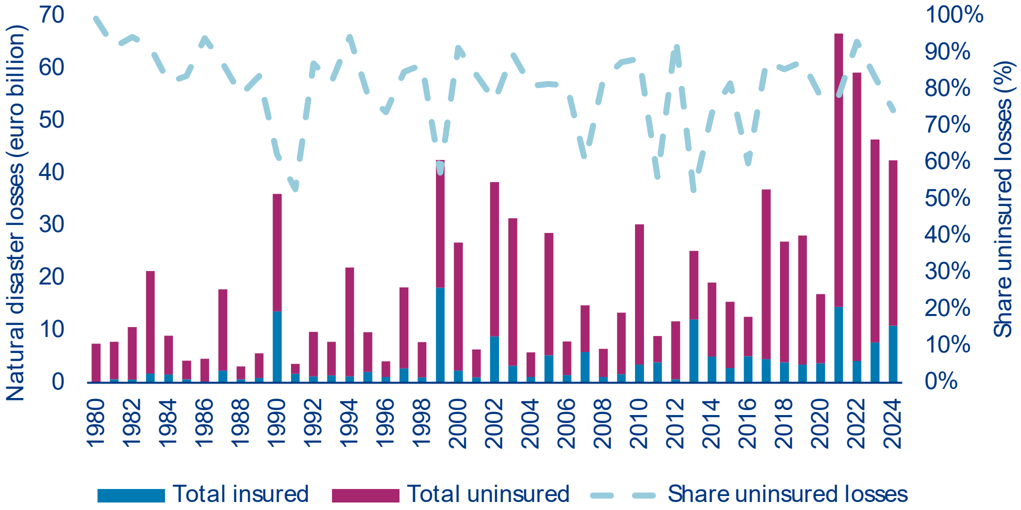


Europe's climate-adaptation deficit: rising losses, lagging investment

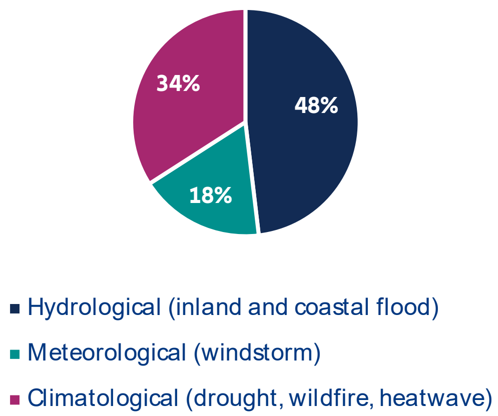
Natural catastrophe losses in Europe have trended upward over the past decades, reflecting both growing asset exposure and intensifying climate-related hazards. Total losses reached EUR67bn in 2021 and remained elevated at EUR59bn in 2022, marking the two costliest years on record in terms of direct damages. While annual losses fluctuate depending on the dominant hazard, the overall trajectory points to increasing economic vulnerability. Between 1980 and 2024, uninsured losses accounted on average for 81% of total losses in Europe (Figure 3a). In 2021, 78% of total damages, equivalent to EUR52bn, were uninsured. The situation worsened in 2022, when 93% of losses were uninsured, corresponding to EUR55bn, the highest uninsured loss level recorded in Europe since 1980. The composition of events further illustrates the systemic nature of the risk. In 2021, Europe experienced severe and destructive flooding, whereas 2022 was dominated by widespread and extreme drought. These consecutive but contrasting extremes demonstrate how climate change generates compound pressures on infrastructure, households, and public finances. Hydrological events account for nearly half of uninsured losses (Figure 3b), highlighting the structural exposure to flooding. Italy, Germany, Spain, and France show particularly high shares of uninsured losses, underlining the urgent need to strengthen resilience and risk-transfer mechanisms across the region.

Figure 3: Development of NatCat losses in Europe

a) NatCat losses (2024 EUR bn)



b) Uninsured losses by event type



Sources: CATDAT, Allianz Research

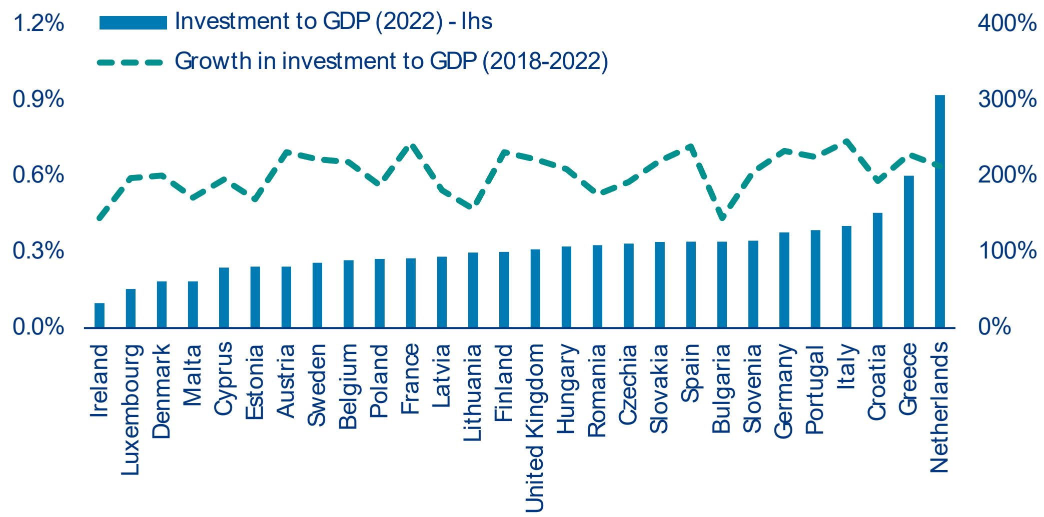
While climate-related damages are increasing across Europe, investment in climate-change adaptation remains at an embryonic stage. On average, adaptation spending across Europe amounts to only around 0.3% of GDP, a level that appears strikingly low when set against the magnitude of both current and projected climate risks (Figure 4a). This underinvestment becomes even more apparent when compared with other public spending priorities: fossil-fuel subsidies provided by EU member states reached approximately 0.8% of EU GDP between 2022 and 2023, fueled by the energy crisis[7]. In other words, subsidies intended to cushion infrequent and unexpected energy shocks have become increasingly frequent and reoccurring, placing a growing burden on public finances and further constraining fiscal space for climate transition and adaptation investments. These repetitive energy crisis are a reminder of the necessity to reduce reliance on fossil fuels and speed up the energy transition to better allocate budget towards increasing social resilience against climate change. Beyond the aggregate picture, Figure 4a also reveals a highly uneven distribution of adaptation investment across European countries. While many member states cluster around or below the 0.3% of GDP average, a small number of countries stand out as clear outliers. In particular, the Netherlands allocates

[7] Fossil fuel subsidies in Europe | Indicators | European Environment Agency (EEA)

close to 0.92% of GDP to adaptation, reflecting not only stronger political commitment but also a markedly higher urgency, given the country's structural exposure to sea-level rise and flooding risks. This suggests that adaptation investment is often driven less by long-term risk assessments and more by immediate and acute threats.

Despite the still modest level of climate change adaptation investment in Europe, recent data point to a marked acceleration between 2018 and 2022, signaling a growing awareness of adaptation needs. Over this period, average adaptation investment relative to GDP increased by around 204%, meaning that adaptation spending in 2022 was more than three times higher than in 2018 (Figure 4). However, this rapid growth should be interpreted in light of a very low initial baseline, which helps explain why strong percentage increases coexist with relatively small absolute investment levels. The cross-country picture reveals important differences in both levels and dynamics. The Netherlands remains the largest investor in adaptation in relative terms (Figure 4).

Figure 4: European investment in climate adaptation



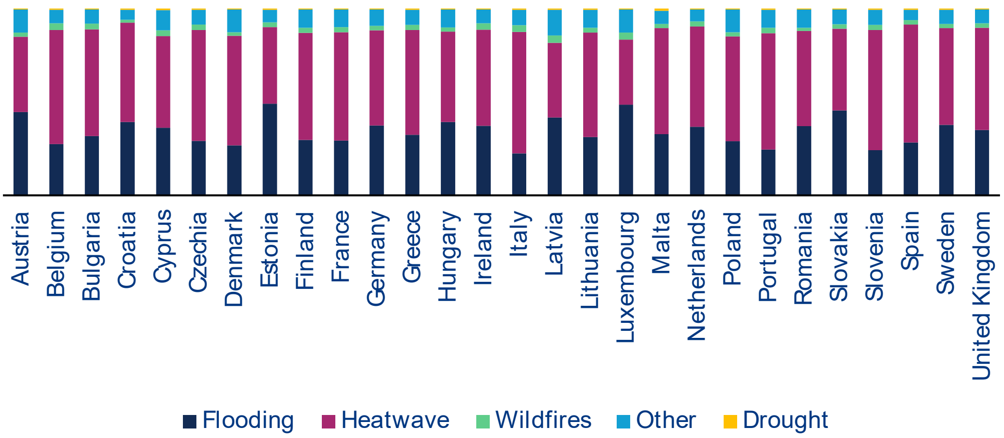
Sources: Cortes et al. (2025)[8], Allianz Research

The breakdown of adaptation investment by hazard across Europe points to a clear and consistent prioritization of heatwaves and flooding mirroring future climate-adaptation needs (Figure 5). Heat- and flood-related risks will remain the primary drivers of adaptation demand across European economies, with a +5% and +3% increase in people exposed to fluvial flooding and heat stress between 2030 and 2050. Over the 2018–2022 period, heatwaves account for the largest share of adaptation spending in nearly all European countries, often exceeding half of total investment, while flooding represents the second most important category. Heatwave adaptation dominates largely because the associated measures are relatively easy to deploy, modular and deliver immediate private benefits. Investments such as air conditioning, ventilation and cooling systems directly protect labor productivity and business continuity, making them particularly attractive to firms. As a result, even countries with different climate profiles converge toward a similar heatwave-heavy investment structure. Flood adaptation, by contrast, is more capital-intensive and spatially specific, which explains why its share is especially high in riverine and Central European countries such as Austria, Slovakia and Hungary, where exposure to fluvial flooding is structurally embedded in geography and infrastructure.

[8] Private investments in climate change adaptation are increasing in Europe, although sectoral differences remain | Communications Earth & Environment

In contrast, wildfires and drought receive only marginal shares of adaptation investment, typically a few percentage points for wildfires and well below 1% for drought. This pattern does not necessarily reflect lower risk exposure, but rather weaker investment incentives. Private adaptation investment can take different forms, ranging from firms strengthening the resilience of their own assets, such as reinforcing facilities, supply chains or production processes, to institutional investors financing large-scale resilient infrastructure. However, many adaptation measures related to drought and wildfires exhibit strong public-good characteristics. Wildfire risks in Europe disproportionately affect natural and protected areas, where economic returns are difficult to monetize, while drought resilience often depends on water management systems, landscape-level interventions and agricultural practices whose benefits extend beyond individual investors. Because these investments generate diffuse and widely shared benefits, private actors are often unable to capture sufficient financial returns, limiting the incentives for private capital to engage. As a result, these hazards remain structurally underrepresented in aggregate adaptation spending, reinforcing the central role of public investment and policy frameworks in addressing adaptation gaps.

Figure 5: Investment in climate adaptation per hazard in Europe (average 2018 – 2022)



Sources: Cortes et al. (2025), Allianz Research

Table 1 illustrates the relative intensity of adaptation investment across economic sectors, measured as the ratio between each sector's share in national adaptation expenditure and its contribution to gross value added (GVA). A ratio above one indicates that a sector invests more in adaptation than would be expected given its economic weight, while a ratio below one signals relative underinvestment. Several consistent patterns emerge across the EU and the UK. First, public administration and defense, water supply and waste management and mining and quarrying stand out as systematically adaptation-intensive sectors. This is largely structural. Water-related sectors are inherently exposed to floods and droughts and are closely linked to critical infrastructure, making adaptation both unavoidable and often publicly coordinated. Public administration naturally concentrates public adaptation spending by definition, while mining exhibits high ratios despite its small GVA share, reflecting high adaptation costs relative to economic returns and strong exposure to physical climate risks. In contrast, manufacturing and wholesale–retail trade consistently appear as non-adaptation-intensive across most countries, often investing four to five times less in adaptation than their GDP share would suggest. This is striking given that manufacturing is one of the largest contributors to European GDP and holds substantial fixed capital vulnerable to flooding and heat stress. Cortés et al. (2025) interpret this as evidence of delayed or reactive adaptation, where firms may rely on insurance, public protection or post-disaster recovery rather than proactive investment. Tourism-related sectors (accommodation and food services) display marked cross-country heterogeneity. Despite high climate exposure in Southern Europe, adaptation intensity remains relatively low in countries such as Greece and Spain, pointing to capacity constraints, short investment horizons and reliance on seasonal revenues rather than long-term resilience planning. Finally, agriculture shows a clear income divide: higher-income countries tend to display stronger adaptation intensity, while lower-income Southern and Eastern European countries invest below average despite high exposure. Cortés et al. (2025) highlight the central role of public subsidies and policy design in shaping these outcomes, suggesting that targeted public support can significantly influence private adaptation behavior.

Table 1: Investment in climate adaptation per hazard in Europe (average 2018 – 2022)

	A. Agriculture, Forestry and Fishing	B. Mining and Quarrying	C. Manufacturing	D. Electricity, Gas, Steam and Air Conditioning	E. Water Supply; Sewerage, Waste	F. Construction	G. Wholesale and Retail Trade; Repair of Motor	H. Transportation and Storage	I. Accommodation and Food Service Activities	J. Information and Communication	K. Financial and Insurance Activities	L. Real Estate Activities	M. Professional, Scientific and Technical Activities	N. Administrative and Support Service Activities	O. Public administration and defence; compulsory	P. Education	Q. Human Health and Social Work Activities	R. Arts, Entertainment and Recreation	S. Other Service Activities
Austria	2.5	10.2	0.2	2.4	4.0	0.5	0.2	0.8	0.8	1.6	1.5	0.5	0.9	1.3	4.9	0.8	0.5	1.1	4.2
Belgium	4.5	48.0	0.2	3.0	4.6	0.7	0.2	0.8	2.2	1.3	1.0	0.5	0.5	1.1	3.4	0.6	0.5	1.7	5.2
Bulgaria	0.8	1.9	0.2	1.3	4.7	0.9	0.1	0.8	1.5	0.8	1.0	0.5	1.2	2.2	3.8	1.1	0.8	1.2	6.7
Croatia	0.9	11.4	0.2	1.8	3.0	0.7	0.2	0.8	0.7	1.1	1.2	0.5	0.9	2.5	3.4	0.8	0.7	0.6	3.5
Cyprus	2.0	22.7	0.5	3.8	5.5	0.6	0.2	0.7	0.8	0.7	0.7	0.5	0.6	2.3	2.9	0.7	0.8	0.8	4.5
Czechia	1.5	5.6	0.1	1.7	4.2	0.7	0.2	0.8	2.3	0.9	1.5	0.5	0.9	3.0	4.1	0.9	0.7	1.1	6.4
Denmark	2.3	3.7	0.2	3.9	5.1	0.7	0.1	0.7	2.2	1.3	1.2	0.4	0.8	1.8	5.4	0.7	0.4	1.0	4.4
Estonia	1.4	4.1	0.2	1.4	5.5	0.5	0.2	0.6	2.4	0.9	1.4	0.4	0.9	1.5	4.1	0.9	0.8	0.6	6.9
Finland	1.1	6.5	0.2	2.0	4.5	0.5	0.2	1.0	2.3	1.0	2.0	0.3	0.9	1.6	4.6	0.8	0.4	0.9	3.8
France	1.7	34.2	0.3	2.5	5.8	0.7	0.2	0.9	1.6	1.1	1.6	0.3	0.6	1.0	3.3	0.8	0.4	0.8	4.9
Germany	3.7	19.2	0.1	2.1	4.1	0.7	0.2	1.0	2.8	1.2	1.6	0.4	0.8	1.1	3.9	1.0	0.5	0.9	2.9
Greece	0.7	7.5	0.3	1.3	3.8	2.1	0.2	0.6	0.6	1.8	1.2	0.3	1.4	3.2	2.5	0.8	0.8	0.8	4.2
Hungary	0.8	9.3	0.2	3.0	5.4	0.6	0.2	0.7	2.1	1.2	1.7	0.4	0.8	1.5	3.2	1.0	0.8	0.8	4.7
Ireland	3.3	25.0	0.1	4.9	10.4	1.5	0.3	2.8	3.1	0.4	1.4	0.8	1.0	0.9	9.4	1.7	0.8	1.7	13.4
Italy	1.5	13.2	0.2	2.4	3.8	0.8	0.2	0.8	1.1	1.6	1.3	0.3	0.8	1.6	3.9	1.1	0.6	1.2	3.8
Latvia	0.7	6.1	0.2	2.2	4.9	0.6	0.1	0.6	2.3	1.0	2.0	0.4	1.1	1.8	3.3	0.9	0.8	0.7	6.9
Lithuania	0.9	10.9	0.2	2.6	4.2	0.5	0.1	0.4	2.2	1.5	2.3	0.7	1.2	1.7	4.5	0.9	0.7	1.1	6.7
Luxembourg	14.9	50.9	0.6	5.8	9.0	0.7	0.2	0.8	2.6	1.1	0.2	0.6	0.5	1.4	4.0	1.0	0.5	1.8	7.5
Malta	5.5	19.0	0.4	5.9	5.7	0.8	0.2	0.9	1.2	0.7	0.7	0.7	0.5	0.8	4.4	0.9	0.6	0.1	6.6
Netherlands	1.7	4.0	0.3	3.5	6.4	0.7	0.1	0.9	2.1	1.2	1.0	0.6	0.6	0.8	3.6	0.9	0.4	1.2	5.7
Poland	1.2	1.9	0.2	1.7	3.1	0.5	0.1	0.6	2.7	1.3	1.4	0.8	0.8	1.8	4.6	0.9	0.8	1.5	5.6
Portugal	1.4	9.1	0.2	2.2	4.3	0.8	0.2	0.9	0.7	1.4	1.2	0.4	1.1	1.4	3.6	0.8	0.5	1.3	5.0
Romania	0.6	3.7	0.2	1.6	4.5	0.5	0.2	0.6	2.2	0.9	2.3	0.5	0.9	2.1	4.3	1.2	0.7	0.7	4.4
Slovakia	1.5	15.4	0.1	2.7	4.3	0.5	0.2	0.7	2.7	1.2	2.3	0.4	0.8	1.7	3.4	1.1	0.8	0.6	6.4
Slovenia	1.4	9.8	0.1	2.3	4.8	0.6	0.2	0.7	1.7	1.4	1.6	0.6	0.7	1.9	4.3	0.8	0.6	1.0	6.0
Spain	1.1	9.9	0.3	1.7	3.6	0.6	0.1	1.0	0.7	1.5	1.5	0.4	1.0	1.4	4.0	0.8	0.5	0.6	3.5
Sweden	2.0	3.8	0.2	1.9	6.3	0.6	0.2	0.9	2.5	0.7	1.5	0.5	0.6	1.6	5.3	0.8	0.3	0.9	4.3
United Kingdom	4.4	3.6	0.3	3.7	3.4	0.6	0.2	1.2	1.4	0.9	0.8	0.3	0.6	1.1	4.9	0.8	0.4	0.8	3.7

Legend

Investment ratio	
Low	
Medium	
High	
Very high	

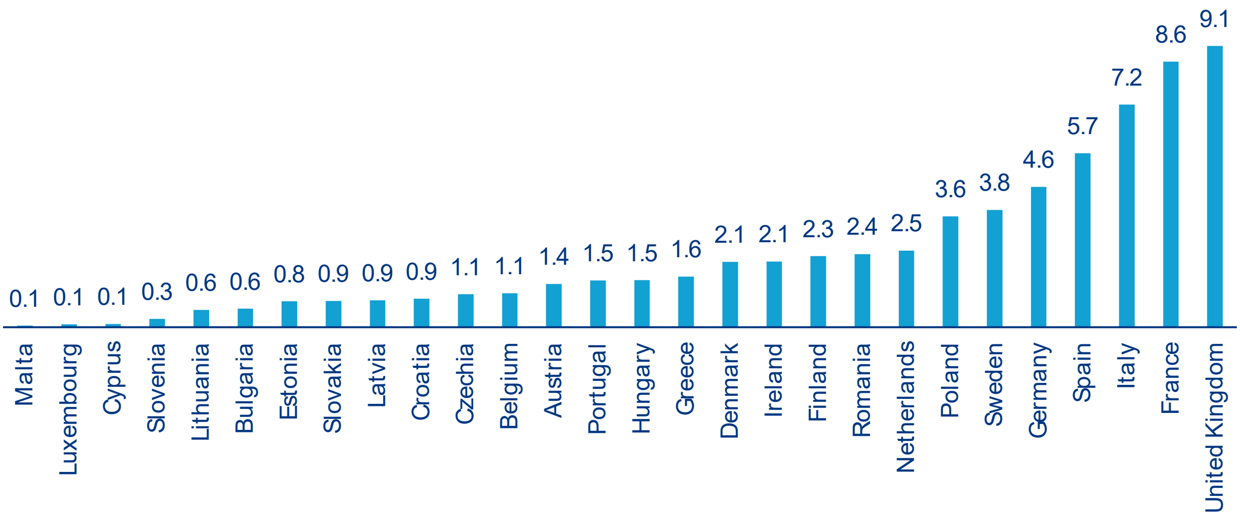
Sources: Cortes et al. (2025), Allianz Research

Under strong simplifying assumptions, our estimates suggest that the EU-27 and the UK would need to mobilize an additional EUR67.5bn per year in climate adaptation investment. This metric is constructed at the sector–country level using the heatmap presented in Figure 6, and using the adaptation requirement published by the EU[9] and the UK[10]. As discussed above, a sector with a ratio below one invests less in adaptation than its economic weight would suggest, where economic weight is measured by the sector's share in national GVA. We therefore define the possible climate-adaptation gap as the additional investment required to raise a sector's ratio from its current level to one[11]. This strong simplifying assumption means that if the manufacturing sector in Germany displays a ratio of 0.1, it would require an increase of 0.9pp to reach parity with its economic contribution. This assumption provides a transparent and comparable benchmark across countries and sectors, allowing us to translate macro-level adaptation targets into sector-specific investment signals. However, it abstracts from sectoral heterogeneity in physical risk exposure, adaptive capacity and cost structures, and therefore should be interpreted as an indicative allocation rule rather than a precise estimate of optimal investment needs. Finally, we assume that all sectors should raise their investments in climate adaptation based on the targets set by the EU members states and the UK. Therefore, the corresponding increase in adaptation spending constitutes the sector's possible adaptation gap.

Building on this simplified calculation of the climate adaptation gap, and without accounting for the respective climate vulnerabilities, Figure 6a reveals pronounced cross-country heterogeneity across Europe. While the adaptation gap is present in all countries, it is concentrated in nominal terms within the largest European economies and the UK, which together account for the bulk of the required additional investment. The five largest countries alone represent more than 50% of total climate adaptation needs in Europe (Figure 6a). When the gap is assessed relative to economic size, however, a markedly different picture emerges (Figure 6b). On average, European countries and the UK would need to increase current adaptation spending by a factor of four, from around 0.3% of GDP to approximately 1.2% of GDP (based on 2022 real GDP), in order to close the minimal adaptation gap. In several countries the adjustment required is of a similar magnitude, typically around 1pp of GDP. In a few cases, however, the gap is considerably larger. Estonia, for example, currently invests only 0.2% of GDP in climate adaptation and would need to raise this share to around 3.6% of GDP to reach the benchmark.

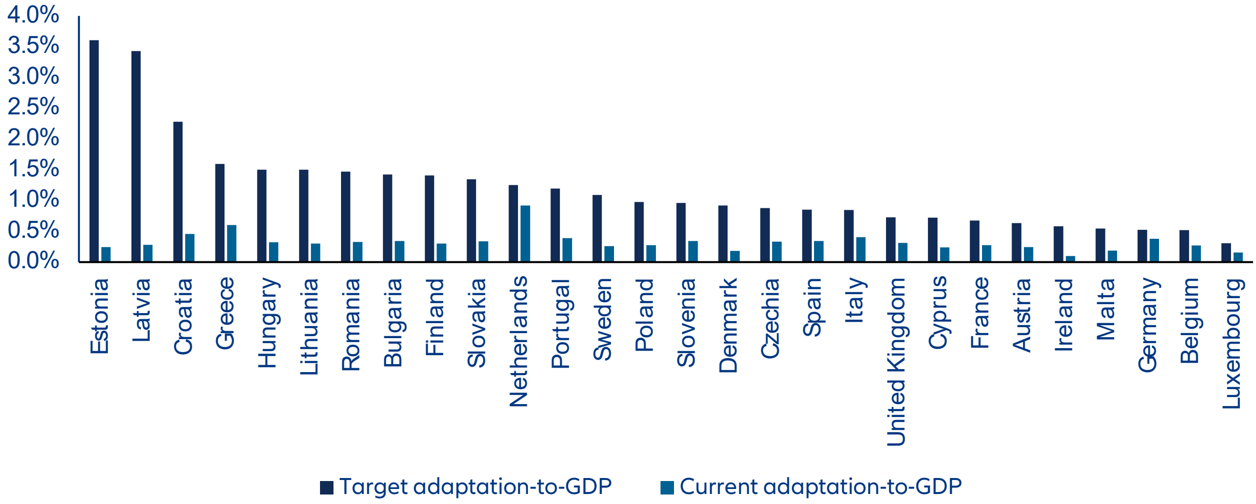
Figure 6: Yearly estimated climate adaptation gap in Europe using 2022 data

a) country-level estimated climate adaptation gap (EUR bn)



9 preventionweb.net/media/114764/download?startDownload=20260205
10 Adapting to climate change
11 Cortes et al. (2025) argue that sectors such as manufacturing, construction and wholesale and retail trade require substantial additional investment in climate adaptation, given the scale, concentration and capital intensity of the assets they hold.

b) target versus current adaptation investment-to-GDP



Sources: Cortes et al. (2025), Allianz Research

Challenges and policy landscape of climate adaptation

Adaptation as a coordination problem rather than a financing gap. Climate-change adaptation is often framed as a problem of insufficient funding, which is true as we discussed above. However, this perspective is incomplete and risks obscuring the deeper structural forces that shape adaptation outcomes. A significant body of literature suggests that lack of investment in climate adaptation is better understood as a coordination failure across time, actors and governance scales, rather than a simple shortage of capital. From a temporal perspective, adaptation suffers from a pronounced mismatch between when costs are incurred and when benefits materialize. Investments in flood defenses, heat-resilient infrastructure or water systems typically require large upfront expenditures, while their benefits take the form of avoided losses that may only become visible years or decades later, and often only in counterfactual terms. Empirical evidence shows that political systems systematically discount such preventive investments. For example, Healy and Malhotra (2009)[12] by discussing the concept of Myopic voters, demonstrate that elected officials are rewarded by voters for post-disaster relief spending, but not for ex-ante risk-reduction measures. This creates a structural bias toward reactive adaptation, even when preventive investment is economically efficient.

This intertemporal bias is compounded by a second coordination problem: misaligned incentives among public authorities, private firms and households. Adaptation rarely fits neatly into either purely public or purely private investment categories. Governments may hesitate to invest in protective infrastructure if benefits accrue primarily to specific regions or sectors, while private actors often delay adaptation in anticipation of public protection or post-disaster compensation. The World Bank[13] has documented this dynamic extensively, noting that firms tend to underinvest in adaptation when protective infrastructure, insurance frameworks or regulatory standards are uncertain or fragmented. The result is a strategic waiting game in which each actor rationally postpones action, even though collective outcomes deteriorate.

[12] Myopic Voters and Natural Disaster Policy | American Political Science Review | Cambridge Core
[13] Firm-Level Climate Change Adaptation : Micro Evidence from 134 Nations

A third dimension of coordination failure arises from scale mismatches. Climate risks are inherently local yet adaptation financing and policy frameworks are largely organized at national or supranational levels. This disconnect complicates prioritization and implementation. The Intergovernmental Panel on Climate Change (IPCC)[14] repeatedly highlights that adaptation planning is "fragmented and uneven," with institutional capacity and governance constraints playing a more decisive role than technical feasibility or financial availability. Even where national adaptation plans exist, implementation often stalls because local authorities lack stable funding streams, technical capacity or decision-making autonomy.

Finally, adaptation faces a unique political economy challenge: successful adaptation is largely invisible. When investments are effective, losses are reduced and the benefits remain unobserved. By contrast, failures are immediate, visible and politically salient. Kunreuther et al. (2014)[15] show that this asymmetry leads to systematic underinvestment in preventive measures as avoided damages are rarely credited to prior policy choices. This "invisibility problem" further weakens accountability mechanisms and reinforces short-term decision-making.

Measurement and taxonomy failures

Beyond coordination failures, an equally binding constraint on climate adaptation lies in measurement and missing standardized classification frameworks. Unlike mitigation, which benefits from relatively standardized metrics and accounting frameworks, such as the EU taxonomy[16], adaptation remains conceptually diffuse and empirically fragmented. As a result, adaptation is systematically miscounted in both public statistics and private financial reporting, with important consequences for investment and policy design.

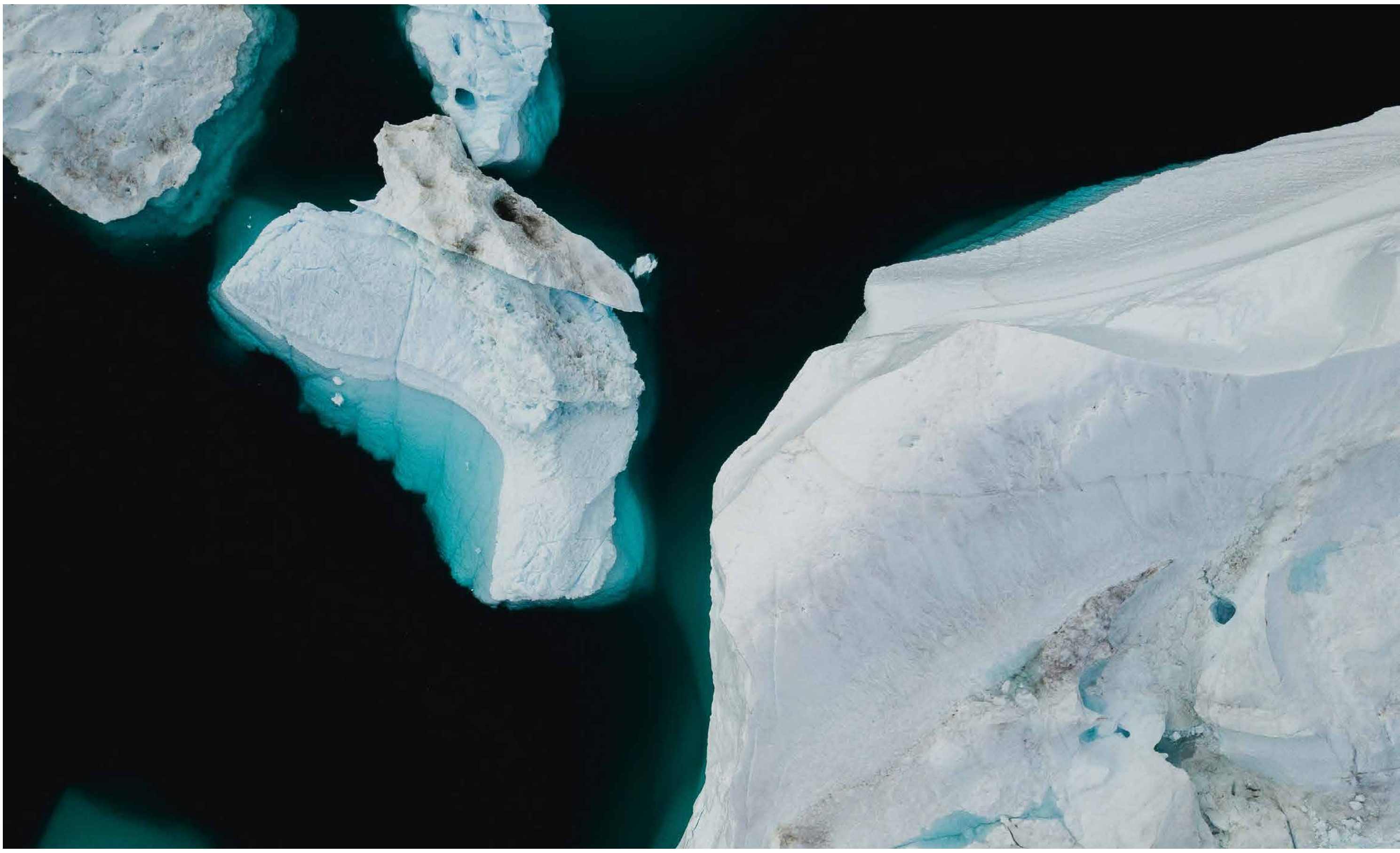
A first issue is the absence of an agreed and operational taxonomy of adaptation activities[17]. While mitigation can rely on clear proxies such as emissions reductions or energy substitution, adaptation encompasses a wide range of actions whose primary objective is risk reduction rather than output generation. This diversity complicates classification and has led to inconsistent treatment across datasets and institutions. IPCC notes that adaptation tracking remains "partial and uneven," with large variations in what countries and institutions label as adaptation. In practice, similar investments, such as flood-proofing infrastructure or upgrading water systems, may be classified as adaptation, resilience, maintenance or general capital expenditure, depending on context. This ambiguity weakens comparability and obscures the true scale of adaptation effort.

Closely related is the blurred boundary between adaptation, mitigation and maladaptation. Many investments simultaneously affect climate risks and emissions, sometimes in opposing directions. Cooling technologies provide a clear example: they reduce heat exposure and improve labor productivity, yet often increase electricity demand and, in carbon-intensive systems, emissions. Without a shared taxonomy that distinguishes effective adaptation from maladaptation, such investments are difficult to evaluate ex ante and even harder to assess ex post. This ambiguity complicates policy guidance and discourages private investors, who face reputational and regulatory risks when the classification of an investment is unclear.

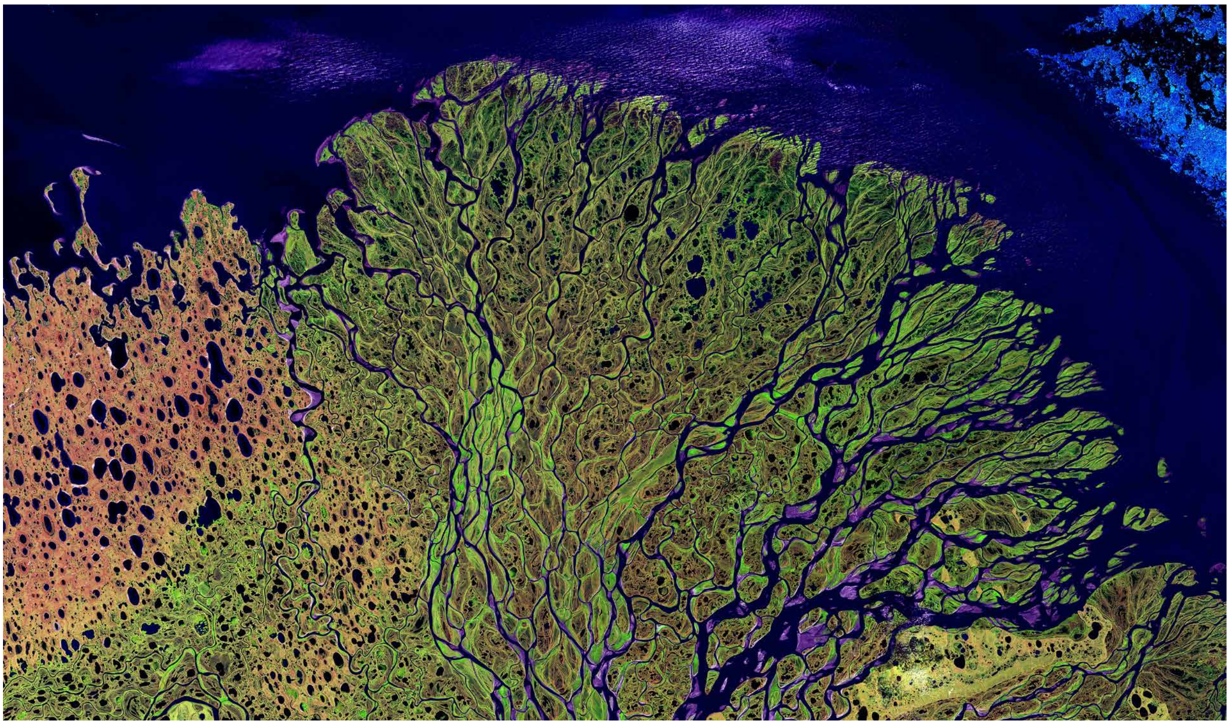
[14] Reflections on the IPCC AR6 Synthesis Report: adaptation, loss and damage - weADAPT
[15] Aiding Decision Making to Reduce the Impacts of Climate Change | Journal of Consumer Policy | Springer Nature Link
[16] The EU Taxonomy is a classification system that defines which economic activities are considered environmentally sustainable
[17] Tracking and Mobilizing Private Sector Climate Adaptation Finance - CPI

A third challenge concerns the poor tracking of "embedded adaptation", adaptation that is integrated into broader investment decisions rather than undertaken as a standalone project. Spending on water efficiency, building retrofits, drainage upgrades or resilient materials often occurs within standard capital expenditure or maintenance budgets and is rarely labeled as adaptation. As a result, a significant share of adaptation investment remains invisible in official statistics. The Climate Policy Initiative estimates that tracked adaptation finance substantially understates actual spending, particularly in advanced economies where private – corporate and household – investments dominate. This invisibility biases assessments toward underinvestment and reinforces the perception that adaptation lacks scale or investible opportunities.

Measurement challenges are further amplified by high uncertainty in forward-looking climate risk metrics (Kunreuther et al. 2014)[18]. Adaptation decisions require expectations about future hazard intensity, frequency and spatial distribution, yet climate models differ widely in projections at the local scale. For investors and policymakers alike, this uncertainty complicates the quantification of avoided losses and weakens the economic case for upfront investment. While uncertainty is inherent to climate projections, the lack of standardized exposure metrics makes it difficult to compare risks across sectors and regions or to assess whether adaptation spending is commensurate with expected impacts.



[18] ipcc_wg3_ar5_chapter2.pdf



Defining a taxonomy for climate adaptation

Climate adaptation refers to adjustments in systems, practices and structures to moderate harm from climate and natural hazards making systems, communities or assets resilient to shocks induced by climate change. The scale of investment required to close the climate-adaptation gap is substantial and likely exceeds the fiscal capacity of governments alone. While public investment will remain central, mobilizing private capital will be essential to meet the volume of financing required to implement adaptation projects at scale. However, adaptation investments differ significantly in their economic characteristics, particularly in terms of cost structures, distribution of benefits and the ability to generate monetizable revenue streams. As illustrated in Table 2, climate change adaptation investments span a continuum of public and private involvement, reflecting differences in cost structures, benefit distribution and market viability. Certain adaptation measures generate predominantly public benefits and lack clear or monetizable revenue streams, such as coastal protection through mangroves, flood defenses or labor interventions to protect workers from extreme heat, and therefore require full public financing. At the other end of the spectrum, some adaptation investments yield primarily private benefits and commercially attractive returns, including air conditioner for heat, flood-proofing of commercial real estate, technological solutions for climate-resilient supply chains or climate risk assessment tools for private assets, making them well suited for full private financing. Between these two extremes lies a broad class of adaptation projects characterized by joint costs and shared public–private benefits, such as water management systems, protection of critical infrastructure or climate-smart agriculture, where market returns are often insufficient to attract private capital on their own. For these projects, public–private partnerships (PPPs) play a critical role by combining public finance, risk-sharing instruments and regulatory support with private capital and expertise, thereby overcoming market failures and enabling the scaling of adaptation investments that would otherwise remain underfunded.

Table 2: Financing structure of climate-adaptation measures

Primarily publicly financed	Public–private financing	Primarily privately financed
Costs borne mainly by the public sector	Shared costs and risk allocation	Costs borne mainly by private actors
.imited or no direct market returns	Below-market returns / market failures requiring public support	Direct commercial returns
Public co-benefits dominate: avoided disaster losses, public health protection, ecosystem preservation	Shared co-benefits: infrastructure resilience, food security, supply chain continuity	Private returns with public co-benefits: reduced fiscal exposure, lower disaster relief costs, broader economic resilience
E.g., Coastal protection (mangroves), flood defences, labor time management for health protection against heat	*E.g., Water management, critical infrastructure protection (railways), climate-smart agriculture*	*E.g., Flood-proofing commercial real estate, heat-resilience food chain technologies, AI-based climate risk assessment*

Source: Allianz Research

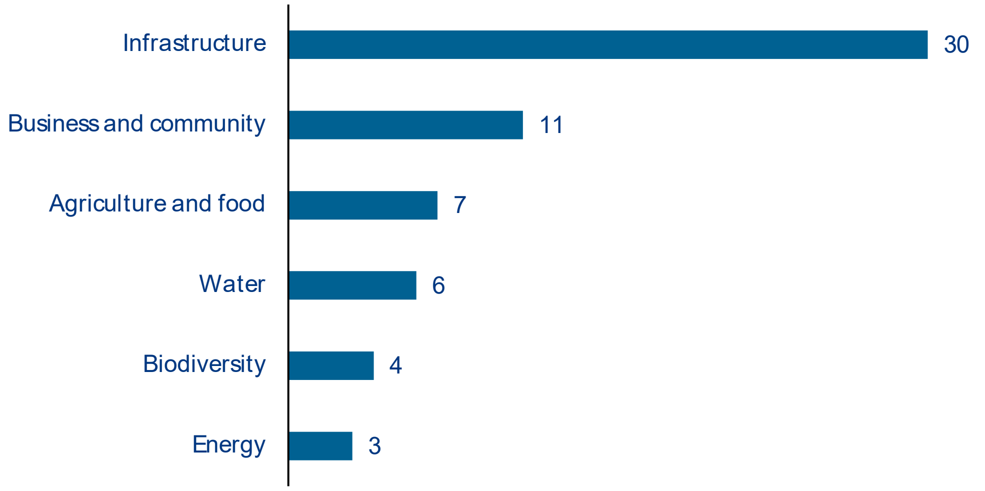
Effectively framing climate adaptation as an investible opportunity for private actors requires moving beyond broad notions of resilience and toward a clearer articulation of how physical risk reduction can translate into economic value and, ultimately, provide financial returns. Much of the adaptation debate has historically focused on public planning and social welfare, which has unintentionally reinforced the perception that adaptation is largely non-investible for return-seeking private investors. Recent evidence, however, suggests that this view reflects more a problem of framing and measurement than a fundamental absence of private-sector opportunities. At its core, investible adaptation can be understood as capital deployment that measurably reduces exposure or vulnerability to physical climate risks and converts this risk reduction into predictable cash flows, either directly through revenues or indirectly through cost savings, avoided losses or improved financial conditions (Barrett and Chaitanya, 2023)[19]. This distinction is critical. Private investors do not invest in "adaptation" for its own sake, but in products, services and assets that improve performance under changing climate conditions. The literature increasingly converges on this point, emphasizing that adaptation becomes investible when the link between climate risk, adaptation action and market return is explicit and credible.

To help clarify these links, we compile a set of 61 climate-adaptation measures spanning multiple hazards. We develop a taxonomy that clarifies where and through which channels private capital can contribute to climate-adaptation investment; Figure 7 shows the decomposition by themes and the full taxonomy is presented in Figure 8. The taxonomy of climate adaptation measures is constructed through a meta-analytical consolidation of existing classification frameworks. We combine the adaptation-measure inventories developed by Cortes et al. (2025) and Oehling et al. (2025) to derive a harmonized and more comprehensive set of measures spanning multiple hazards and sectors. The classification of measures across financing structures builds directly on the analytical framework proposed by Oehling et al. (2025), which distinguishes adaptation opportunities based on the presence and strength of market-based investment signals. In this framework, measures associated with strong current and forward-looking investment opportunities, typically characterized by identifiable revenue streams, scalable business models or clear cost-saving potential, are interpreted as commercially investible and therefore classified as primarily private. Conversely, measures with weak or limited investment signals, often reflecting diffuse benefits, public-good characteristics or the absence of monetizable returns,

[19] Getting private investment in adaptation to work: Effective adaptation, value, and cash flows - ScienceDirect

are classified as primarily public. Measures falling between these two categories, where market potential exists but remains constrained or dependent on enabling conditions, are assigned to the public–private category. This approach ensures that the taxonomy remains grounded in observable investment dynamics and existing literature, while providing an economically intuitive mapping between adaptation measures and their likely financing structures.

Figure 7: Number of adaptation measures by themes



Source: Allianz Research

Figure 8: Taxonomy of 61 identified adaptation measures

Climate Resilience Action Framework:

Resilience themes:	Public	Public - Private	Private
1. Agriculture & Food	/	1.1.1 Water Irrigation 1.2.1 Climate-Driven Crop Cultivation 1.2.3 New Species Improvement 1.2.4 Pest Suppression 1.3.1 Farm Equipment Adaptation 1.3.2 Agricultural Management Improvement	1.2.2 Drought-Resistant Seeds
2. Business & Community	2.5.1 Evacuation Services 2.7.1 Wildfire Training	2.1.1 Adaptation Finance 2.3.1 Earth Observation 2.6.1 New Distribution Systems 2.6.2 + 2.6.3 Supply Chain Management	2.2.1 Climate Insurance 2.4.1 Risk Modelling 2.4.2 Consulting 2.6.4 Sustainable Sourcing Consulting
3. Energy	3.1.1 Grid Robustness	3.2.1 External Resource Management 3.2.2 New Transmission Systems	/
4. Infrastructure and Built	4.4.2 Heat-Resistant Infrastructure 4.5.1 Climate Risk in Energy Planning 4.5.2 Underground Cabling 4.6.1 Dyke & Ditch Expansion 4.6.2 Sinkhole Engineering 4.6.3 Landslide Underpinning 4.7.2 Gabion Installation 4.7.3 Temporary Flood Barriers 4.7.4 Sandbags 4.7.7 Flood Barrier Setup 4.8.2 Vegetation Stabilization 4.9.1 Stormwater Management 4.10.3 Firebreak Operations	4.2.2 Air Management Systems 4.3.1 Reflective Building Surfaces 4.3.2 Insulation Installation 4.4.1 Green Roofs & Walls 4.4.4 Structural Surveys 4.7.1 Power Station Flood Protection 4.7.6 Stormwater Mitigation 4.8.1 Green Infrastructure Installation 4.10.1 Aerial Firefighting Equipment 4.10.4 Smokejumpers	4.1.1 Energy-Efficient Cooling 4.2.1 Supercooling Equipment 4.2.3 Solar Cooling 4.4.2 Building Retrofit Services 4.7.4 Stormwater Engineering 4.7.8 Pumping Equipment 4.10.2 Firebreak & Firefighting Equipment
5. Water	5.1.1 Porous Pavement Installation 5.4.2 Dam Height Increase 5.4.3 Sustainable Drainage	5.3.1 Wastewater & Sewage Processing	5.2.1 Water Efficiency Technologies 5.4.1 Advanced Water Management
6. Biodiversity	6.1.1 Storm-Related Tree Surgery 6.2.1 Forestry Services 6.2.1 Forest Management Improvement 6.2.3 Timber Resource Management	/	/

Source: Allianz Research

A systematic assessment of these measures confirms the structural importance of public capital in climate-change adaptation, a finding that is consistent with the collective nature of many adaptation needs. Within our taxonomy, 38% of adaptation measures are primarily public in nature (23 out of 61; Figure 9a). Public capital requirements are particularly concentrated in flood protection, which accounts for 65% of all public-related adaptation measures, reflecting the predominance of large-scale infrastructure, spatial planning and regulatory interventions in managing flood risks (Figure 9b). It is important to note that adaptation measures are not hazard-specific in a one-to-one manner. Several measures apply across multiple climate risks. For instance, integrating climate risk into energy infrastructure planning is a public-sector intervention that enhances resilience to floods, heat stress, droughts and wildfires alike, rather than addressing a single hazard in isolation.

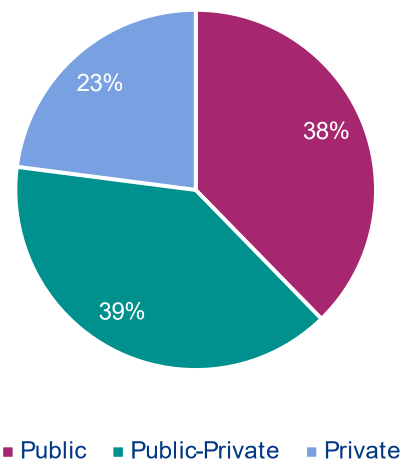
Private capital, by contrast, accounts for 23% of the identified adaptation measures (14 out of 61). While smaller in number than public measures, private investment plays a critical role in capital-intensive and innovation-driven segments of adaptation, particularly where technological development and specialized services are required. These include advanced climate risk modelling, water-management technologies, adaptation consulting services and energy-efficient cooling solutions for buildings. In hazard terms, heat stress emerges as the dominant area for private adaptation investment, representing 57% of privately financed measures (Figure 9b), consistent with the prevalence of scalable, market-based solutions in this domain.

Notably, the largest category in the taxonomy is public–private investment, which accounts for 39% of adaptation measures (24 out of 61). This highlights the central role of cooperation between public and private actors in accelerating adaptation investment. For example, flood protection for power stations falls under human-engineered flood defenses, where public capital typically finances protective infrastructure, while private capital contributes through the development of more resilient, cost-efficient construction technologies. When analyzed by hazard, public–private partnerships dominate across all risk categories, accounting for 67% of flood-related measures, 67% for heat stress, 54% for drought and 58% for wildfire adaptation (Figure 9b). This underscores that, across hazards, effective climate adaptation is most often delivered through coordinated public–private investment structures, rather than through purely public or purely private channels. Overall, the analysis shows that climate adaptation is primarily driven by public capital. However, scaling investment will also require private finance in segments with viable market potential, while public capital remains essential to de-risk investments in areas where returns are uncertain or non-commercial.

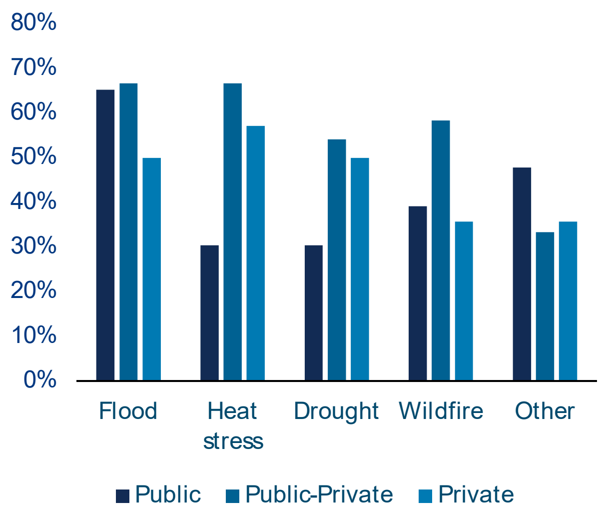
Importantly, the taxonomy reflects the distribution of adaptation measures, not the distribution of investment volumes. The relative shares (38% public, 39% public–private, 23% private) should therefore not be interpreted as direct proxies for the optimal allocation of adaptation finance. Capital intensity varies significantly across measures: large-scale flood protection infrastructure, for example, requires substantially higher investment volumes than many private adaptation solutions. The taxonomy instead provides a structural mapping of investability and financing modalities, rather than a capital-weighted allocation.

Figure 9: Structure of the public and private investment in climate change adaptation

a) Structure considering all identified 61 climate adaptation measures



b) Structure considering hazard-type adaptation measures



Sources: Cortes et al. (2025), Oehling et al. (2025), Allianz Research

Public and private investment cases in climate adaptation

Structured frameworks help investors better assess the risks and opportunities of climate adaptation investments. Assessing adaptation investments becomes easier when investors apply structured evaluation frameworks. While private investors can participate without deep technical expertise, clearer definitions, stronger evidence and systematic approaches help assess climate risks and evaluate the risk–return profile of adaptation investments.

Adaptation investments can be identified by linking climate vulnerabilities, project intent and risk-reduction outcomes. A commonly used framework, outlined by the European Investment Bank (2022), evaluates adaptation investments along three elements: identifying the relevant climate vulnerability, establishing an explicit intent to reduce that vulnerability and demonstrating a credible link between project activities and the climate risk addressed. Moreover, the Joint Multilateral Development Bank methodology distinguishes three types of adaptation activities: Type 1, integrating climate risk management into investments (e.g. adjusting road culvert designs); Type 2, directly reducing climate risks and strengthening adaptive capacity (e.g. diversifying municipal water sources) and Type 3, enabling systemic adaptation by addressing knowledge, capacity or technological barriers (e.g. developing drought-resilient crop varieties)[20].

How adaptation finance is measured depends on whether resilience is the core objective or only one component of a project. Type 3 activities – such as research, policy support or capacity building – are typically counted as 100% adaptation finance because adaptation is their primary objective. By contrast, Type 1 and Type 2 projects usually combine development and adaptation objectives, so only the adaptation component is counted, either through incremental cost estimates or proportional allocation. In practice, these projects often involve strengthening physical or natural assets, such as resilient infrastructure or ecosystem services.

[20] European Investment Bank, 2022

The type of adaptation activity shapes the scale, structure and investability of financing opportunities. Type 3 activities are often linked to early-stage innovation or enabling environments, meaning investment opportunities mainly arise in venture capital or specialized private-market vehicles where volumes remain limited and risks higher. Type 1 and Type 2 activities, by contrast, are more easily embedded in infrastructure and development projects and therefore generate larger, more structured investment opportunities, including green bonds, resilience bonds or infrastructure financing. Despite the growing range of such instruments, private capital still accounts for only around 2% of tracked adaptation finance, reflecting limited revenue models and persistent information gaps[21].

Limited traceability makes adaptation investments difficult to identify in public markets. In public corporate bond and equity markets, institutional investors struggle to target adaptation and resilience investments because disclosure remains limited and fragmented. Few listed companies explicitly report themselves as providers of adaptation solutions, and corporate revenues or capital expenditures related to resilience are rarely identifiable. Although the EU Taxonomy aims to improve transparency by reporting the share of turnover aligned with adaptation objectives, disclosures remain limited due to reporting complexities and structural constraints. Unlike mitigation, which relies on a clear metric such as GHG-emission reduction, adaptation requires detailed, site-specific climate vulnerability assessments, making classification more complex.

Better disclosure and harmonized taxonomies would improve investment visibility. Standardizing disclosure requirements within existing regulatory frameworks would significantly improve data availability and allow investors to identify and track adaptation-related activities more effectively. At the same time, data providers would be able to play a stronger role in systematically collecting and disseminating information on adaptation investments. Current taxonomies remain fragmented – often designed for specific sectors, regions or institutions – making it difficult for globally diversified investors to apply consistent classifications. More harmonized standards would support comparability and enable investors to integrate adaptation considerations more systematically across portfolios.

Green bond frameworks often lack sufficient transparency on adaptation spending. While green bonds support climate investment, they rarely provide clear visibility on the share of proceeds allocated specifically to adaptation. Most instruments bundle multiple climate objectives, particularly mitigation, meaning adaptation projects are typically assessed at the individual project level rather than through consistent market-wide classifications.

Private markets offer targeted adaptation investments but remain difficult to scale. In private corporate debt and equity markets, adaptation investments are often concentrated in early-stage companies developing solution-oriented technologies such as climate-resilient seeds (USD50-60bn Mkt and 4-7% CAGR[22]) climate resilient building materials such as façade materials (USD100-120bn Mkt and 5-10% CAGR[23]). These investments can demonstrate a clear link between capital allocation and climate resilience outcomes, but they typically involve small ticket sizes, limited investable universes and higher risk profiles. Expanding dedicated private debt and equity funds focused on adaptation could help pool capital, diversify risk and scale investment opportunities.

Public finance is central to adaptation but remains constrained by transparency and project pipeline challenges. Although the public sector plays a key role in climate adaptation and resilience investments, important constraints remain, particularly regarding transparency, reliability and investment planning. Sovereign green bonds are expected to play an increasingly important role in mobilizing capital for national adaptation strategies by financing projects that strengthen the resilience of infrastructure, communities and economic systems. In practice, however, investors often struggle to identify sovereign green bonds with meaningful allocations to adaptation and resilience. This is frequently due to structural barriers such as limited strategic planning and insufficient project development capacity at the national level, which contribute to a shortage of viable, investment-ready adaptation projects. Adaptation initiatives are often highly localized, relatively small in scale, and embedded within larger infrastructure projects, making them more difficult to identify and finance. In many cases governments also lack a clear and transparent strategy integrating adaptation initiatives with national adaptation plans,

21 Joint methodology for tracking climate change adaptation finance; Standard-Chartered-Bank-Guide-For-Adaptation-And-Resilience-Finance-FINAL.pdf
22 Investment Opportunities in the Climate A&R Market | BCG
23 Investment Opportunities in the Climate A&R Market | BCG

sector priorities and NDCs, as well as disaster risk reduction plans. Finally, administrative processes can be complex and time-consuming.

Blended finance can help mobilize capital but still faces significant investor barriers. Blended finance vehicles provide another avenue for governments and companies to catalyze private capital into climate adaptation to meet the funding gap. It is particularly well suited for reducing financial risks associated with such projects and make incentives more attractive to private investors. However, investors require clear information on risk–return profiles in order to allocate capital confidently. While blended finance can reduce financial risks, asset owners – particularly in emerging markets – often struggle to track which adaptation and resilience projects are funded and lack transparent frameworks for risk allocation. Combined with regulatory constraints (such as high risk charges), volatile returns (since adaptation projects often generate lower or indirect cash flows) and complex investment structures, these challenges increase perceived risks and discourage private investors from participating. Table 3 provides examples of public and private investment approaches in climate adaptation.

Table 3: Examples of corporate and sovereign investments

Asset class	Project
Listed Equity and Debt	CTP N.V., Netherlands-based commercial real estate developer, integrating adaptation and mitigation into its standard design at both the building and park level, generating a 46.4% EU Taxonomy adaptation aligned turnover
Private Equity	Lightsmith, a private equity firm dedicated to climate adaptation technologies, closed with USD186mn in commitments from major global investors and development institutions. The fund targets growth stage companies delivering solutions such as water efficiency technologies, resilient food systems, agricultural and supply chain analytics and geospatial intelligence. The objective is to build private capital to scale climate resilience technologies–particularly in emerging markets
Private Debt (Blended finance structure)	GAIA Climate Loan fund to finance climate adaptation and mitigation projects across emerging markets. Long-term private credit prioritizing adaptation projects in climate-vulnerable markets. At least 70% of capital will be dedicated to climate adaptation – such as sustainable agriculture, water management, ecosystem resilience and climate-smart infrastructure.
Sovereign Debt	Dutch green bond (NL0015001RG8) with main focus on “Climate change adaptation and sustainable water management”: Expenditures under the Dutch Delta Program focus on ensuring long term flood risk management, particularly through dike improvements needed to meet the 2050 protection standards. Based on BB data: Issuance: EUR15bn, Allocation to adaptation: 58%. Given that many adaptation and resilience initiatives are developed and executed at the local level, sub-sovereign funding is expected to rise accordingly. For instance, California's Proposition 4 Climate Bond allocates USD10bn toward local projects aimed at enhancing community resilience, including the protection of drinking water, mitigation of wildfire and flood risks

Source: Allianz Research

Appendix

A1 – Climate hazard exposure methodology

This appendix documents the methodology used to compute population exposure to climate hazards used in Figure 2. The approach is designed to produce continuous, interpretable exposure metrics at the grid-cell level and to allow consistent aggregation to national and regional scales. The methodology is applied globally and is fully reproducible.

For each climate hazard and each grid cell i, an exposure weight $w\,i\,E$ [0,1] is computed as a function of hazard intensity. Expected exposed population are then calculated as weighted sums:

$$\text{Exposed population} = \sum_{\mathrm{i}} (\mathrm{pop}_{\mathrm{i}} \times \omega_{\mathrm{i}})$$

All socio-economic layers are spatially aligned to the hazard grid. Country polygons are rasterized once onto the hazard grid and cached. Country-level exposure is obtained through zonal aggregation, while regional aggregates are computed by mapping ISO3 country codes to Natural Earth subregions.

For river flooding, exposure is represented using a fractional inundation measure. The flood hazard dataset provides, for each grid cell, the fraction of area affected by flooding during a given year. This fraction is normalized to lie in the interval [0,1] and directly used as the exposure weight w_i. This approach captures the fact that flooding is spatially bounded but rarely affects an entire grid cell uniformly. Using fractional exposure avoids overestimating impacts that would arise from binary flooded/non-flooded classifications and allows exposed population to scale proportionally with the extent of inundation within each cell.

For wildfires, exposure is also treated as a continuous measure, rather than a binary burned/not-burned indicator. Annual wildfire intensity is constructed from burned-area data and transformed into a normalized exposure weight in [0,1]. This reflects the fact that wildfire impacts vary with the extent and persistence of burned area within a grid cell and that partial burning can still generate significant economic and population exposure. Treating wildfire exposure continuously ensures consistency with the aggregation framework and avoids abrupt threshold effects.

By contrast, for drought and heat stress, exposure cannot be meaningfully represented by fractional area alone. These hazards are diffuse and cumulative, with impacts that increase progressively as conditions intensify rather than appearing abruptly once a spatial boundary is crossed. Therefore, for heat stress and drought hazards, exposure is derived using a smooth logistic function, which transforms hazard intensity into an exposure weight:

$$\omega(\mathrm{x}) = \frac{1}{1 + \exp(-\mathrm{k}(\mathrm{x} - \mathrm{d}_0))}$$

where x denotes the hazard metric, d_0 is the midpoint of the transition, and k controls the slope of the curve. This functional form ensures that exposure increases gradually with hazard intensity rather than through a binary threshold, reflecting the progressive nature of climate impacts.

To ensure data-driven calibration and cross-country comparability, the logistic function is anchored to the empirical distribution of the hazard metric in a reference calibration year (default: 2020). Two population-weighted quantiles are defined:

- Qlow: 5th percentile
- Qhigh: 95th percentile

The anchoring conditions are imposed as:

$$\omega(Q_{\mathrm{low}}) = 0.1,\ \omega(Q_{\mathrm{high}}) = 0.9$$

And, the midpoint of the logistic function is defined as:

$$d_0 = \frac{Q_{\mathrm{low}} + Q_{\mathrm{high}}}{2}$$

This approach ensures that the transition zone of exposure reflects the observed hazard distribution rather than arbitrary thresholds. For drought exposure, the metric used is the annual maximum number of consecutive dry days (CDD), computed as the ensemble mean across climate model members. For heat stress, exposure is based on the annual count of days with daily maximum temperature exceeding 35°C (TX35), aggregated from monthly values. In both cases, the smoothed logistic function is applied using population-weighted quantiles from the calibration year. For each projection year, hazard intensity is computed, transformed into exposure weights using the calibrated function, and aggregated to exposed population and GDP using the weighted sums described above.

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