Fundación MAPFRE

# CLIMATE CHANGE: EXTRAORDINARY RISKS AND PUBLIC POLICIES

MAPFRE Economics

# Climate Change: Extraordinary Risks and Public Policies

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# MAPFRE Economics


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# Contents


**Presentation** . . . . . 9

**Introduction** . . . . . 11

**Executive summary** . . . . . 13

**1. Climate change and extraordinary risks** . . . . . 17
- 1.1 Climate cycles . . . . . 17
- 1.2 Intensity of weather phenomena . . . . . 19
- 1.3 Climate predictive models . . . . . 22

**2. Economic losses from natural disasters and insured damages: insurance protection gap** . . . . . 25
- 2.1 Insurance gap in relation to natural disasters . . . . . 25
- 2.2 Insurance gap in relation to climate-related natural disasters . . . . . 29

**3. Analysis of protection mechanisms against natural disasters** . . . . . 33
- 3.1 Analysis of systems in selected countries . . . . . 33
- 3.2 Regional mechanisms for protection against natural disaster risk . . . . . 52

**4. Reinsurance and securitization through catastrophe bonds** . . . . . 55
- 4.1 Reinsurance and catastrophic risks . . . . . 55
- 4.2 Catastrophe bonds . . . . . 60

**5. Climate change and insurance companies' investment portfolios** . . . . . 67

5.1 Investment risks related to climate change . . . . . 67
5.2 Global initiatives on sustainability criteria in investments . . . . . 69
5.3 Green bonds and sustainability bonds . . . . . 70
5.4 Initiatives in the European Union . . . . . 72

**6. Climate change and the carbon emission trading market** . . . . . 77

6.1 Greenhouse gas emissions . . . . . 77
6.2 Greenhouse gas emission allowance trading systems . . . . . 78

**7. A public policy analysis** . . . . . 87

7.1 Current trends . . . . . 87
7.2 European Central Bank Initiative . . . . . 95

**References** . . . . . 99

**Index of tables, charts, and boxes** . . . . . 105

# Presentation

This new study by MAPFRE Economics analyzes the growing impact of climate change on extraordinary risks covered by the insurance industry, against a backdrop of intensification of extreme weather events and the widening of the insurance protection gap for natural disasters. Climate change represents one of the main challenges to social and economic stability, profoundly altering the nature and intensity of extraordinary risks. These increasingly frequent and severe phenomena pose a growing challenge for the insurance industry and for traditional mechanisms of damage coverage and compensation.

As our report highlights, catastrophic natural disasters are sometimes too large and potentially systemic for the private market or public sector to address on their own, resulting in natural disaster insurance gaps. Closing this gap undoubtedly constitutes a public policy challenge that must be addressed from a multifaceted perspective, requiring coordinated action by insurance companies and other stakeholders at all levels of local, national, and international government. The lessons drawn from the analysis conducted throughout this report also allow for the compilation of various public policy approaches identified globally, which can be used as a reference for addressing the effects of catastrophic risks related to extraordinary natural events.

Fundación MAPFRE has been striving for decades to promote a safer, more resilient society, better prepared to face major global challenges. Due to its impact on the frequency and severity of extreme natural events, climate change poses a major challenge to both economic stability and the protection of citizens' property and personal well-being. With this publication, Fundación MAPFRE aims to continue contributing to a better understanding of topics that are particularly relevant to society, fulfilling its founding purpose of supporting the dissemination of knowledge on topics related to insurance and social protection.

**Fundación MAPFRE**

# Introduction

MAPFRE Economics presents this report focused on the analysis of climate change and extraordinary risks. It opens with a brief review of climate cycles, the intensity of weather phenomena, and the characteristics of the predictive models used to quantify them. Chapter Two of our study addresses the measurement of economic damages caused by natural disasters, as well as their level of insurance coverage, resulting in estimates of the insurance gap for these types of events. The third part of this report focuses on reviewing international experience related to loss protection and compensation mechanisms, through which governments (often in collaboration with the insurance industry) address the effects of these types of extreme natural events.

Meanwhile, the fourth part of our study analyzes the role of reinsurance and other financial instruments, such as catastrophe bonds, in compensating for economic damages caused by catastrophes. Chapter Five then discusses the impact of these risks on the investment portfolios of insurance companies, considering transition and legal risks. These efforts include the creation and development of carbon emission trading markets, which are addressed in Chapter Six of this report. Finally, Chapter Seven presents a compilation of public policies identified by analyzing international experience, which can serve as a reference for adapting to, preventing, and mitigating the impact of catastrophic risks related to extreme weather events.

We trust that this report will enhance the understanding of the complex challenge posed by climate change and its impact on the insurance industry through the materialization of extraordinary risks. It also aims to highlight the vital role that insurance can play—often in partnership with public authorities—to implement mechanisms that serve as a foundation for sustaining economic activity in the face of such events, thus strengthening societal resilience, protection, and well-being.

**MAPFRE Economics**

# Executive summary

## Climate change and extraordinary risks

The Earth's climate is influenced by multiple interacting cycles operating on different time scales. From the insurance industry's perspective, the primary concern lies in short- and medium-term cycles, particularly those identifiable over the past few centuries or even recent decades—since these are the ones that most directly influence natural catastrophes triggered by adverse weather conditions.

These climate cycles include what are known as *natural cycles*. Natural cycles affect the climate on scales lasting a few years or decades, with significant variations in temperature, rainfall, and global weather patterns, potentially contributing to more extreme weather. Such cycles include but are not limited to the decadal oscillations in the Pacific and North Atlantic, or the El Niño and La Niña phenomena (ENSO cycle). Similarly, since 1850, anomalies have been recorded in average land and ocean temperatures, with global warming significantly higher than the long-term average. Numerous studies attribute this trend to the industrial revolutions, due to the impact of greenhouse gas emissions on the atmosphere, which are accelerating the rise in the planet's average temperature.

An analysis of historical data shows that catastrophic losses caused by climate-related events follow a pattern with large annual fluctuations (as is logical given the extraordinary nature of these events) alongside a clear long-term upward trend. This growth is also evident in the portion of these losses covered by insurance contracts. This increase is often attributed to the impact of climate change caused by global warming. However, other factors may also help explain the phenomenon, such as economic and population growth or urban expansion—sometimes in vulnerable areas with poorly developed early warning systems, evacuation plans, or general prevention measures—as well as the rise in property values. These elements can also lead to significant variations in loss ratio patterns depending on the affected locations. Despite this, global warming is considered to be playing a decisive role in the intensification and frequency of catastrophic events, particularly what are known as "secondary perils."

To this end, as regards extreme weather phenomena, the main global reinsurers and intermediaries specializing in insuring large risks have come to distinguish between *primary* perils and *secondary* perils. The former (primary perils) mainly include high-intensity hurricanes, typhoons, and tropical cyclones (along with geological events like earthquakes, tsunamis, or volcanic eruptions), while the latter (secondary perils) refer to lower-intensity, higher-frequency climate events. In the current context of insurance and reinsurance activity, secondary perils are causing a growing impact in terms of human lives and economic losses, with extraordinary damage to infrastructure and ecosystems.

The variety of climate-related secondary perils is vast. Generally, these include events such as windstorms, tornadoes, hailstorms,

wildfires, droughts, heat waves, severe thunderstorms, cold snaps, blizzards, ice storms, frost, bomb cyclones, extratropical cyclones (low-pressure systems with strong winds, heavy rain, flooding, and snowfall), atmospheric rivers (which can dump large amounts of rain over specific areas, causing severe flooding), convective gusts, extreme cold, blizzards, storm surges, avalanches and isolated upper-level depressions with flash flooding caused by intense rainfall over short periods (cold drops). The distinction between primary and secondary perils is commonly reflected in reports issued by reinsurance companies (given its usefulness for descriptive purposes and to measure insurance gaps), although it may vary depending on the criteria applied. Regulations do not typically distinguish between the two perils when establishing public policy frameworks addressing extraordinary risks, which feature their own definitions of catastrophes and covered damages.

## Insurance protection gaps in relation to natural disasters

Catastrophic natural disasters are sometimes too large and potentially systemic for the private market or public sector to manage alone. This results in insurance coverage gaps or underinsurance in the face of natural catastrophes, a phenomenon referred to as the "NatCat Gap." On a global scale, Asia is the region with the largest insurance protection gap, with insurance contracts covering just 17.2% of total losses caused by natural disaster-related risks, based on the average over the past decade (2015-2024). This implies a coverage shortfall of 82.8%. Next is Latin America, which shows an average gap of 81.0%. This stands in stark contrast to North America, which has the smallest protection gap, with an average of 43.2% of losses not covered by insurance contracts. In the specific case of the European Union, a joint study by the European Central Bank and the European Insurance and Occupational Pensions Authority (EIOPA) revealed that just a quarter of economic losses in the European Union were insured, and that this proportion was less than 5% in some Member States, based on the average of a long-term historical series.

## Public policies to close the protection gap

Closing the insurance protection gap for catastrophic risks undoubtedly poses a public policy challenge. This challenge must be addressed from a multifaceted perspective, requiring coordinated action by insurance companies and other stakeholders at all levels of local, national, and international government. International experience confirms that insurance and reinsurance companies can make a substantial contribution to managing the impacts of natural disasters by providing recovery funds in a timely manner and incentivizing the reduction of risks. However, in the absence of the necessary protection and compensation measures and mechanisms, climate risks become uninsurable or unaffordable, meaning that the insurance gap not only fails to narrow, but sometimes even increases.

In this regard, public administrations must collaborate, and even take the initiative, to adopt proactive public policies to maintain the feasibility of insurance markets and, at the same time, leverage insurance mechanisms to promote climate adaptation and loss prevention with a view to protecting the population and maintaining economic activity. This report analyzes four key aspects of public policy measures to address the insurance protection gap when it comes to climate-related disasters:

- *Public-private insurance partnerships for climate disasters*. Development of collaboration frameworks between public administrations and the insurance industry to manage and share disaster risks.

- *Incentives for prevention and risk reduction of adverse climate events*. Use of insurance as a tool to incentivize risk reduction, and integration of insurance

into broader climate adaptation and disaster risk management efforts, early warning systems and their transfer to the capital market.

- *Measures for the collection and management of catastrophic loss data*. Improved risk data, modeling, and pricing strategies.

- *Measures aimed at expanding coverage through parametric solutions*. Coverage expansion through combinations of parametric (index-based) insurance solutions, along with conventional insurance.

It is worth noting that all efforts aimed at preventing and reducing the risks caused by adverse weather events, including the fight against environmental degradation and climate change, can be hugely beneficial to the insurance industry, which faces a twofold exposure. On the one hand, through the insured risks underwritten in insurance policies (physical risks), and on the other, through investment portfolios due to transition risks and legal risks. These aspects are analyzed in detail in Chapter Five of this report. These efforts include the creation and development of carbon emission rights markets are addressed in Chapter Six. Finally, Chapter Seven of this study provides further details of the compilation of public policies identified through the analysis of international experience, which can be used as a reference for adapting to, preventing, and mitigating the impact of catastrophic risks related to extraordinary events caused by adverse weather conditions.

# 1. Climate change and extraordinary risks

Within the broader concept of so-called *natural disasters*, events caused by adverse weather conditions play a particularly significant role. In recent years, and with few exceptions, these climate-related events have consistently resulted in the greatest aggregate losses, both economically and in terms of human lives. In addition to climate-related events, there are also anthropogenic catastrophes and lower-frequency natural events triggered by geological phenomena such as earthquakes, tsunamis, and volcanic eruptions. Other sources, such as extraterrestrial impacts (e.g., meteorite strikes), can likewise cause extraordinary, catastrophic-scale losses. In this context, this report focuses on risks arising from adverse weather conditions. It does not cover extraordinary risks caused by anthropogenic disasters unrelated to climate, nor those caused by geological or astronomical events, although reference is occasionally made to them for explanatory purposes.

## 1.1 Climate cycles

The Earth's climate is influenced by multiple interacting cycles operating on different time scales. From the perspective of insurance activity, analytical focus is primarily placed on short- and medium-term cycles, primarily those occurring in recent centuries or even decades. Nevertheless, it is also important to briefly outline the broader cycles in which these cycles take place, to provide an overview of the phenomenon. With this in mind, climate cycles can be classified into three main categories depending on their duration: long-term cycles (measured in billions of years), medium-term cycles (which unfold over centuries), and short-term cycles (measured in decades).

### 1.1.1 Long-term cycles

Long-term cycles, spanning thousands or millions of years, are related to the Earth's continental, orbital, and axial dynamics; they affect the climate in the form of changes in ocean currents and the distribution of solar radiation they cause.

#### Continental drift and ocean currents

The movement of continents occurs over millions of years and can significantly influence ocean circulation, thereby impacting the Earth's climate. A notable example is the opening of the Drake Passage, which isolated Antarctica, allowing the formation of the Antarctic Circumpolar Current, and led to the continent's glaciation, when it had previously been covered in trees. Similarly, the formation of the Isthmus of Panama, connecting North and South America roughly three million years ago, changed the ocean currents, contributed to glaciation in the Northern Hemisphere. These processes accelerated as the ice sheets expanded, increasing Earth's albedo (reflectivity) and reinforcing cooling trends—and vice versa, as is occurring today, when ice loss contributes to warming. The duration of these cycles is such that their impact is not perceivable in the medium and short term, as far as climate change is concerned. However, they remain relevant when assessing the extraordinary risks caused by geological events in these time periods.

#### Milankovitch cycles

Milankovitch cycles are climate cycles related to changes in the Earth's orbit around the Sun, which influence the amount of solar radiation received. The Earth's current orbit around the Sun is slightly elliptical (nearly

circular). However, its eccentricity varies cyclically, with more elliptical shapes occurring approximately every 100,000 years. Other similar movements involve those related to the Earth's rotational axis, also resulting in changes in the climate by altering solar radiation input. Consequently, there are cycles that affect the obliquity, or tilt, of the Earth's axis in relation to the ecliptic plane (cycles of approximately 41,000 years), which influence the intensity of the seasons, and a conical motion in the axis's orientation, known as *precession*, which alters the seasonal pattern over a cycle of roughly 26,000 years. According to research in this field, these cycles have been key to the alternation of ice ages and interglacial periods for millions of years.

## 1.1.2 Medium-term cycles

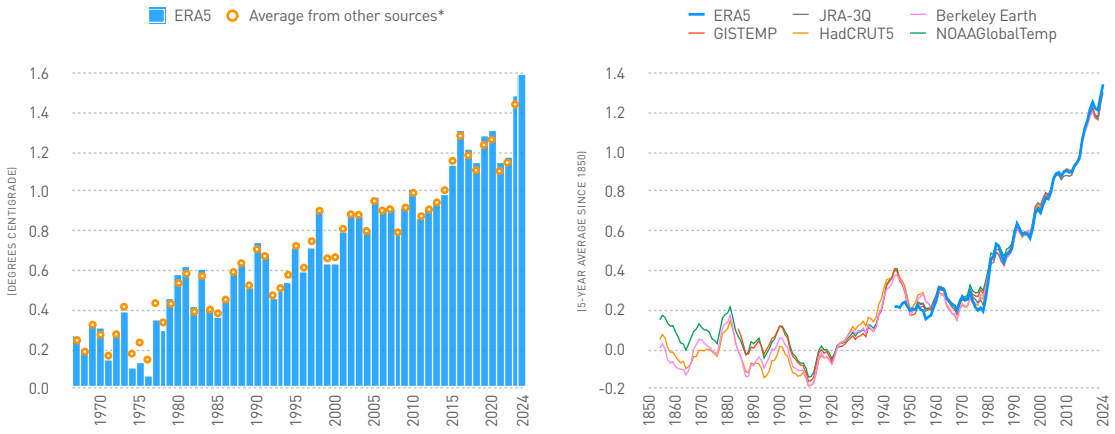
### Solar cycles

Within the category of medium-term cycles are solar cycles, which allow us to identify changes in the amount of solar radiation that reaches the Earth. This can influence temperatures on our planet over timescales spanning several decades to millennia, as seen with the Suess cycle, which lasts approximately two centuries, or the Bond cycle, which lasts around 1,500 years. Similarly, geological events, such as volcanic eruptions, can also lead to changes in medium-term climate cycles.

### Industrial revolutions and climate change

The industrial revolutions driven by human activity have had a significant impact on the Earth's atmosphere through the emission of greenhouse gases. Since 1850, anomalies in average land and ocean temperatures have been recorded, which numerous studies have linked to this phenomenon. Unlike natural cycles, this is a human-induced change. During the first Industrial Revolution (18th-19th centuries), the widespread use of steam engines led to an increase in the use of fossil fuels, mainly coal, increasing $CO_2$ emissions. During the Second Industrial Revolution (19th-20th centuries), the use of oil and electricity increased, further intensifying the volume of greenhouse gas emissions. The Third Industrial Revolution (20th and 21st centuries), saw a massive surge in technology use and energy consumption—trends that continue today in what is referred to as the Fourth Industrial Revolution.

Chart 1.1.2
Increase of the global surface temperature over pre-industrial levels
(reference period: pre-industrial, 1850-1900)




Source: MAPFRE Economics (with data from the European Commission, Copernicus)
* Average of the following measurements: JRA-3Q, Berkeley Earth, GISTEMP, HadCRUT5, and NOAAGlobalTemp

While this new phase increasingly promotes the adoption of renewable energy, the cumulative impact of $CO_2$ continues to rise.

According to the latest estimates (see Chart 1.1.2), 2024 was the hottest year on record, with a temperature range of 1.57 to 1.6°C above the average temperature recorded during the pre-industrial era (the 1850-1900 period).[1]

### 1.1.3 Short-term cycles

Finally, short-term cycles affect the climate on scales of a few years or decades, with an impact on temperature, rainfall, and global weather patterns.

#### El Niño and La Niña phenomenon (ENSO cycle)

This category includes the ENSO ("El Niño Southern Oscillation") phenomenon. This oceanic-atmospheric cycle oscillates from one extreme to the other, with the two opposite extremes known as El Niño and La Niña. Both play a major role in the climate variability observed today. During El Niño events, the waters of the equatorial Pacific Ocean warm up, causing changes in rainfall and temperature patterns across the planet. This can lead to droughts in some regions, primarily Asia, and extreme rainfall in others, such as the west coast of equatorial Latin America or the western United States on account of the atmospheric rivers it triggers. Conversely, during La Niña episodes, the opposite occurs: the equatorial Pacific Ocean cools down, often causing the same effects as El Niño in other parts of the planet; for example, more hurricanes in the Atlantic, droughts in South America, flooding in Asia, and other extreme events in virtually every region of the world.

El Niño and La Niña episodes have been linked to the Southern Oscillation or cycles in the Walker circulation of the trade winds, which blow more strongly along the equator from east to west (due to the Coriolis effect, or the deflection of wind currents from the Hadley cell caused by the Earth's rotation). When these winds slow down, they cause a warming of the Pacific Ocean surface along the equator (El Niño), and when they speed up, the opposite happens, cooling the surface of the Pacific Ocean in this area (La Niña).[2] These cycles usually alternate every two to seven years and typically last around one year, though they can sometimes persist for longer. The transitional phases are known as *ENSO-neutral* periods.

One of the strongest El Niño events on record took place in 2024, following months of unprecedented ocean temperatures. Among its consequences were coral reef damage, droughts in the Amazon rain forest (and the Panama Canal), and extreme rainfall in North America. Ultimately, both of these phenomena contribute to increased climate extremes, causing significant damage to ecosystems and severe losses of human life as well as economic losses (due to property damage and the disruption of ocean currents that bring phytoplankton from colder depths to the surface of the equatorial Pacific Ocean).

#### Pacific and North Atlantic decadal oscillations

This category of short-term cycles also includes temperature variation cycles of the Pacific Ocean (PDO), which occur approximately every 20-30 years (less frequently than the El Niño phenomenon in the equatorial Pacific), influencing weather patterns in the Americas and Asia. On the other hand, there are the temperature variations in the North Atlantic (AMO), which occur roughly every 60 to 70 years and affect hurricane activity and temperatures in Europe and North America.

## 1.2 Intensity of weather phenomena

Temperature anomalies on land and in the oceans, whether caused by natural or anthropogenic factors, can affect weather

patterns and the intensity of extreme weather events, currently as a result of global warming. These include both high-intensity, infrequent weather events, as well as lower-intensity, more frequent events that, in the context of insurance and reinsurance activities, are often referred to as secondary perils, causing a significant impact on human lives, infrastructure, and ecosystems.

### 1.2.1 Primary perils (extreme weather events)

The distinction between primary and secondary extreme weather events is primarily used in the insurance industry and is employed by major global reinsurers and others involved in catastrophic risk modeling, including but not limited to the Insurance Information Institute,[3] Verisk,[4] and the World Meteorological Organization (WMO), which study and model extreme weather events.

#### Hurricanes, typhoons, and major tropical cyclones

The terms *hurricane*, *typhoon*, and major *tropical cyclone* all refer to the same event: massive tropical storms consisting of strong winds, heavy rains, and storm surges, or to abnormal increases in sea levels resulting in coastal flooding. It is, in fact, the same weather phenomenon, named differently depending on the region where it occurs. Thus, the term *hurricane* is used when the phenomenon occurs in the North Atlantic and the Northeastern Pacific; *typhoon* when it occurs in the Northwestern Pacific; and *tropical cyclone* when it occurs in the Indian Ocean or the South Pacific.

Climate perils classified as *primary* are high-intensity storms (hurricanes, typhoons, or tropical cyclones) with winds of at least 119 km/h. There are a variety of classifications or categories to measure their intensity. The most common are as follows:

**Saffir-Simpson Hurricane Scale (Atlantic and Northeast Pacific)**

This scale was created to correlate wind intensity with the potential for structural damage caused by a hurricane, although the actual damage depends on various circumstances. Therefore, it is now primarily used as a wind speed classification system. The scale ranges from:

- Category 1: 119-153 km/h (minimum damage)
- Category 2: 154-177 km/h (moderate damage)
- Category 3: 178-208 km/h (significant damage, considered a major hurricane)
- Category 4: 209-251 km/h (severe damage)
- Category 5: over 252 km/h (catastrophic damage)

**Typhoon Scale (Northwestern Pacific)**

In the Northwestern Pacific, the Japan Meteorological Agency (JMA) and the Joint Typhoon Warning Center (JTWC) use a classification structured around three categories:

- Typhoon: 118-156 km/h
- Severe typhoon: 157-193 km/h
- Super typhoon: over 194 km/h

**Tropical Cyclone Scale (Indian Ocean)**

In the Indian Ocean, the Regional Specialized Meteorological Center (RSMC) uses the following classification for tropical cyclones:

- Tropical cyclone: 63-118 km/h (not particularly intense)
- Severe tropical cyclone: 119-167 km/h
- Very severe tropical cyclone: 168-221 km/h
- Super tropical cyclone: Over 222 km/h

The North Atlantic hurricane season runs from June 1 to November 30, peaking between August and October. In the

Northeastern Pacific, there is cyclonic activity between May 15 and November 30, and it is most intense from July to September. In the Northwestern Pacific, typhoons can form year-round, although they are most frequent between June and December, peaking in August and September. In the Northern Indian Ocean, cyclones take place during two main periods: April to June and October to December, peaking in May and November. In the Southern Indian Ocean, the cyclone season runs from November to April, with activity peaking between January and March (summer in the Southern Hemisphere).

These extreme storms are categorized and tracked by different meteorological agencies, including: the U.S. National Hurricane Center (NHC) for the Atlantic and Northeastern Pacific,[5] the Japan Meteorological Agency (JMA) for the Northwestern Pacific,[6] the Joint Typhoon Warning Center (JTWC) for the Pacific and Indian Ocean,[7] and the Australian Bureau of Meteorology (BOM) for the South Pacific and Southern Indian Ocean.[8]

Table 1.2.1 shows the worst events of this kind across five continents since records began. According to this information, Asia is the region with the highest number of fatalities, with several cyclones causing more than 10,000 deaths. The deadliest event was the Bhola Cyclone (1970), a major tropical cyclone that made landfall in what was then East Pakistan (now Bangladesh) and is estimated to have caused between 300,000 and 500,000 deaths, making it one of the deadliest cyclones ever recorded. In addition to the loss of life, the cyclone caused massive flooding and widespread destruction in the Ganges Delta region and the wider economy. The region with the highest economic losses is the Americas,

Table 1.2.1
Global: major catastrophic weather events since records began

| Event | Year | Region | Type | Number of deaths | Approximate damages (millions of USD) |
|---|---|---|---|---|---|
| **Cyclone Bhola** | 1970 | East Pakistan (Bangladesh) | Cyclone | 300,000-500,000 | Massive destruction |
| **Cyclone Tracy** | 1974 | Australia | Cyclone | 71 | Massive destruction |
| **Hurricane Katrina** | 2005 | United States | Hurricane | 1,800 | 125,000 |
| **Hurricane Harvey** | 2017 | United States | Hurricane | 100 | 125,000 |
| **Hurricane Maria** | 2017 | Puerto Rico | Hurricane | 3,000 | 90,000 |
| **Hurricane Helene** | 2024 | United States, Mexico, Cuba | Hurricane | 232 | 79,000 |
| **Typhoon Haiyan** | 2013 | Philippines | Typhoon | 6,300 | 13,000 |
| **Typhoon Yagi** | 2024 | Southeast Asia | Typhoon | 829 | 12,600 |
| **Hurricane Mitch** | 1998 | Central America | Hurricane | 11,000 | 6,000 |
| **Cyclone Nargis** | 2008 | Myanmar | Cyclone | 138,000 | 4,000 |
| **Cyclone Yasi** | 2011 | Australia | Cyclone | 1 | 3,500 |
| **Cyclone Idai** | 2019 | Mozambique, Zimbabwe, Malawi | Cyclone | 1,300 | 2,200 |
| **Cyclone Winston** | 2016 | Fiji | Cyclone | 44 | 1,400 |
| **Typhoon Bopha** | 2012 | Philippines | Typhoon | 1,900 | 1,000 |
| **Cyclone Pam** | 2015 | Vanuatu | Cyclone | 15 | 600 |
| **Hurricane Ophelia** | 2017 | Ireland, United Kingdom | Hurricane | 3 | 87 |
| **Cyclone Eloise** | 2021 | Mozambique | Cyclone | 27 | Significant |

Source: MAPFRE Economics (with data from NOAA, AON, Munich Re, and CEPAL)

especially the United States, with the most costly events on record being Hurricanes Katrina (2005) and Harvey (2017), each with estimated losses of 125 billion dollars.

It should be noted that hurricanes affect Europe to a lesser extent compared to regions such as the Caribbean, North America, and Southeast Asia.[9] This is due to several factors, although it primarily comes down to water temperature, as hurricanes require warm waters to form and sustain themselves. The eastern North Atlantic and European seas are generally too cold to sustain powerful hurricanes. Moreover, atmospheric currents typically steer most hurricanes northeastward before they reach Europe, except in rare cases.

### Other primary catastrophic perils

In addition to these severe meteorological phenomena (hurricanes, typhoons, and high-intensity tropical cyclones) are other geological phenomena considered *primary* perils, particularly earthquakes and tsunamis,[10] which are less frequent but can cause even greater damage on an individual scale. This was the case of the Tohoku earthquake and tsunami (2011, Japan), with approximately 18,000 deaths and economic losses amounting to 360 billion dollars, including the Fukushima nuclear disaster.[11]

## 1.2.2 Secondary perils (related to climate events)

The variety of so-called *secondary* perils related to climate is very broad, and includes hailstorms, wildfires, droughts, heat waves, severe thunderstorms, cold snaps, blizzards, ice storms, frost, bomb cyclones, extratropical cyclones (low pressure systems that can cause strong winds, heavy rain and snowfall), atmospheric rivers (which can dump large amounts of rain on specific areas causing severe flooding), windstorms, convective gusts, extreme cold, blizzards, storm surges, avalanches, and isolated upper-level depressions with flash flooding caused by intense rainfall in a short period (cold drops). *Secondary* perils also include phenomena categorized by the World Meteorological Organization (WMO) as tropical depressions (winds less than 63 km/h), tropical storms (winds between 63 and 118 km/h), and tornadoes (which can reach wind speeds of more than 400 km/h and cause extensive damage in small areas).

This group of events categorized as *secondary* perils has increasingly contributed to global economic losses, occurring with greater frequency and intensity based on information compiled by the main insurers, reinsurers,[12] and other specialized entities worldwide.[13] This is largely attributable to climate change caused by global warming, but also to other factors, primarily increased urban development rates and a lack of adequate infrastructure, which have increased uncertainty in insured losses and led to additional efforts in risk modeling.

In Europe, although hurricanes are far less frequent than in other regions of the world, secondary atmospheric events are increasing in both frequency and intensity, causing significant economic and human losses, as was the case in examples such as: Storm Xynthia (2010, Western Europe), resulting in 59 deaths and estimated losses of 4.3 billion dollars; Storm Kyrill (2007, Europe), which left 47 dead and estimated damages of 10 billion dollars; Storm Darya (1990, Western Europe), causing 94 deaths and losses of 6 billion dollars; the rains and flooding in Germany in 2021, which caused 243 deaths and damages worth more than 40 billion dollars;[14] the isolated high-level depression in 2024 in eastern Spain, causing 224 deaths and damages amounting to several billion dollars, and the still-undetermined damages from the wildfires in California and Australia.

## 1.3 Climate predictive models

The use of climate predictive models has become one of the main tools for estimating the levels of risk and economic losses caused by extreme weather events. Among

the most relevant techniques are weather modeling, climate change-related models, and artificial intelligence and machine learning applied to climate models.

## Weather modeling

Weather modeling is a highly complex process, becoming increasingly so as the forecasting horizon expands, due to the large number of variables and data required. A variety of different predictive weather models are used worldwide, some of which are open-source. Many of them focus on short- and medium-term weather forecasts (though some extend further), in an attempt to model trends and patterns related to climate change, using complex algorithms and data from historical and real-time sources obtained from weather stations, drones, and artificial satellites.

Among these open-source models for short- and medium-term forecasting, several noteworthy systems have been developed in the United States, such as the: "Global Forecast System" (GFS),[15] developed by the National Oceanic and Atmospheric Administration (NOAA),[16] which provides 16-day forecasts. Also worth noting is the "Weather Research and Forecasting Model" (WRF),[17] developed by the National Center for Atmospheric Research (NCAR),[18] which offers short- and medium-term weather forecasts, also open-source.

In Europe, models include the Integrated Forecast System (IFS) from the European Centre for Medium-Range Weather Forecasts (ECMWF),[19] with data accessible only at certain levels and restricted code and medium-term forecasts. The Consortium for Small-Scale Modeling (COSMO)[20] is used by several meteorological services in Europe for short-term, high-resolution forecasts. In Germany, a model developed by the German Meteorological Service (DWD)[21] is also available and is also open-source.

## Climate change-related models

Among the models related to climate change, in the United States, NASA (National Aeronautics and Space Administration) has developed its own model known as the Goddard Earth Observing System Model (GEOS),[22] for climate change and atmospheric chemistry research, with some of its modules being open-source. Other such models include the Community Earth System Model (CESM),[23] developed by NCAR, and the Model for Prediction Across Scales (MPAS),[24] developed jointly by NCAR and Los Alamos National Laboratory for long-term climate studies, which is open-source and used in scientific research. In the United Kingdom, the Met Office[25] operates a closed model for its own forecasts, using it to collaborate on projects such as the Hadley Centre Climate Model. In France, high-resolution operational prediction models such as ARPEGE and AROME[26] are available, but not as open source, as is the case with the Japan Meteorological Agency (JMA)[27] model.

## Artificial intelligence and machine learning applied to climate models

Financial investment in the development and improvement of climate and weather models, especially those that integrate generative artificial intelligence (AI) and machine learning, has the potential to revolutionize climate prediction by making models faster, more accurate, and more accessible. These techniques are being integrated with traditional models, analyzing results, and running multiple simulations, which could help improve preparedness for extreme weather events in the future. Collaboration between public institutions and private corporations has a contribution to make in this regard. For example, the European Centre for Medium-Range Weather Forecasts (ECMWF) has launched the Artificial Intelligence Forecasting System[28] (AIFS), which is estimated to improve forecast accuracy by 20%.[29]

Another noteworthy example is the artificial intelligence model developed by Google DeepMind, known as GraphCast,[30] for weather prediction, which has the capacity to offer more accurate and faster forecasts than traditional systems.[31] It is an AI model based on Graph Neural Networks (GNNs) used to process spatially structured data, representing atmospheric conditions in nodes distributed globally and at different altitudes. The model was trained on four decades of weather analysis data from the European Centre for Medium-Range Weather Forecasts (ECMWF), allowing GraphCast to learn patterns and causal relationships in climate evolution, accurately estimating the trajectory of events such as cyclones, atmospheric rivers associated with the risk of flooding, and the occurrence of extreme temperatures.[32] By doing so, it correctly predicted the location where Hurricane Lee would make landfall ten days in advance, although it has not yet been able to accurately predict extreme weather conditions.[33]

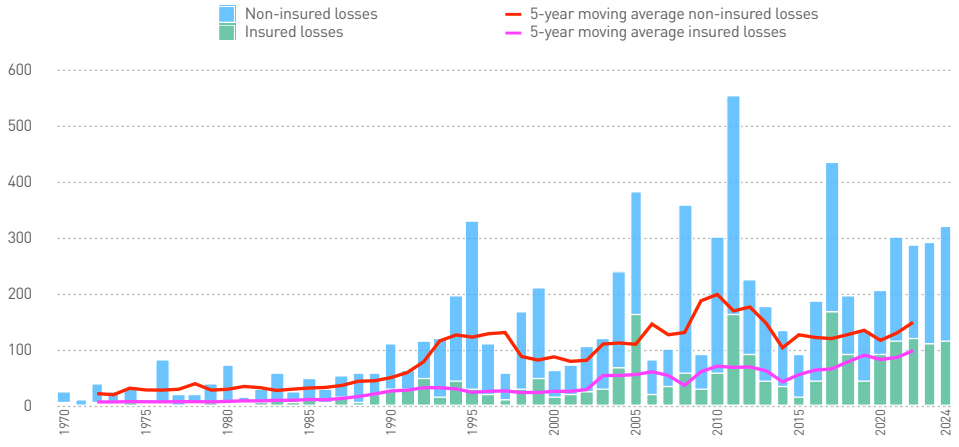
# 2. Economic losses from natural disasters and insured damages: insurance protection gap

## 2.1 Insurance gap in relation to natural disasters

The natural catastrophe insurance gap ("NatCat Gap") can be defined as the difference between the total economic losses caused by natural catastrophes and the losses covered by insurance contracts, this being the most common definition and the one considered for the purposes of this report.[34] Quantifying losses caused by natural disasters is complex and requires estimates, which means that figures vary substantially depending on the sources providing them. This is unlike the portion of these losses covered by insurance contracts, for which more precise estimates always exist based on information provided by insurance and reinsurance companies, as well as by some of the major brokers specializing in this type of risk.

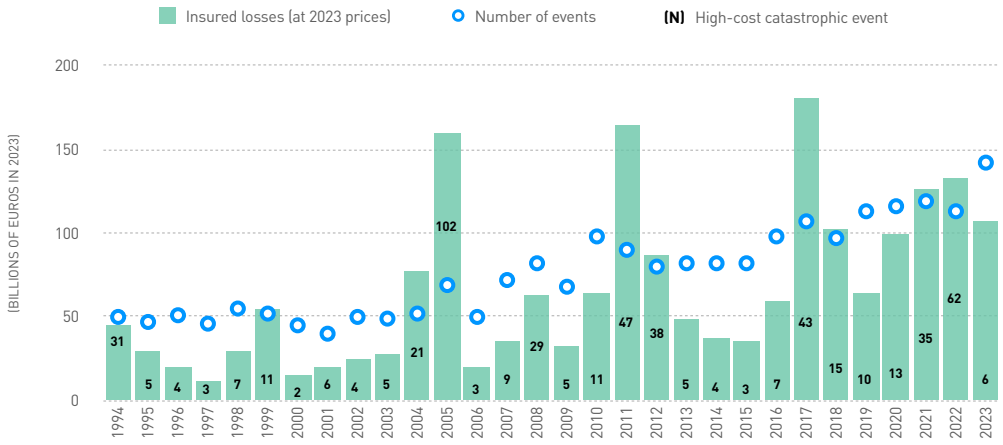
Analyzing the information presented in Figure 2.1-a, a pattern of behavior can be observed with large annual variations in global losses caused by natural disasters, as is logical given the extraordinary nature of this type of event and an underlying upward trend. According to data from the Swiss Re Institute, insured losses resulting from catastrophic events have shown a sustained long-term upward trend, with an annual growth rate of 5% to 7% since 1992.[35] Although this increase is often attributed to the impact of climate change, in reality, this phenomenon can also be explained by other factors, such as economic and population growth or urban expansion (sometimes in vulnerable areas with poorly developed early warning systems or evacuation and prevention plans, or rising property values), also leading to significant variations in loss ratio patterns. However, there is broad consensus that global warming plays a determining role in the intensification and frequency of climate-related natural disasters, as can be seen in the upward trend in the number of such events (see Chart 2.1-b) and, particularly, in the so-

Chart 2.1-a
Global: losses due to natural disasters
(billions of USD, amount at constant prices in 2024)




Source: Swiss Re Institute

Chart 2.1-b
Global: insured losses, cost of major event, and number of catastrophes by year




Source: MAPFRE Economics (based on Swiss RE data)

called "secondary perils," which in recent years have systematically accounted for more than half of the recorded losses.

However, when analyzing the information by region, taking the average for the last available decade (2015-2024), it can be seen that Asia is the region where the gap in insurance protection is largest, with just 17.2% of total losses from risks related to natural disasters (caused by adverse weather conditions and earthquakes) covered by insurance contracts, representing a gap of 82.8%,[36] followed by Latin American region, which has an average gap of 81.0%. The above contrasts with North America, which boasts the smallest protection gap, where an average of 43.2% of losses are not covered by insurance contracts[37] (see Table 2.1). This is despite North America facing all types of natural hazards ranging from tropical cyclones, winter storms and tornadoes to wildfires, flooding, earthquakes, and tsunamis. The protection gap in the region can mainly be traced to uninsured losses from floods and earthquakes.

The main natural hazards in Oceania are flooding, tropical cyclones, windstorms, earthquakes, and tsunamis. While rainfall-related flooding has dominated losses from secondary hazards over the past decade, damage caused by severe convective storms

Table 2.1
Global: economic losses, insured losses, and protection gap

| | 2015-2024 decade (billions of USD) | | |
|---|---|---|---|
| | Total economic losses | Insured losses | Protection gap (NatCat Gap) |
| Latin America and the Caribbean | 100 | 19 | 81.0% |
| North America | 1,411 | 801 | 43.2% |
| Asia | 645 | 111 | 82.8% |
| Oceania | 56 | 33 | 41.1% |
| Europe, Middle East, and Africa | 385 | 117 | 69.6% |
| Global | 2,597 | 1,081 | 58.4% |

Source: MAPFRE Economics (based on Swiss Re data)

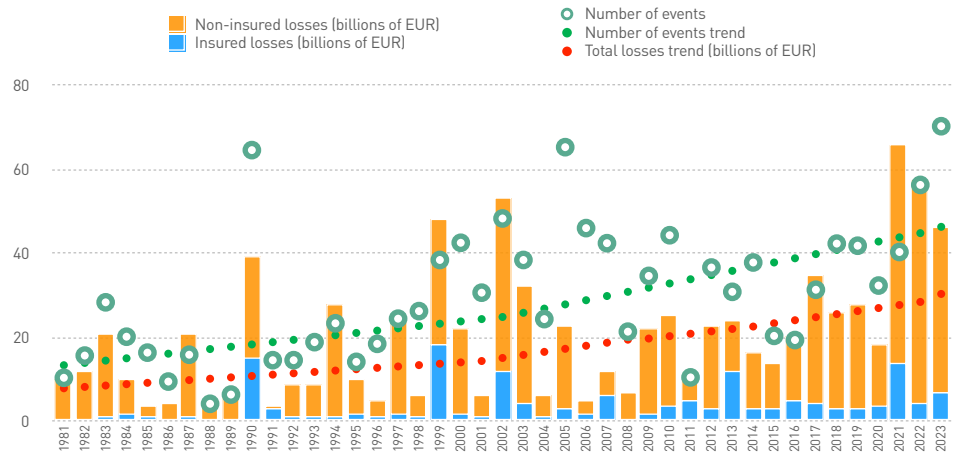
(including hail and tornadoes) is on the rise. In the case of developing markets, mostly the Pacific Islands, the natural catastrophe protection gap can primarily be attributed to a lack of insurance and awareness, as well as the generally low penetration rate.

Asia's lack of protection against natural disasters stems primarily from the rapid growth and population density of its cities, combined with the accumulation of assets at risk from weather-related events such as flooding, for which insurance cover tends to be lower than the cover of windstorms. In the EMEA region (spanning Europe, the Middle East, and Africa), the average insurance gap for the 2015-2024 decade stood at 69.6%, meaning that only 30% of total losses were covered by insurance contracts. In this region, the case of the European Union is worth highlighting, for which the European Central Bank (ECB), in cooperation with the European Insurance and Pensions Authority (EIOPA), has calculated the insurance protection gaps for natural disasters with a high level of disaggregation for each Member State and by type of catastrophic event, as well as an aggregate calculation for the European Union as a whole[38] (see Chart 2.1-c).

The joint document prepared by the ECB and EIOPA concludes that only a quarter of economic losses in the European Union were insured, and that this proportion was less than 5% in some Member States.[39] These figures were obtained by taking the historical averages of the proportion of insured economic losses relative to total economic losses in each country over a 42-year period (1980 to 2021). The report's main conclusion is that the economic losses caused by extreme weather and climate events are increasing, and they are expected to continue rising due to the growing frequency and severity of disasters caused, among other factors, by global warming. Between 1981 and 2023, natural disasters caused around 900 billion euros in direct economic losses across the European Union, with more than one-fifth of these losses occurring in the last three years.

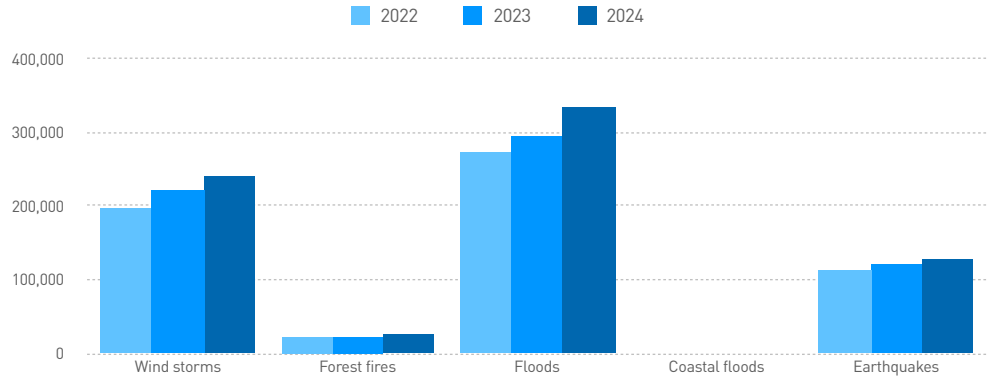
Two key factors are driving this upward trend. The first is the growth in economic exposure as wealth and property values increase, leading to increased losses associated with natural disasters (aggravated by the fact that property growth is often concentrated in high-risk areas such as floodplains or

Chart 2.1-c
European Union: economic losses and number of natural disaster events
(billions of EUR in 2023)




Source: CATDAT (Risklayer GmbH Europe Climate related impact Analysis Project) EIOPA's Dashboard on insurance protection gap for natural disasters European Union and EM DAT

Chart 2.1-d
European Economic Area: evolution of catastrophe risk
(millions of EUR)




Source: MAPFRE Economics (based on EIOPA data)

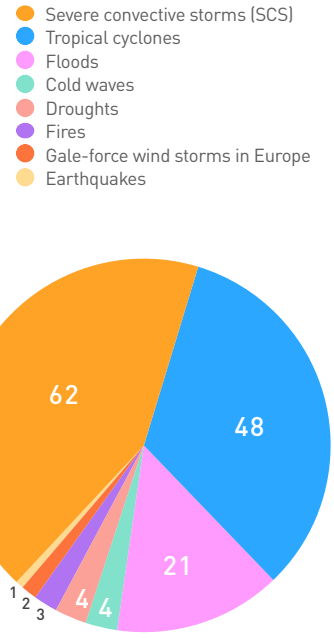
coasts[40]). The second factor is climate change, and particularly global warming, which is increasing the frequency and severity of climate-related disasters (flooding, wildfires, storms, droughts, and heat waves). Although it is difficult to untangle the contribution of these two factors, the ECB and EIOPA report highlights that Europe is the fastest-warming continent in the world, and that the number of climate-related disasters in the European Union is on the rise, coming to a record high in 2023.

According to EIOPA,[41] the catastrophic insurance protection gap in the European Union was 79.2% in 2022, 79.6% in 2023, and 80.0% in 2024, which represented 7.8%, 9.3%, and 9.0% of the EU's GDP, respectively. Broken down by risk type, 45% of losses in 2022 were caused by flooding, 32.7% by storms accompanied by strong winds (windstorms), and 18.5% by earthquakes (the Italian earthquake was the costliest event). Lower coverage and, therefore, a bigger insurance gap, are typical of this type of seismic event (97% of economic losses are not covered by insurance), followed by wildfires (93%), and flooding (84%). Greece and Italy are the countries where the protection gap is largest, especially given the high frequency and low penetration of earthquake insurance coverage. The figures for 2023 and 2024 are similar in terms of the distribution of catastrophes by risk type and insurance gap. Regarding the evolution of risks, those that grew the most compared to the previous year were windstorms (12.3%) and wildfires (10.4%) in 2023, and flooding (12.8%) in 2024 (see Chart 2.1-d).

## Insured losses and global gap in 2024

In 2024, global natural catastrophes caused economic losses amounting to at least 368 billion dollars (397 and 365 billion dollars in 2023 and 2022, respectively), according to the most recent estimates published by Aon,[42] marking the ninth consecutive year in which losses exceeded 300 billion dollars, and 14% above the long-term average. Of these, around 145 billion dollars were insured (126 and 155 billion dollars in 2023 and 2022), which amounts to an insurance coverage rate of 48% (31.7% and 42.5% in 2023 and 2022, respectively), due mainly to severe convective storms, tropical cyclones, and floods (see Chart 2.1-e). It is worth noting that the most devastating event in 2024 was Hurricane Helene, which caused an estimated 79 billion dollars in direct damages.

Chart 2.1-e
Global: insured catastrophic losses, 2024
(billions of USD)



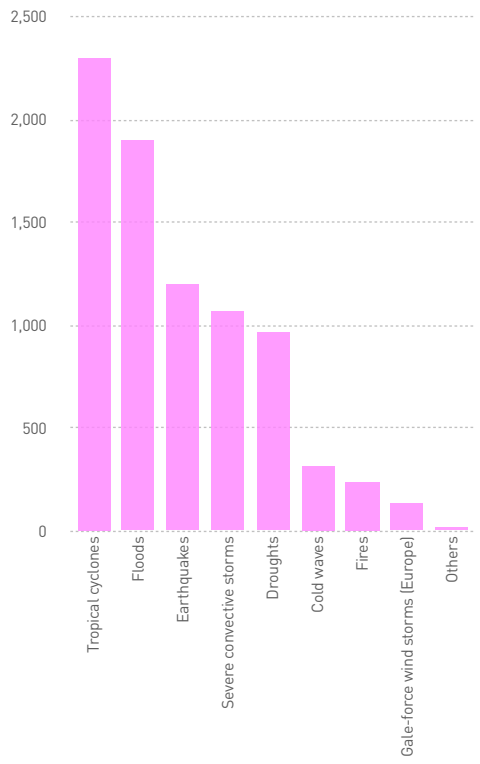

Source: MAPFRE Economics (based on AON data)

Similarly, estimates published by Munich Re in 2025 place the total economic losses from natural catastrophes in 2024 at 320 billion dollars, again above 300 billion dollars, of which only 140 billion dollars were insured, amounting to a coverage rate of 44%. In turn, the estimate prepared by Swiss Re places the catastrophic insurance gap at 181 billion dollars, representing a 4 billion dollar increase over the previous year. In this case, the factors that explain the natural catastrophe insurance gap (NatCat Gap) include low insurance penetration in emerging economies, a greater concentration of the population in cities and high-risk areas, and the increased frequency and severity of extreme events due to climate change.

## 2.2 Insurance gap in relation to climate-related natural disasters

Globally, Aon[43] has estimated the total accumulated losses from 2000 to 2024 due to catastrophic events, broken down by type of event, with tropical cyclones and flooding responsible for the greatest accumulated losses during the period, followed by earthquakes and severe convective storms (see Chart 2.2-a). In this regard, the protection gaps for this type of event—calculated as the average over the past decade using available data from Swiss Re and shown in Table 2.2—highlight that, among climate-related events (excluding geological phenomena), floods present the largest insurance protection gap during that period (slightly lower but close to that of earthquakes). Now, if we focus solely on

Chart 2.2-a
Global: accumulated losses, 2000-2024
(billions of USD)




Source: MAPFRE Economics (based on AON data)

Table 2.2
Global: global protection gap (NatCat Gap)

| | Global protection gap (NatCat Gap) | | |
|---|---|---|---|
| | Average, decade | Percentage covered by insurance | Protection gap |
| Hurricanes, typhoons, cyclones | 2013-2022 | 40.0% | 60.0% |
| Floods | 2013-2022 | 19.4% | 80.6% |
| Total climate events | 2012-2021 | 40.7% | 59.3% |
| Earthquakes | 2012-2021 | 14.7% | 85.3% |
| Total natural disasters | 2012-2021 | 38.7% | 61.3% |

Source: MAPFRE Economics (based on Swiss Re data)

natural disasters related to climate events (excluding those related to geological events), there is a pattern of behavior similar to the trend seen for natural disasters as a whole, with large annual variations and an underlying upward trend (see Chart 2.2-b).

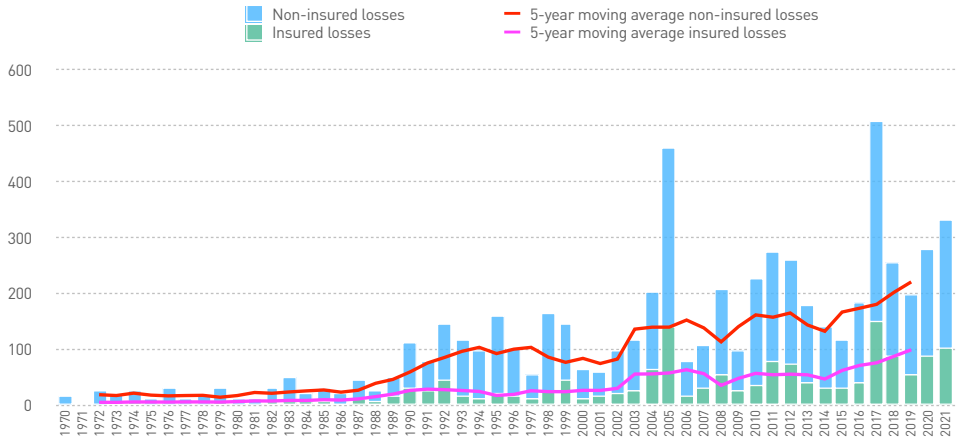
## Protection gaps for climate-related catastrophic events

### Tropical cyclones, typhoons, and hurricanes

Natural disasters caused by rotating storm systems (tropical cyclones, typhoons, and hurricanes) with extremely strong winds, torrential rainfall, and sometimes accompanied by severe flooding, have a high destructive potential, making them among the costliest natural disasters on record on aggregate. In this regard, according to Swiss Re estimates, hurricanes caused estimated economic losses of 899 billion dollars between 2013 and 2022, of which only 360 billion dollars were covered by insurance, representing insurance coverage of 40.0% of total economic losses (see Chart 2.2-c). Expanding the period from 2000 to 2024, Aon places estimated aggregate losses at 2.3 trillion dollars.[44]

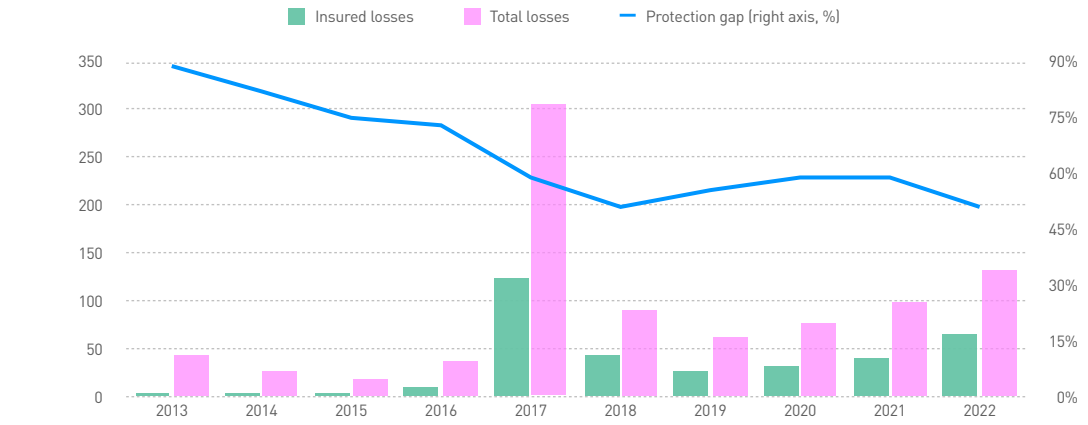
This relatively high protection rate can generally be attributed to the fact that many of these events occur in the United States, a country where insurance penetration is relatively high. However, this still means that

Chart 2.2-b
Global: catastrophic losses by climate-related event
(billions of USD, amount at constant prices in 2021)




Source: Swiss Re Institute

Chart 2.2-c
Global: insured and total losses caused by tropical cyclones and protection gap
(billions of USD)



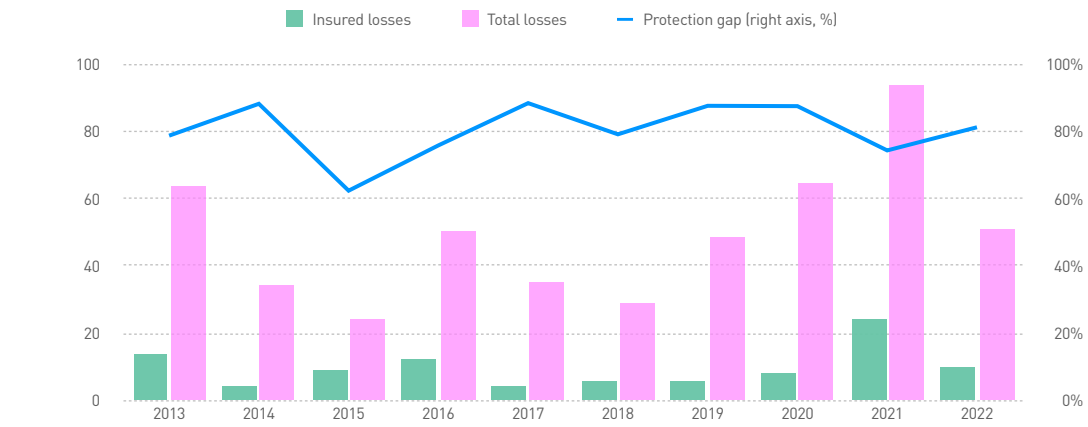

Source: Swiss Re

60% of economic losses from these types of events are uninsured. From the information indicated above, 2017 is worth particular note, as economic losses, both total and insured, were more than double the losses recorded in other years on record. That year saw the convergence of two of the most damaging hurricanes in history (excluding Hurricane Katrina in 2005, which holds the absolute record with 218 billion dollars in losses, 46.8% of which were insured): Hurricane Irma, with 112 billion dollars in total losses, of which 43 billion were insured (38.4%), and Hurricane Harvey, with 93 billion dollars in total losses, of which 37 billion were insured (39.8%).[45]

## Flooding

Flooding represents the natural threat affecting the largest number of people globally. It is estimated that approximately 29% of the world's population lives in areas exposed to this risk. According to records

Chart 2.2-d
Global: global losses due to floods (2013-2022)
(billions of USD)




Source: Swiss Re

from the Swiss Re Institute, these events have been responsible for more than one-third of all deaths linked to natural disasters since 2011, making them the most recurrent phenomenon among these types of hazards. To illustrate just how prevalent they are, over the past 15 years, floods have been recorded three times more than tropical cyclones, and 1.2 times more than severe convective storms (SCS), highlighting their persistent occurrence and the challenge they pose to global risk management.

Over the 2013-2022 period, flooding generated approximately 496 billion dollars in damages, with an insurance coverage gap of 80.6% (see Chart 2.2-d); when expanding the period from 2000 to 2024, Aon estimates that these aggregate losses come to 1.9 trillion dollars.[46] The 2011 floods in Thailand is a case in point: they caused 61 billion dollars in total losses, of which only 20 billion was covered by insurance, equivalent to a gap of 67.2%. It is worth noting that insured expenses and the protection gap as the percentage of expenses generated by hurricane claims not covered by insurance decreased between 2013 (88.9%) and 2022 (51.1%).[47]

In short, losses caused by flooding have been on an upward trend worldwide, increasing at a significantly faster rate than global GDP. The protection gap (difference between insured losses and total losses caused by flooding) has grown over the past decade, although in percentage terms, 2015 (62.5%) and 2021 (74.5%) are worth particular note as they fall below the average of 80.5%. In some countries, flood insurance has often been considered part of government programs, in part because of the potential cost associated with this hazard and the difficulty of modeling said cost. However, the insurance industry, including the growing private flood insurance market, has an increasingly important role to play in supporting society's resilience to the evolving flood risk landscape.

# 3. Analysis of protection mechanisms against natural disasters

To provide a general overview of the different disaster protection mechanisms at the global level, the following section analyzes the solutions adopted in a selection of countries from various world regions. It is important to note that this review focuses on the consequences of adverse catastrophic weather, although it also references protection systems for other types of catastrophic phenomena, all within a selected group of countries. Additionally, although relatively uncommon, the second part of this section refers to certain regional solutions that have emerged at the supranational level, encompassing several countries, in an attempt to increase, within certain thresholds, the geographical pooling of catastrophic risks.

## 3.1 Analysis of systems in selected countries

### United States

In the United States, standard homeowner and renter policies, as well as most commercial property insurance policies, cover losses or damages caused by a variety of perils, including those linked to natural disasters, except for flooding and earthquake losses, which require separate coverage. Flooding is covered by standard automobile insurance policies, as well as by some specialty commercial insurance policies, and most notably by the National Flood Insurance Program (NFIP). Earthquake risk, for its part, is excluded from standard home or business insurance policies, although it can be taken out as an addendum or through separate policies. Mudflows are covered under flood insurance and excluded from standard homeowner and business insurance policies. Landslides are also excluded from standard insurance policies, but may be covered by what is known as a "Difference in Conditions" policy, which generally offers comprehensive coverage for landslides, mudflows, earthquakes, and flooding, and is marketed by surplus line insurers.

Flood insurance is not required for most homeowners in the United States, although it is for those with government-backed mortgages in Special Flood Hazard Areas (SFHAs), defined as areas with an annual flood risk of 1% or more. Under the NFIP, the federal government provides flood insurance coverage, offering flood risk insurance policies to homeowners, renters, and businesses. As a result, a suitable alternative to the lack of insurance coverage is offered in many states. The NFIP was established by the 1968 National Flood Insurance Act and is administered by the Federal Emergency Management Agency (FEMA) through the Federal Insurance and Mitigation Administration (FIMA). The U.S. Congress must periodically renew the NFIP's statutory authority to operate. In December 2024, President Biden signed legislation passed by Congress extending the NFIP's authorization through March 14, 2025.

Among the amendments to the Act, the Biggert-Waters Flood Insurance Reform Act (Biggert-Waters Act) was enacted in 2012. This established measures including but not limited to regulated lending institutions being required to accept private flood insurance policies, which could previously only be purchased through the NFIP. Coverage under this policy had to be at least as broad as the cover provided under a standard flood insurance policy (SFIP). After a series of modifications, regulators announced a final rule implementing the requirement in February 2019. The rule allows these institutions to accept an insurer's guarantees

contained in a private flood insurance policy that the criteria are met, clarifying that institutions may, under certain conditions, accept private flood insurance policies that do not meet the Biggert-Waters Act criteria.

Private insurers play an important role in administering the NFIP through the Write-Your-Own (WYO) program, in which private insurance companies are paid to issue and service NFIP policies, while retaining the financial risk of paying claims on these policies. It should be noted that relatively few private insurers compete with the NFIP in the primary residential flood insurance market, although their interest has recently increased.

The NFIP has three types of standard flood insurance policies (Dwelling, General Property, and Residential Condominium Building Association policies), which have maximum coverage limits established by law. Insurance policies are sold and serviced by a network of more than 50 insurance companies and NFIP Direct, and can cover the building, the contents, or both. FEMA administers a Risk Mapping, Assessment, and Planning (Risk MAP) process to produce Flood Insurance Rate Maps (FIRMs), which reflect the Special Flood Hazard Areas. Communities are not legally required to participate in the NFIP, and their participation is based on an agreement between local communities and the federal government, whereby the latter provides insurance coverage for flood damage in exchange for the communities adopting appropriate floodplain management measures to reduce their vulnerability to this risk in Special Flood Hazard Areas.

The NFIP receives financing through four sources: (i) premiums (rates and surcharges paid by NFIP policyholders); (ii) annual appropriations for flood hazard mapping and risk analysis; (iii) treasury loans when the National Flood Insurance Fund balance is insufficient to pay NFIP obligations; and (iv) reinsurance, in the event that NFIP losses are sufficiently large.

On the other hand, in some areas of the United States where private insurance is unavailable or too expensive, homeowners can take out an insurance plan on what is known as the *residual market*. A last resort insurer is an insurance plan designed by a government to cover gaps in the private property insurance market. They typically offer coverage to homeowners and renters who are unable to find private coverage or who find it too expensive because their properties are located in a high-risk area. However, just because a state-sponsored insurer is a last resort, this doesn't mean it has to accept all applicants. In the United States, this market comprises the Fair Access to Insurance Requirements (FAIR), the Beach and Windstorm Plans, and two state insurance companies: Florida Citizens Property Insurance Company (Florida Citizens) and Louisiana Citizens Property Insurance Corporation (Louisiana Citizens). FAIR Plans typically provide property insurance in both urban and coastal areas, while Beach and Windstorm Plans predominantly cover only wind risks in designated coastal areas. Hybrid plans, like those in Florida and Louisiana, provide statewide property insurance.

A FAIR plan is a high-risk homeowner insurance program. Although created for a different purpose, over time, in many states, these residual market plans have evolved to provide insurance for homeowners who do not qualify in the standard market. All private insurers authorized to operate in states with FAIR plans contribute to them financially. In this regard, each insurer shares the profits, losses, and expenses of the FAIR plan proportionate to its market share in the state in question. As far as actual coverage goes, homeowner insurance through a FAIR plan is quite limited. Beach and Windstorm Plans, on the other hand, are state-sponsored insurance funds that are very similar to FAIR plans; they provide last-resort insurance coverage to homeowners whose properties are located in high-risk coastal communities, particularly those along the Atlantic and Gulf of Mexico coasts.

Another government institution that provides insurance coverage in the event of a natural disaster is the California Earthquake Authority (CEA). This publicly managed, privately funded, non-profit organization offers residential earthquake insurance. Since the 1980s, a state law in California has required homeowner insurance companies to offer earthquake coverage to residential customers, although consumers are not obliged to purchase it. Commercial earthquake insurance does not have a mandatory offer scheme similar to that of homeowners insurance, and commercial earthquake insurance rates are not regulated. After the 1994 Northridge earthquake, which struck Southern California's San Fernando Valley, causing a high volume of insured losses, California insurance companies drastically reduced the issuance of new policies statewide or stopped issuing them altogether, raising fears that insurance-dependent operations, such as home sales, would soon be affected. These concerns led the California Insurance Commissioner to propose the creation of the CEA, which began operations in 1996. Created with an unusually high degree of independence and autonomy for a government-affiliated entity, the CEA has no financial ties to, nor does it receive funding or any other financial support from, the United States federal government or the government of California. By law, the CEA must maintain actuarially sound rates, meaning the full cost of insurance must be recovered through the premiums collected.

A similar case occurred in Florida in 1992 following Hurricane Andrew. Fearing that the home insurance market would be short of coverage following the massive losses recorded, regulations were enacted establishing a moratorium on policy cancellations. Subsequently, with a view to increasing the possibilities of acquiring home insurance in Florida, the Florida Hurricane Catastrophe Fund (FHCF) was set up in late 1993. This tax-exempt state trust fund reimburses residential property insurance companies for a portion of their catastrophic hurricane losses in Florida. The FHCF is managed and overseen by the State Board of Administration and operates exclusively for the purpose of protecting and promoting the state's interest in maintaining insurance capacity in Florida. Participation in the FHCF is mandatory for all residential property insurance companies operating in Florida, and each company must enter into a reimbursement contract with the FHCF. The coverage provided is similar to private reinsurance (although with several significant differences), although at a lower cost than prices on the private market. The FHCF is designed to be self-supporting (except in extraordinary circumstances) and funded solely by revenue from premiums paid by residential property insurance companies, investment income, and, in certain cases, revenue bonds backed by emergency appraisals on most types of property and casualty insurance premiums.[48]

Finally, the federal government also provides assistance to communities and households to help them recover from disasters. This includes providing funds to meet the immediate needs of people in an affected community, as well as to repair and improve infrastructure to make future disasters less costly. The largest source of federal financial assistance to respond to disasters is the Disaster Relief Fund (DRF), managed by the Federal Emergency Management Agency. It is the primary source of funding for the federal government's general disaster relief programs, supporting state, local, tribal, and territorial governments in their response to and recovery from a variety of incidents, and becoming involved when non-federal levels of government are overwhelmed by an event.

## Mexico

The federal government of Mexico established the Natural Disaster Fund (FONDEN) in 1996, with the purpose of supporting emergency, recovery, and reconstruction activities after a disaster occurs. FONDEN's initial objective was to ensure the availability of funds immediately after the occurrence of a natural disaster to finance the reconstruction of public infrastructure and housing for low-income populations, without compromising existing budgets or approved public programs. Since then, FONDEN has evolved significantly. In 2005, with a view to increasing the fund's coverage, the federal government granted it the authority to develop a catastrophic risk coverage strategy, which included financial instruments and/or mechanisms for risk retention and transfer. In 2006, Mexico issued the world's first sovereign catastrophe bond, which has been renewed in successive periods. However, on November 6, 2020, the Official Journal of the Federation reported the dissolution of 109 national trusts, including FONDEN, which is in the process of being wound up.

Currently, Mexico has the Program for the Natural Disaster Fund, which emerged as a replacement for FONDEN and whose main goal is to implement programs and projects aimed at mitigating damage caused by natural phenomena. The country has insurance coverage for damages caused by natural phenomena (catastrophe insurance), valid from July 5, 2024, to July 5, 2025. This coverage comes to 5 billion pesos, with operational deductibles that vary by sector and an aggregate annual deductible of 750 million pesos. It also has 595 million dollars in financial protection against losses from earthquakes and hurricanes through four classes of catastrophe bonds from the International Bank for Reconstruction and Development, valid from 2024 to 2028.[49]

Mexico is located in one of the most seismically active regions in the world: the Circum-Pacific Belt, which concentrates the highest level of seismic activity on the planet. At present, Mexico is divided into four seismic zones (A, B, C, and D), which have different levels of catastrophic exposure depending on the characteristics of the soil and subsoil in each region. Seismic gaps represent critical areas within Mexico's broader seismic zones. These are segments of tectonic faults where no major earthquake has occurred an extended period, indicating the buildup of tension that may ultimately be released in the form of an earthquake. The seismic gaps in Guerrero, Jalisco, and Chiapas are currently regarded as the highest-risk areas in the country. Although Mexico City is officially classified as being in Zone B, the particular conditions of the Valley of Mexico's subsoil mean the city is effectively treated as a distinct seismic zone. Within this area, three sub-zones are identified based on soil type: zone I, hills (earthquakes of a short duration), zone II, transition (intermediate soil between hard and soft), and zone III, lake (soft soil, favors prolonged earthquakes).

In Mexico, homeowners can take out catastrophic coverage as an add-on to their standard home insurance policy. This additional protection covers events such as earthquakes, volcanic eruptions, and hydro-meteorological phenomena. Some policies also include coverage for business interruption, debris removal, and extraordinary expenses. The factors considered when pricing the earthquake risk premium include: the type of house, its age, the nature of the soil, and its proximity to known geological faults. Most policies apply a deductible as a percentage of the insured amount.

## Brazil

Insurance protection against severe climate risks in Brazil can be achieved by adding specific coverages to property insurance policies. Home insurance protects buildings and their contents against a variety of risks, including fire, theft, explosion, and electrical damage; additional coverage can also be

taken out for windstorms, hailstorms, floods, and landslides. Most automobile insurance policies contain comprehensive coverage, meaning they offer coverage for damages from natural causes. For small business insurance, the most common coverage includes losses caused by fire, lightning and explosion. Coverage against severe climate risks can be added separately, for example for damage caused by strong winds and hailstorms.[50]

Agricultural insurance is the most developed segment in the Brazilian catastrophe insurance market, receiving support in the form of subsidies from the Brazilian government. The Rural Insurance Stability Fund (FESR) protects rural producers against the negative impacts of extreme weather events and natural disasters. In relation to agricultural, livestock, aquaculture and forestry insurance, local insurance and reinsurance companies can recover from the Fund the portion of their retained claims between 100% and 150% of loss ratios, as well as amounts exceeding 250%, while covering losses between 150% and 250% through reinsurance contracts.[51] Furthermore, in 2003, the government established the Rural Insurance Premium Subsidy Program through Act No. 10,823/2003, regulated by Decree No. 5,121/2004. Through this regulation, the federal government subsidizes part of the value of the agricultural insurance premium, making it more affordable for producers.

Aside from these measures, Brazil currently lacks an integrated catastrophic risk management and financing mechanism, meaning the government often relies on disaster relief programs to provide urgent assistance to vulnerable populations. In this regard, worth particular mention is the National Fund for Public Disasters, Protection, and Civil Defense (Funcap), initially known as the Special Fund for Public Calamities. Its aim is to ensure resources and facilitate transfers to prevent, assist, and rebuild cities and states after disasters. Although the fund has existed since 2012, following a variety of legislative changes, the regulations for the mechanism to effectively function are still pending approval.

## United Kingdom

In the United Kingdom, coverage for natural risks is provided by private insurance companies, which generally include it within the basic guarantees of commercial and home insurance policies. Flood coverage is a special case, as the most common and costly natural disaster faced by private insurers in the UK. Flood insurance is voluntary, although homeowners with a mortgage are required to purchase building insurance that includes flood coverage. In response to the growing increase in flood losses across the country, and to ensure that homeowners and small businesses could obtain affordable flood insurance, an agreement was reached between the Government and the Association of British Insurers (ABI) in 2000, known as the "Statement of Principles." This guaranteed that ABI members would offer flood coverage as part of a standard policy for households and SMEs, up to a certain risk level, and the Government committed to continue investing in flood risk mitigation. This agreement, which was intended to be temporary, was renewed in June 2008 and expired in June 2013. Subsequently, following the approval of the 2014 Water Act, the Flood Reinsurance Plan (Flood Re) was created.

Flood Re manages the Flood Reinsurance Scheme and is primarily engaged in providing reinsurance coverage against flood risks in the United Kingdom. This joint initiative between the Government and the insurance industry is aimed at promoting the availability and affordability of flood insurance for eligible households as well as managing, over its lifetime, the transition to risk-reflective pricing for home flood insurance. To this end, Flood Re offers reinsurance coverage at a subsidized fixed rate to ceding companies. Flood Re is a temporary scheme scheduled to exit the

market by 2039. It must be reviewed at least once every five years during its term and report its findings to the Secretary of State. The ultimate goal is to create a home insurance market with affordable premiums that reflect the level of risk, with accessible and widely available flood insurance for homes.

When Flood Re accepts a flood risk, it charges the insurer a fixed premium based on the property's council tax band. A standard excess of 250 pounds also applies to each policy. In addition to premiums and excess, it collects an annual surcharge from all insurers offering home insurance in the UK. For the year ending March 31, 2024, the annual surcharge was 135 million pounds, used to pay claims and manage Flood Re. The surcharge also funds the purchase of an external reinsurance program to protect the company, up to a maximum liability limit of 2.1 billion pounds in 2024. Policy pricing, excesses, and terms are set by the insurers, which maintain a direct relationship with their customers, who pay premiums and submit claims directly to the insurer.

Flood Re is only intended to cover properties at the highest flood risk. Policies ceded to Flood Re must meet certain eligibility criteria. Most homes in high-risk flood areas are eligible for Flood Re, but some exclusions apply. For example, properties built after January 1, 2009, are excluded to avoid incentivizing construction in flood risk areas. Businesses and commercial properties are also excluded; the challenges faced by small businesses obtaining flood coverage are considered nationally much lower and of a different nature than those for homes.

Aside from natural catastrophic risks, the UK also has a system covering another type of catastrophic political-social event: terrorism. Terrorism insurance is provided through Pool Reinsurance Company (Pool Re), a mutual established in 1993 as a public-private response to restrictions on terrorism reinsurance coverage in the UK commercial property insurance market. This followed a series of terrorist attacks that led reinsurers to withdraw from the terrorism insurance market. Any insurer licensed to insure commercial property in Great Britain can apply to become a member of Pool Re, and the vast majority of Lloyd's insurers and syndicates operating in the commercial property market are members. Pool Re's mission is to ensure that all businesses in Great Britain can access affordable and comprehensive terrorism insurance, building confidence and resilience in the British economy and insulating the taxpayer from the financial impacts of catastrophic terrorist attacks.[52]

Pool Re offers commercial property reinsurance coverage for losses caused by terrorism in policies written on an "all risks" basis, including chemical, biological, radiological, and nuclear (CBRN) damage, as well as damage caused by remote digital interference and business interruption without physical damage. This applies to properties in England, Scotland, and Wales, but excludes Northern Ireland, the Isle of Man, and the Channel Islands. Terrorism coverage can only be purchased together with a commercial property insurance policy. All claims, whether for damage or terrorism, are handled by the underlying insurer that is a member of the scheme. The scheme is backed by a commitment from HM Treasury to support Pool Re if it ever lacks sufficient funds to pay a claim.

It should be noted that there is an agreed process for HM Treasury to certify an event as an act of terrorism. In the event of claims resulting from an act of terrorism certified by HM Treasury, Pool Re member insurers must first pay losses up to a predetermined threshold (retention). Only when losses have exceeded that threshold can member insurers claim from Pool Re's reserves, and Pool Re would only call on government guarantees if reserves and commercial reinsurance are exhausted. This situation has not yet occurred in the

company's history. The Retrocession Agreement with HM Treasury explains how the government will step in to pay claims in full if Pool Re's funds prove insufficient. Pool Re pays a premium to HM Treasury for its guaranteed support, along with Corporation Tax on the profits generated by its mutual fund.

## Spain

In Spain, there are two organizations responsible for managing extreme weather insurance: the Insurance Compensation Consortium (*Consorcio de Compensación de Seguros*, CCS) for private and commercial property, and Agroseguro for agricultural insurance. The CCS covers catastrophic risks through a public-private insurance system in which private insurers collaborate in the management of the system. The Spanish Combined Agrarian Insurance System is configured as a system of coverage for damages caused to agricultural, livestock, aquaculture, and forestry productions, to cover them against damages caused by unforeseeable, uncontrollable risks and catastrophic consequences. The insurance companies are grouped together to manage the risk in a coinsurance pool (Agroseguro) where state and autonomous community administrations subsidize part of the premium and the CCS acts as direct insurer and mandatory and non-exclusive reinsurer (see Box 3.1).

The CCS is a public business entity attached to the Ministry of Economy, Trade, and Enterprise, through the General Directorate for Insurance and Pension Funds. The CCS' objective in covering extraordinary risks is to indemnify, under a compensation system and on the basis of a policy contracted with any private company in the market, claims arising from extraordinary events occurring in Spain and causing damage to persons and property located in Spanish territory. However, damage to persons due to events occurring abroad is also covered, provided that the policyholder's primary residence is in Spain. Compensation is only granted when, in the event of an extraordinary occurrence covered by the system, the affected party holds an insurance policy, taken out with a private entity in the market, in the following lines: fires and natural events, land vehicles, third-party liability involving land motor vehicles (mandatory insurance), railway vehicles, other property damage (theft, broken glass, damage to machinery, electronic equipment and computers), various pecuniary losses and, in personal insurance, the Life and accident lines (even if these coverages are taken out in addition to another type of insurance or within the framework of a pension plan). The CCS assumes this compensatory mission when the extraordinary risk is not specifically and explicitly covered by the insurance policy taken out with the insurance company or, when covered by an insurance contract for damages arising from extraordinary events, the obligations of the insurance company issuing said policy cannot be fulfilled due to it having been declared bankrupt or insolvent and being subject to court-ordered liquidation. However, the CCS warns that, to date, cases of insurance policies covering extraordinary risks by private insurance companies are truly exceptional.

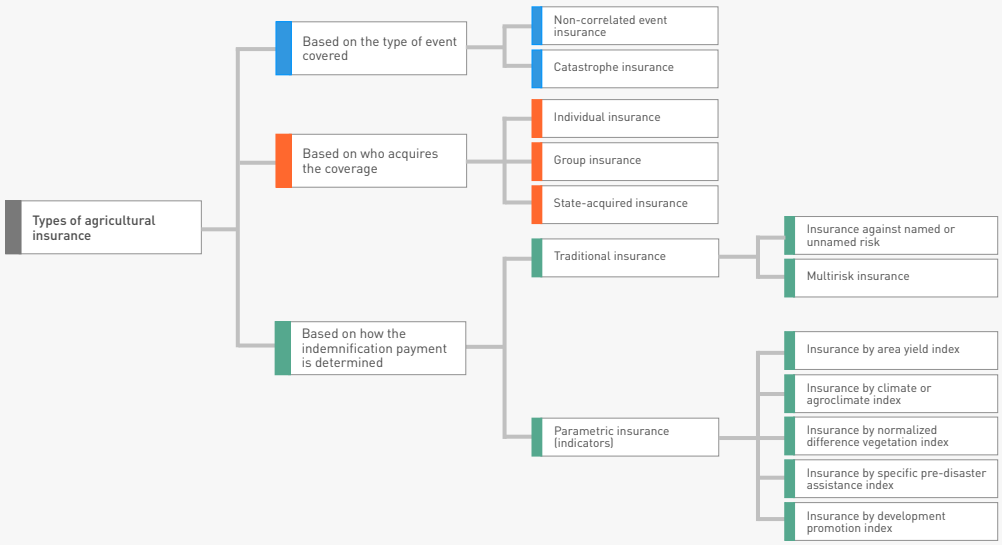
Taking out an insurance policy in any of the aforementioned lines automatically includes coverage for extraordinary risks; this coverage will cover the same property or persons and for the same insured amounts specified in the policy. To be eligible for compensation, an official declaration of a disaster or disaster area is not required once any of the risks covered by the system have occurred: (i) natural hazards: earthquakes, tidal waves, or tsunamis, extraordinary floods, volcanic eruptions, atypical cyclonic storms (including tornadoes and winds with gusts in excess of 120 km/h), and falling space debris or aerolites; (ii) violent events resulting from: terrorism, rebellion, sedition, riot, civil unrest; and (iii) events or actions of the Armed Forces or Security Forces and Corps in peacetime.

## Box 3.1
## Coverage of extraordinary risks for agriculture

Catastrophic risks stemming from natural phenomena that affect the agricultural sector often receive special treatment, with coverage provided through schemes specifically designed for them, normally within the framework of each country's agricultural policy. This policy often encompasses all public policy measures related to that sector, with catastrophic risk coverage being one of its components. The UN Food and Agriculture Organization (FAO), in its report "The Impact of Disasters on Agriculture and Food Security,"[1] points out how the increase in natural disasters (including but not limited to flooding, storms, droughts and frosts) is increasingly affecting the global population, recording losses in agricultural and livestock production amounting to 3.8 trillion dollars over the last 30 years. In this context, the agricultural sector is one of the most affected, as it depends directly on natural resources and weather conditions for its survival.

It is difficult to predict exactly when events such as flooding, frost, fires, or torrential rains will occur, but preventive and mitigation measures can be taken to prepare for such events. The insurance industry plays a key role in designing protection mechanisms against catastrophic risks caused by adverse weather, enabling compensation for lost crops and the development of agricultural insurance schemes focused on prevention and risk management—thus ensuring the continuity of agricultural operations. Given the magnitude of the impact of such events, in early 2024, the World Bank[2] proposed a series of measures to support countries affected by the impacts of natural disasters, such as: suspending debt payments to allow countries to focus on what matters, without worrying about repayment; giving countries greater flexibility to quickly redirect a portion of their funds toward emergency response, providing immediate access to cash; helping governments

Chart A.
Types of agricultural insurance




Source: MAPFRE Economics (with data from FAO)

1/ See: https://openknowledge.fao.org/server/api/core/bitstreams/79e51aaf-7f9a-426c-9146-d661a057aeb1/content
2/ See: https://www.bancomundial.org/es/topic/disasterriskmanagement/overview

**Box 3.1 (continued)**
**Coverage of extraordinary risks for agriculture**

establish advanced emergency systems so they are ready to respond from day one; offering new types of insurance to support development projects and allow work to be resumed quickly; and creating better catastrophe insurance to provide resources without increasing debt.[3]

There is a wide range of models for covering extraordinary agricultural risks, combining various tools, such as specific insurance funds and different types of agricultural insurance (see Chart A),[4] with subsidized insurance premiums to make coverage more accessible to farmers, and risk zoning to identify areas with the highest climate risk—thus guiding crop planning and insurance design. The most appropriate model depends on the specific characteristics of the country, the type of agriculture, the most common risks, and farmers' ability to afford insurance costs.

In conclusion, and as a general rule, the introduction of agricultural insurance is essential for the sound development of the primary sector. It is usually managed jointly through public-private partnerships, with the aim of protecting against losses caused by natural disasters.[5] Below is a summary of some models for extraordinary agricultural risk coverage that can be used as a reference for the design of public policies.

**United States**

In the United States, there is a public corporation, the Federal Crop Insurance Corporation (FCIC), which promotes agricultural stability through an integrated crop insurance system.[6] This public corporation is administered by the Risk Management Agency (RMA) of the United States Department of Agriculture (USDA). The system has been set up as a public-private partnership in which the RMA manages Federal Crop Insurance together with *approved insurance providers*[7] (AIP), which offer and service crop insurance policies across all states and in Puerto Rico. In turn, the RMA supports AIPs that share the risks associated with catastrophic losses caused by climatic events,[8] increasing the availability and effectiveness of agricultural insurance.

A wide variety of products are marketed under the Federal Crop Insurance Program, including:

- *Multi-Peril Crop Insurance* (MPCI). This is probably the best known type of crop insurance. It is backed and regulated by the federal government and offers broad coverage for more than 120 different crops.[9]

- *Yield Protection Insurance*. Provides coverage against losses caused by phenomena such as drought, excessive humidity, hail, wind, frost, insect damage, and disease. The guarantee is based on the farmer's own historical average yield, depending on the crop grown on the insured plot.

- *Revenue Protection Insurance.*[10] This guarantee is also based on the farmer's historical yields; however, unlike Yield Protection Insurance, this insurance

3/ See: https://www.bancomundial.org/es/news/factsheet/2023/06/22/comprehensive-toolkit-to-support-countries-after-natural-disasters

4/ See: https://blog.iica.int/blog/cultivando-seguridad-financiera-papel-los-seguros-agricolas-en-america-latina-caribe

5/ See: https://www.transparenciapresupuestaria.gob.mx/work/models/PTP/Reingenieria_Gasto/imagenes/Ventanas/Ramo_6/06S265.pdf

6/ See: https://www.rma.usda.gov/about-rma/fcic

7/ AIPs are property and casualty insurance companies established in a state that have entered into a Standard Reinsurance Agreement (SRA) and/or a Livestock Price Reinsurance Agreement (LPRA) with the Federal Crop Insurance Corporation (FCIC). As part of the SRA, these companies are authorized to sell and service federal crop insurance regulated by the USDA. See: https://cropinsuranceinamerica.org/who-are-approved-insurance-providers-aips/

8/ See: https://www.usda.gov/es/about-usda/general-information/initiatives-and-highlighted-programs/usda-cares-partner-portal/key-programs-catalog/key-programs-individuals/programa-federal-de-seguro-de-cultivos#:~:text=La%20Corporaci%C3%B3n%20Federal%20de%20Seguros,naturales%20o%20ca%C3%ADda%20de%20precios.

9/ See: https://www.worldinsurance.com/blog/how-does-crop-insurance-work

10/ See: https://www.extension.iastate.edu/agdm/crops/html/a1-54.html

**Box 3.1 (continued)**
**Coverage of extraordinary risks for agriculture**

protects the farmer from drops in both crop prices and yields. The guarantee is based on market prices and the actual performance of their farm.

- *Area Risk Protection Insurance and Area Revenue Protection Insurance*. This coverage is based on the overall performance of a farmer's region, rather than their individual experience.
- *Adjusted Gross Revenue (AGR) and Adjusted Gross Revenue Lite (AGR-Lite) Insurance Programs*. These programs determine the guarantee based on the farmer's average historical income over a five-year period, as reported in their federal tax returns. The indemnity is based on the difference between the guaranteed amount and the farmer's actual income during that year. These programs are available to farmers who wish to insure multiple crops along with livestock and animal products, some of which are not insurable through other forms of coverage.
- *Rainfall and Vegetation Index Insurance Programs*. These programs provide indirect protection for livestock forage, compensating the farmer for lack of rainfall and insufficient pasture vegetation in a given region, using local weather stations or satellite data. Other programs insure trees that produce citrus and similar crops, in addition to insuring the crop itself.[11]

**Mexico**

Mexico is one of the countries most vulnerable to natural disasters.[12] Protection for agricultural activity against extreme weather events began in 1961 with the creation of the National Agricultural and Livestock Insurance Company (*Aseguradora Nacional Agrícola y Ganadera*, ANAGSA). The initiative was designed to stimulate direct, individual insurance by subsidizing the premiums paid by producers and making insurance a requirement for obtaining credit. The goal was to protect both the producer's investment and to promote and secure agricultural credit.[13].

However, this system proved unsustainable due factors including the high cost of subsidies. It was therefore shut down in 1990, and the decision was made to create Agroasemex, S.A., a national insurance institution responsible for protecting the assets and productive capacity of the rural sector by developing insurance products tailored to the sector's needs. This agency is regulated by the Law of Insurance and Bonding Institutions, the Law on Insurance Contracts, the Organic Law of the Federal Public Administration, and the Federal Law of State-Owned Entities and its regulations.[14] The actions and programs run by Agroasemex include Catastrophic Agricultural Insurance,[15] of which there are two types: (i) *Parametric Catastrophic Agricultural Insurance*, which relies on weather stations that track rainfall and daily temperatures to determine the required values for crops, and (ii) *Catastrophic Agricultural Insurance with On-Site Assessment*, which involves physical inspections of risk units to assess possible crop damage. This guarantees an average yield weighted by crop type, insurance modality, agricultural cycle, and municipality.

In addition, through the National Commission of Aquaculture and Fisheries[16] and subject to meeting certain sector-specific requirements,

11/ See: https://app.mapfre.com/mapfrere/docs/html/revistas/trebol/n65/es/articulo1.html

12/ To this end, consult the *WorldRiskReport 2023*, prepared by Ruhr University Bochum, at: https://weltrisikobericht.de/wp-content/uploads/2024/01/WorldRiskReport_2023_english_online.pdf

13/ See: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.transparenciapresupuestaria.gob.mx/work/models/PTP/Reingenieria_-Gasto/imagenes/Ventanas/Ramo_6/06S265.pdf

14/ See: https://www.gob.mx/agroasemex/que-hacemos

15/ See: https://www.gob.mx/agroasemex/acciones-y-programas/seguro-agricola-catastrofico

16/ See: https://www.conapesca.gob.mx/wb/cona/atencion_a_desastres_naturales_en_el_sector_agrope

**Box 3.1 (continued)**
**Coverage of extraordinary risks for agriculture**

support is provided to low-income rural, agricultural, fishing, and aquaculture producers who lack any public or private insurance and whose activities are affected by natural phenomena such as frost, torrential rains, tornadoes, or floods. Mexico also has a *catastrophe bond,*[17] a financial mechanism designed to provide protection against losses caused by natural disasters. Through this mechanism, affected populations can receive the necessary assistance in the event of such incidents. This bond is managed by the federal government in collaboration with the World Bank, allowing for the transfer of risks to the capital markets. Via the catastrophe bond, the Natural Disaster Fund receives the necessary capital to respond to unpredictable disasters, especially those whose magnitude exceeds the financial response capacity of federal agencies, state-owned entities, and regional governments.[18]

**Brazil**

In Brazil, agricultural insurance was first made available by the National Agricultural Insurance Company in 1954, which in turn created the Insurance Stabilization Fund, which would later become known as the Rural Insurance Stabilization Fund (1966), the purpose of which was to provide financial assistance to farmers.[19] In 1995, the National Program to Strengthen Family Farming (PRONAF) was created through the public budget. Its objective is to promote the sustainable development of rural areas through actions aimed at increasing production capacity, generating jobs, and increasing income, thereby improving the quality of life and the ability of family farmers to fully participate as active citizens. This program supports agricultural and non-agricultural activities carried out by family farmers on their own land or in nearby rural-urban areas, and it provides credit lines tailored to the needs of family farmers.[20]

PRONAF offers a "Harvest Guarantee" (*Garantia Safra*), whose purpose is to guarantee that, in case of severe climatic events such as drought or excessive water, farmers can receive benefits to help with their survival.[21] Other coverage to help mitigate these extraordinary risks is the Agricultural Activity Guarantee Program (*Programa de Garantia da Atividade Agropecuária*, Proagro), administered by the Central Bank.[22] It is primarily aimed at small and medium-sized producers, although it is open to everybody within the coverage limits established by the regulations. There are two available modalities: (i) *Proagro Mais*, providing assistance to family farmers in the National Program to Strengthen Family Agriculture (Pronaf), and (ii) *Proagro*, which provides assistance to all other farmers. This program is financed by resources from the federal government and by contributions paid by rural producers. It guarantees the repayment of rural agricultural financing when the covered crop experiences reduced income due to weather-related events or uncontrollable pests and diseases.[23] Currently, with support from the federal government, the Rural Insurance

17/ See: https://www.gob.mx/shcp/prensa/nota-informativa-349793
18/ See: https://www.gob.mx/segob/documentos/fideicomiso-fondo-de-desastres-naturales-fonden
19/ See: https://www.mapa.gob.es/es/enesa/publicaciones/19_presentacion_brasil_es_tcm30-130493.pdf
20/ See: https://opsaa.iica.int/initiative-1330-programa-nacional-de-fortalecimiento-de-la-agricultura-familiar-(pronaf)
https://conafer.org.br/es/pronaf/
21/ See: https://www.gov.br/pt-br/servicos/consultar-o-garantia-safra
22/ This program was created under Law 5,969/1973 and is governed by Law 8,171/1991, both regulated by Decree 175/1991 and by Federal Law 12,058/2009. Its rules are approved by the National Monetary Council (CMN) and codified in the Rural Credit Manual (MCR-16), published by the Central Bank of Brazil.
23/ See: https://www.gov.br/agricultura/pt-br/assuntos/riscos-seguro/programa-nacional-de-zoneamento-agricola-de-risco-climatico/proagro
https://www.bcb.gov.br/content/estabilidadefinanceira/proagro_docs/resumo_instrucoes_Proagro.pdf

## Box 3.1 (continued)
## Coverage of extraordinary risks for agriculture

Premium Subsidy Program (RSP), managed by the Ministry of Agriculture and Livestock, offers farmers the opportunity to insure their production at a reduced rate.[24] Additionally, a tool called ZARC (Agroclimatic Risk Zoning) was created to help farmers identify the best planting dates and areas least exposed to climate risks. Given its effectiveness, farmers must follow its recommendations in order to benefit from insurance coverage.[25]

Agricultural risk management also involves public institutions, which are responsible for initiatives including but not limited to the management of climate-related disasters, pests and diseases, and private institutions that are mainly tasked with addressing climate-related disasters through agricultural insurance.[26] Table A presents the agricultural risk management policies in Brazil, based on the summary prepared by the UN Food and Agriculture Organization (FAO) and the Inter-American

Table A.
Brazil: summary of agricultural risk-management instruments and programs

| | | |
|---|---|---|
| Instruments that consider the minimum price guarantee policy (PGPM) | Public market-directed intervention instruments | Federal government procurement (AGF) |
| | | Put option contract for agricultural products (COVPA) |
| | | Product flow premium (PEP) |
| | | Product flow value (VEP) |
| | | Financing for stock of agricultural products covered by the minimum price guarantee policy (FEPM) |
| | | Producer guarantee financing (FGPP) |
| | | Special financing for agricultural product stocks not covered by the PGPM (FEE) |
| | Public/private market intervention instruments | Risk premium for private option contracts (PROP) |
| | | Producer payment equalization premium (PEPRO) |
| Family farm marketing support instruments | | Family farm direct purchase (CDAF) |
| | | Family farm stock formation support (CPR-ESTOQUE) |
| | | Seed procurement (AS) |
| | | Simultaneous purchase and donation (CDS) |
| | | Institutional purchase under the family farm food acquisition program (CI) |
| Programs with compensation mechanisms similar to agricultural insurance | | Agricultural activity guarantee program (PROAGRO) |
| | | Agricultural activity guarantee program for family farms (PROAGRO MAIS, family farm insurance) |
| Agricultural insurance | | Cost-based agricultural insurance |
| | | Productivity or yield-based agricultural insurance |
| | | Agricultural income insurance |
| Other risk management programs in agriculture | | Rural insurance premium subsidy program (PSR) |
| | | Safra guarantee (GS) |
| | | Climate risk agricultural zoning (ZARC) |
| | | Family farm price guarantee program (PGPAF) |

Source: MAPFRE Economics (with information from the FAO and the Inter-American Institute for Cooperation on Agriculture, IICA)

24/ See: https://www.gov.br/agricultura/pt-br/assuntos/riscos-seguro/seguro-rural/seguro-rural
25/ See: https://www.mapa.gob.es/es/enesa/publicaciones/5_brasil_tcm30-661258.pdf?form=MG0AV3
26/ See: https://openknowledge.fao.org/server/api/core/bitstreams/5fdbb399-4dc7-4d02-a1e9-196a6414f3ba/content

**Box 3.1 (continued)**
**Coverage of extraordinary risks for agriculture**

Institute for Cooperation on Agriculture (IICA) in their study on integrated disaster risk management in the agricultural sector and food security in the countries who form part of the Southern Agricultural Council.

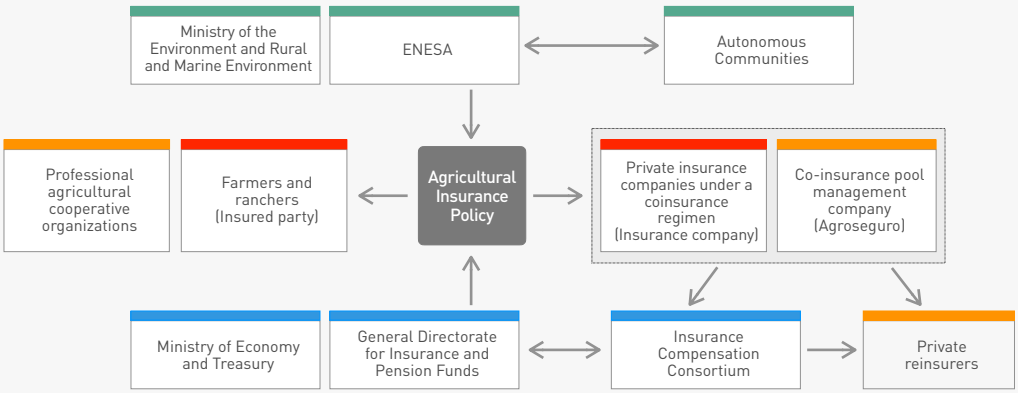
It is important to highlight that, following recent disasters in Brazil caused by extreme droughts, heavy rainfall and floods, high temperatures, etc., measures have been adopted to prevent and restore affected areas, assessing the methods used to recognize such disasters and the availability of resources for recovery. Additionally, a bill has been proposed to secure financial resources aimed at anticipating and responding to these tragedies caused by natural disasters.[27] Specifically, in response to the floods that occurred in southern Brazil, the Chamber of Deputies approved a bill in mid-2024 to forgive or postpone the repayment of rural financing installments taken out by companies located in towns and cities across Rio Grande do Sul.[28]

**Spain**

Coverage of catastrophic agricultural risks in Spain, including atmospheric phenomena (such as hail, fire, drought, frost, floods, hurricane-force winds or hot winds, snowfalls, frost, excess humidity, pests and diseases, and other adverse weather events),[29] is provided through the Agricultural Insurance system, which was constituted as a public-private partnership involving several public organizations and private insurers operating under a co-insurance system and with partially subsidized premiums (see Chart B).

As a result, various organizations are involved in the agricultural insurance system in Spain. Firstly, ENESA (*Entidad Estatal de Seguros Agrarios*, State Agricultural Insurance Entity), an autonomous body of the Ministry of Agriculture, Fisheries, and Food, is responsible for preparing and proposing the annual agricultural insurance plan to the government, controlling the

Chart B.
Spain: operational organizational chart of the Spanish Agricultural Insurance System




Source: MAPFRE Economics (with data from ENESA)

27/ See: https://www.synergiaconsultoria.com.br/es/fique-por-dentro/desastres-naturales/
28/ See: https://www.camara.leg.br/noticias/1075064-camara-aprova-projeto-que-perdoa-ou-adia-parcelas-de-emprestimos-rurais-no-rs
29/ See: https://www.consorseguros.es/documents/10184/13689/Ley_fundacional_Seguros_Agrarios/6dd8f43d-ba5d-41bf-b889-d93cd5d8412f

**Box 3.1 (continued)**
**Coverage of extraordinary risks for agriculture**

development of insurance plans, advising the agricultural sector on insurance matters, as well as other duties.[30] Alongside ENESA, Agroseguro (*Agrupación Española de Entidades Aseguradoras de los Seguros Agrarios Combinados, S.A.*) manages combined agricultural insurance on behalf of the insurers operating within the system (coinsurance pool). Its main activities include issuing invoices to policyholders and managing their collection, receiving claims reports from policyholders, and processing appraisals, valuations, and the payment of claims on behalf of co-insurers. In addition, Agroseguro undertakes tasks such as crop inspections and damage assessments for causes not covered by insurance, upon request from public administrations. It also provides technical assistance regarding the organization and management of agricultural insurance.[31] Agroseguro is a non-insurance private entity that operates within the public-private collaboration framework. While the majority of its share capital is owned by private insurers in the co-insurance pool, the Insurance Compensation Consortium is also a stakeholder.

The General Directorate for Insurance and Pension Funds, under the Ministry of Economy, also has an interest in the scheme. It is tasked with overseeing insurance activity and is responsible for approving the percentage of co-insurance distribution among the entities included in Agroseguro and, in cooperation with ENESA, setting the subsidy percentages for insurance costs and the loss adjustment rules. The Insurance Compensation Consortium[32], in turn, acts as the mandatory reinsurer of the system in the event of excessive claims, ensuring that damage assessments are carried out correctly. It also has an interest in the co-insurance scheme, assuming part of the risk of the Agricultural Insurance system. Finally, Spain's regional governments may grant subsidies to farmers and ranchers, in addition to those granted by ENESA.

30/ See: https://www.mapa.gob.es/es/enesa/publicaciones/37_folleto_esp_tcm30-130438.pdf?form=MG0AV3
https://www.mapa.gob.es/es/enesa/enesa/que_es_enesa/
31/ See: https://agroseguro.es/conocenos/quienes-somos/
https://agroseguro.es/conocenos/el-sistema-espanol-de-seguros-agrarios-combinados/
32/ See: https://www.consorseguros.es/ambitos-de-actividad/otras-actividades/seguros-agrarios-combinados/funciones-del-consorcio
https://adaptecca.es/casos-practicos/cobertura-de-riesgos-extraordinarios-derivables-del-cambio-climatico#:~:text=Los%20riesgos%20considerados%20%E2%80%9Cextraordinarios%E2%80%9D%20son,Ministerio%20de%20Econom%C3%ADa%20y%20Empresa

For the purposes of coverage by the CCS, flooding is understood as the inundation of land caused by the accumulation or runoff of rainwater or meltwater, or by water from lakes, rivers, or estuaries due to the overflow of their natural courses or channels. Storm surge on coastal areas is also covered, even in the absence of flooding. Therefore, the following do not fall under the definition of flooding: damage caused by rainfall, snow, or hail directly on the insured risk or collected on its roof or terrace, drainage system, or courtyards; water from dams, canals, sewers, manifolds, and other man-made underground channels, unless the damage or breakage of these structures was caused by an extraordinary event covered by the CCS. Regarding the scale and severity of damages, incidents classified by the Spanish Government as a "national catastrophe or calamity" due to their extreme magnitude are not covered. It should be noted that this scenario has never occurred in the history of the CCS. In the case of property, compensation includes direct property damage, as well as pecuniary losses resulting from such damage, provided these are covered under the ordinary insurance policy. As regards personal injury (Life, accidents), coverage extends to death, temporary disability, and permanent disability.

All insurance policies under these lines include a mandatory CCS surcharge (a fee on insured amounts), whether or not the policy stipulates that coverage of extraordinary risks will be provided by the company that issued the ordinary policy (in which case the CCS would be responsible for the coverage). The CCS surcharge is applied using its own rate schedule based on insured sums. This rate, which varies by the type of assets covered, is generally and uniformly applicable across Spain, regardless of the level of exposure, and for all types of risks included in the system. For property damage insurance, a deductible of 7% of the amount of compensable damage is charged to the insured. The deductible does not apply to personal insurance or to damages affecting vehicles insured under an automobile insurance policy. There is also no deductible for damage to residential properties or homeowners' associations. For business interruption coverage, the applicable deductible is the same as the deductible provided for in the ordinary policy.

## France

Natural disaster coverage in France is provided through two complementary mechanisms: on the one hand, property insurance contracts include coverage for insurable damages; on the other, non-insurable natural risks are covered under the country's natural catastrophe insurance scheme, known as "NatCat." This system was established by Law No. 82-600 of July 13, 1982, concerning compensation for victims of natural disasters, and is based on the principles of mandatory insurance and national solidarity. Under this law, the effects of natural disasters are considered to be direct, uninsurable property damage caused by the abnormal intensity of a natural agent. In the case of differential ground movement following droughts and soil rehydration, damages are also considered the result of a natural disaster when they stem from an abnormal succession of significant drought episodes and when usual preventive measures could not be taken or were insufficient to avoid the damage. The costs of emergency rehousing for disaster victims whose main residence is rendered uninhabitable for reasons of safety, health, or hygiene resulting from such direct uninsurable property damages are also considered to be the effects of natural disasters and covered by the associated guarantee scheme.[53] Natural catastrophe insurance is a mandatory guarantee extension applied to all property damage insurance policies (home multirisk, automobile all risk, business premises, etc.), with the exception of marine insurance contracts. Only property damage is covered, excluding personal injury.

Natural events generally covered by the natural catastrophe insurance policy include: flooding; phenomena related to sea action; droughts; landslides; avalanches; earthquakes; volcanic activity; cyclonic winds with speeds exceeding 145 km/h on average for 10 minutes, or 215 km/h in gusts. The system has an unlimited state guarantee through the Central Reinsurance Fund (*Caisse Centrale de Réassurance*, CCR). The Nat Cat system is a public-private partnership between insurers and the state. Insurers handle distribution of the guarantee and claims management, while the state, through the CCR, guarantees risk pooling and the solvency of the system. The CCR reinsures insurers who request reinsurance. For frequent events, it covers approximately 50% of the total claim amount, which can increase significantly in the case of exceptional incidents.

Funding for the system is provided through a surcharge (premium add-on) paid by all insured persons to their private insurer, regardless of their exposure to natural hazards. This surcharge is calculated by applying a single rate to all "property damage" insurance premiums set by the state: 12% of the premium for the guarantee of damages in basic contracts for property other than motor vehicles, and 6% of the premium for theft and fire (or, failing that,

0.50% of the premium for damage) for land motor vehicles. To restore the financial stability of the Nat Cat system, a decree was issued on December 22, 2023, increasing the natural disaster surcharge from 12% to 20% starting January 1, 2025, for households and businesses (from 6% to 9% for motor vehicles).

In the event of a claim, residents are required to contact their insurance company and the mayor of their town/city, who is responsible for submitting requests for recognition of a natural disaster. The insured will be compensated in the following cases: (i) if the mayor requests that the event be recognized as a natural disaster; (ii) if, following this request, a ministerial decree published in the Official Journal declares disaster status for the relevant risk; or (iii) if the insured's assets are covered by damage insurance (fire, theft, water damage, etc.). It should be noted that assets covered solely by a liability insurance contract are not insured under the natural disaster insurance policy. The ministerial decree specifies the municipalities and natural phenomena recognized, the recognition timelines, and the justifications for the decisions taken. Compensation is subject to a deductible regulated by the Insurance Code. A new deductible system came into force on January 1, 2024, and applies to new contracts entered into after that date. For contracts in force on that date, the new system will take effect upon their renewal.

Damage caused by violent winds that are not classed as cyclonic winds (thunderstorms, tornadoes), as well as damage caused by hail or heavy snow, are covered by other guarantees, which are mandatory in property damage insurance contracts. Weather events such as strong winds and storms are covered by the so-called TGN guarantee (storms, hail and snow). This guarantee covers damage caused by violent winds, hail, the weight of accumulated ice or snow, and even the infiltration of water caused by these phenomena. To activate this guarantee, no prior recognition by the state is required. It is implemented directly by the insurance companies. To qualify, the damage must have been caused by abnormally strong winds (usually more than 100 km/h). If winds reach the cyclonic wind threshold, compensation will be covered by natural disaster insurance.

## Germany

Extraordinary risk coverage in Germany is provided through private insurance, without no involvement from the state. Building and home contents insurance cover damage caused by storms (defined as wind speeds of Force 8 or higher, i.e., 62 km/h or more), hail, and lightning. For other natural hazards, such as flooding, backwater, earthquakes, or snowfall, policyholders must take out extended coverage, known as natural hazard insurance, which is offered as an optional add-on to building and/or home contents insurance. Acceptance of a natural hazard insurance application is based on the claims history of past years or decades and an assessment of the insurability of individual buildings, which is assessed using risk classes determined by the statistical frequency of flooding.

Since 2001, a flood zoning system known as ZÜRS Geo has been used in the German insurance market to assess risk. The information provided by ZÜRS Geo helps insurers calculate their natural hazard insurance premiums. Certain risk regions (so-called ZÜRS zones) are defined using a zoning system for flooding, standing water, and heavy rainfall. Depending on the level of flood risk, each area is assigned one of four hazard classes: Class 1 (based on current data, not affected by flooding from major bodies of water), Class 2 (flood risk less than once every 100 years, especially in areas that can also be flooded in the event of so-called "extreme floods"), Class 3 (statistically, a flood occurs once every 10 to 100 years), and Class 4 (statistically, a flood occurs at least once every 10 years).

## Turkey

The most common natural disasters in Turkey are not due to adverse weather conditions but to earthquakes, as the country is located at the intersection of several major seismic fault lines. Direct property and infrastructure losses caused by earthquakes have placed an enormous financial burden on the Turkish economy and government, with a heavy reliance on government budgets to fund the reconstruction of private property and infrastructure following major disasters. Following the massive losses caused by the 1999 Marmara earthquake, the government decided to develop a catastrophe insurance mechanism to reduce exposure to natural disasters, creating a mandatory earthquake insurance system in 2000 for all residential buildings located on registered land in urban areas. The World Bank provided financial and technical assistance to the Turkish Government to develop the Turkish Catastrophe Insurance Pool (TCIP).

The TCIP was established in 2000 by Legislative Decree No. 587 and incorporated into a legal framework with the Catastrophe Insurance Law No. 6305, which came into force in 2012. TCIP is a public, not-for-profit entity that provides compulsory earthquake insurance coverage at an affordable premium. The management of the TCIP's technical and operational processes is assigned for five-year mandates. Since 2020, Türk Reasürans, a company affiliated with the Ministry of Treasury and Finance, has served as the "technical operator" of the system. The institution's income comes from insurance and reinsurance premiums, commissions on reinsurance and retrocession operations, income from the institution's assets, and other income. If necessary to pay out claims, the TCIP may request loans, subject to Ministry approval, provided that the loan does not exceed the total amount of annual premium income.

Mandatory earthquake insurance provides financial security to insured property owners against earthquakes and any risks of fire, explosion, landslide, and tsunami caused by an earthquake. It is issued by the TCIP through direct sales or through licensed insurance companies and their agents acting on behalf of the institution. However, if the cost of rebuilding the insured sections or independent buildings under the mandatory earthquake insurance exceeds the coverage limit provided by the TCIP, homeowners may purchase an additional voluntary insurance policy to cover the amount exceeding the set limit. Starting January 1, 2024, the maximum guarantee that can be awarded for a home is 1,653,563 Turkish lira, regardless of the type of building.[54]

The insurance premium is calculated by multiplying the insured sum by the applicable rate established in the Compulsory Earthquake Insurance Tariff and Instructions. The insured amount is derived by multiplying the unit construction cost (per square meter) —which is updated annually based on building type—by the total built area of the residence. There are 14 distinct premium rates based on seven risk groups and two different building types (reinforced concrete and masonry). Risk groups are determined using Turkey's earthquake zone map, terrain conditions, and building characteristics. The Insurance and Private Pension Regulatory and Supervision Authority publishes an announcement once a year setting out the official tariff and instructions. Insurance premiums increase each year in parallel with rising unit costs per square meter, although the TCIP aims to keep premiums affordable for homeowners. A 2% deductible applies per claim, calculated as a percentage of the insured amount.

## Japan

In Japan, home insurance is operated under the name of fire insurance, although it covers more than just fire damage. It also includes damage caused by lightning, wind, floods, storms, explosions, snow, theft, falling objects

and external collisions, among the most important. Outside the insurance industry, the Act on Support for the Livelihood Recovery of Disaster Victims, enacted in 1998, aims to assist individuals who have suffered substantial damage to their livelihoods due to natural disasters. It does so through grant-based support funded by prefectural governments.

It should be noted that, in Japan, coverage of natural disasters caused by geological events is particularly relevant. Earthquake insurance is offered as an optional rider to fire insurance policies covering residential buildings and/or personal property. While voluntary for the policyholder, insurers are obliged to provide it if requested. Importantly, fire insurance does not compensate for damage caused by fires resulting from earthquakes or fires spreading due to earthquakes. For commercial and industrial risks, earthquake insurance is only available through private Non-Life insurance companies, as an extension of fire insurance policies.

After the Niigata earthquake of June 1964, the government and the Property & Casualty insurance industry performed an in-depth review of the earthquake insurance system, eventually leading to the Earthquake Insurance Act of 1966, which has been extensively amended several times to provide more tailored coverage and pricing for households. Earthquake insurance provides compensation for damage caused by fire, destruction, burial, or devastation resulting from an earthquake or volcanic eruption, or a tsunami following any of these events. The government provides reinsurance for large-scale earthquake losses that exceed the liability accepted by private insurance companies.

The insurable earthquake risks underwritten by private Property & Casualty insurance companies are ceded 100% to the Japan Earthquake Reinsurance Company (JER),[55] through the so-called Earthquake Reinsurance Treaty A. In turn, the JER passes back part of the risk assumed under Treaty A to private insurance companies (Earthquake Reinsurance Treaty B), and part to the Japanese government through an excess of loss treaty (Earthquake Reinsurance Treaty C). The maximum reinsurance payout the government may cover per earthquake is determined by the Diet (Japan's legislative body) each tax year.[56] This ceiling is always set high enough to respond to major earthquakes. In the event of a disaster,[57] JER and Non-Life insurance companies pay insurance claims up to 153.3 billion yen (first layer) per earthquake. The government and others (Non-Life insurance companies and JER) assume an equal share in insurance claims for the portion exceeding 153.3 billion yen, up to 216.3 billion yen (second layer). The government pays the majority of insurance claims (approximately 99.6%) for the amount exceeding 216.3 billion yen (third layer). As a result, in cases where earthquake insurance claims exceed a certain amount, the excess liabilities are shared between the relevant organizations.[58]

Earthquake insurance covers residential buildings and household items. Excluded from coverage are buildings used as factories or offices and not used for housing, precious metals, gems, or antiques valued at 300,000 yen or more per item, cash, securities (checks, stock certificates, gift certificates), certificates of deposit, revenue stamps, postage stamps, automobiles, and other items. The insured amount under earthquake insurance must be between 30% and 50% of the fire insurance amount, and is capped at 50 million yen for buildings and 10 million yen for household goods. Contracts may be short-term (1 year) or long-term (2 to 5 years).

Earthquake insurance premiums are calculated by the General Insurance Rating Organization of Japan based on the Law concerning General Insurance Rating Organizations. Premiums are determined by multiplying the basic insurance premium rate, which varies based on residential building structure and location, by a discount rate based on its earthquake resistance. There are four types of available discounts:

building age discount, seismic resistance class discount, seismic isolation discount, and seismic resistance diagnostic discount. Discounts of 10% to 50% are applied to standard premiums, depending on the age of the building or its seismic resistance performance, and discounts cannot be combined. For long-term policies (2 to 5 years), a long-term coefficient is also applied. Finally, a tax deduction system allows up to 50,000 yen to be deducted from national income tax and 25,000 yen from local inhabitant tax for earthquake insurance.

## New Zealand

In New Zealand, natural hazard coverage is provided through home insurance that includes fire, and is insured by a Crown entity, the Natural Hazards Commission Toka Tū Ake (NHC Toka Tū Ake).[59] Covered risks include earthquake, landslide, volcanic activity, hydrothermal activity, tsunami, storm or flood (land coverage only), and fire caused by any of the natural hazards listed above. There is also coverage for imminent damage, which is damage that has not yet occurred but is more likely to occur within 12 months of the natural hazard event. Coverage includes the home and certain ancillary buildings, such as sheds and garages. New Zealand is one of the few countries in the world with natural hazard insurance covering residential land, offering limited coverage for certain areas of land beneath and around the home, and limited coverage for certain bridges, sewers, and retaining walls. It does not include losses that could occur after the disaster, such as theft or vandalism. There are a number of key differences in how landslide damage and storm/flood damage are handled. For landslides, NHC Toka Tū Ake provides coverage for both home and land. For storms or floods, it only provides coverage for land, while home damage may be covered by a private insurance policy.

Among the changes that the NHC Toka Tū Ake has undergone over the years, one notable milestone was the approval of the Earthquake Commission Act in 1993 (under which the War and Earthquake Damages Commission became the Earthquake Commission). This new law marked a turning point in natural disaster insurance, eliminating coverage for commercial properties and introducing a broader scope for research into natural hazards and their mitigation, which represents a central pillar of the system. Another milestone occurred in 2021, when the Earthquake Commission established an agreement with the country's private insurers to manage natural hazard coverage claims on its behalf. More recently, in 2023, the government passed new legislation, the Natural Hazards Insurance Act 2023, which came into force on July 1, 2024, and which aims to reduce the impact of natural hazards on people, property, and communities. The Natural Hazards Insurance Act modernized and replaced the Earthquake Commission Act of 1993, and changed the Commission's name to NHC Toka Tū Ake. This, in turn, has led to changes in the names of its EQCover insurance product, now known as NHCover, as well as the Natural Disaster Fund, now the Natural Hazards Fund. Its main functions include facilitating research and education, and contributing to the exchange of information, knowledge, and experience on the risks, impacts, and resilience of natural hazards; collecting surcharges for insurance provided under the NHI Act and managing the Natural Hazards Fund; arranging reinsurance or other risk transfer products for all or part of NHCover; and administering NHCover when claims arise. Should a catastrophic event occur, it works closely with private insurance companies, central and local governments, and the emergency management sector to support community recovery.

The Natural Risks Fund ensures that all New Zealand residents with a home insurance policy that includes fire have a basic level of cover. Money from the fund is also used to purchase reinsurance on international financial markets, to cover the costs of administering the NHC plan, and to fund research and education to improve the understanding of natural disaster risk and how to reduce it. Home insurance premiums include a natural risk insurance surcharge (NHI surcharge, formerly known as the EQC

surcharge), which is set by the government and provides access to natural hazard insurance. This surcharge is calculated based on NHC Toka Tū Ake's periodic analysis of the long-term expected costs of the natural risks covered by the insurance and the costs of administering the fund, including the cost of reinsurance. A key feature of the scheme is that the New Zealand government guarantees that if a major natural disaster occurs and NHC Toka Tū Ake is unable to meet its obligations through the Natural Risks Fund and reinsurance, the government will step in to cover the shortfall.

For each natural disaster, there is a coverage cap, which is generally 300,000 New Zealand dollars plus GST (Goods and Services Tax). In some cases, the cap may be lower if the sum insured for replacement (the cost to repair the damage or replace the home to a similar standard as when it was new) is less than this amount. There is also a separate deductible for construction and land claims. The deductible for a construction claim is 1% of the total settlement amount, with a minimum of 200 New Zealand dollars per insured home up to a maximum of 3,450 New Zealand dollars. The deductible for a land claim is 10% of the total settlement amount, with a minimum of 500 dollars per insured dwelling and a maximum of 5,000 dollars for buildings with more than 10 insured dwellings.

## 3.2 Regional mechanisms for protection against natural disaster risk

There are other mechanisms in which countries from a particular region join together to cover their specific climate risks and create a shared insurance umbrella to protect their populations. By pooling together, risks are shared and distributed among the participants in the consortium, making insurance more cost-efficient for each of the participating parties.[60]

Two of the mechanisms described below offer parametric insurance, which are insurance contracts that pay out based on the intensity of an event (e.g., the wind speed of a hurricane, the intensity of an earthquake, the volume of rainfall) and the amount of losses estimated using a pre-agreed model. It is worth noting that parametric insurance is gaining importance as an innovative strategy to reduce the insurance protection gap against disasters. The main advantage of this is the speed of payment, which allows for an immediate response without lengthy claims processes. Its drawback, however, is the potential basis risk, which occurs when the insurance payout does not match the actual losses experienced.

### Caribbean Catastrophe Risk Insurance Facility

In 2007, the Caribbean Catastrophe Risk Insurance Facility (CCRIF) was established as the world's first mechanism for pooling catastrophe risks across multiple countries. It was developed with technical support from the World Bank and a grant from the Government of Japan, and capitalized through contributions to a Multi-Donor Trust Fund (MDTF) by the Government of Canada, the European Union, the World Bank, the Governments of the United Kingdom and France, the Caribbean Development Bank, and the Governments of Ireland and Bermuda, as well as through membership fees paid by participating governments. CCRIF has continued to evolve with support from the World Bank, which has established two MDTFs and provided additional financing since 2014. The Caribbean Development Bank has also contributed funds from Mexico, and has received contributions from the Government of Ireland and the European Union, through its Caribbean Regional Resilience Building Facility, managed by the Global Facility for Disaster Reduction and Recovery (GFDRR) and the World Bank.

Backed by traditional reinsurance and capital markets, CCRIF has developed and offered parametric tropical cyclone and earthquake insurance. In 2014, the Facility was restructured into a segregated holding company to facilitate expansion into new products and

geographic areas. In 2015, CCRIF signed a memorandum of understanding with COSEFIN (Council of Finance Ministers of Central America and the Dominican Republic) to allow Central American countries to formally join the Facility. It currently provides coverage to 19 Caribbean governments, four Central American governments, and three Caribbean electric utility companies. This is a risk-pooling mechanism aimed at reducing the financial impact of natural disasters through cost-effective risk transfer and facilitating rapid access to liquidity for its members following natural disasters. It offers six parametric insurance products: for tropical cyclones, earthquakes, excessive rainfall, electricity utilities, water utilities, and the fisheries sectors.

## African Risk Capacity (ARC)

The African Risk Capacity (ARC) Group[61] is made up of: the ARC Agency, a specialized agency of the African Union established in 2012 to support African governments in enhancing their capacities to better plan, prepare for, and respond to natural disasters caused by extreme weather events, as well as disease outbreaks and epidemics; and the ARC Insurance Company Limited (ARC Ltd), a hybrid mutual insurer and trading subsidiary of the Group founded in 2014, responsible for performing commercial insurance functions involving risk pooling and risk transfer, pursuant to national regulations for parametric weather insurance. Its initial capital came from premiums paid by participating countries, as well as one-time contributions from partners. The ARC works with countries to calculate national premiums and allocate payouts to member countries based on predetermined and transparent payout rules. Countries determine their desired level of participation by selecting the amount of risk they wish to retain and the amount of funding they wish to receive from the ARC for risks of varying severity.

The ARC uses Africa RiskView, an advanced satellite-based weather monitoring system, as well as software developed by the United Nations World Food Programme (WFP), to estimate the level of damage caused by a disaster and make funds immediately available to African countries to support their response. Countries participate in an index-based insurance mechanism for severe and exceptional droughts. To this end, they must undertake several processes, including but not limited to customizing the Africa RiskView software, signing memoranda of understanding for in-country capacity development, defining a contingency plan for ARC payments, and determining risk transfer parameters. Once these steps are completed, countries receive a Certificate of Good Standing from the ARC Agency's Governing Board and pay a premium to ARC Ltd., after which they become members of the risk pool. They receive a payout when the deviation in rainfall is severe enough that the estimated response costs (calculated by Africa RiskView) exceed a predefined threshold, determined based on the risk transfer parameters selected by each country.

## InsuResilience Global Partnership

Finally, it is worth noting the case of the InsuResilience Global Partnership[62] for Climate and Disaster Risk Financing and Insurance, which was officially launched at the United Nations Climate Conference COP23 in November 2017. It brings together countries from the V20 (Vulnerable Twenty Group) and the G20+, donors, the private sector, international organizations, and civil society organizations. Its objective is to strengthen the resilience of developing countries and protect the lives and livelihoods of poor and vulnerable people against the impacts of disasters in the form of climate and disaster risk financing and insurance (CDRFI) solutions. Programs and projects related to climate and disaster risk financing and insurance are implemented by its members and partners worldwide. In 2021, 24 implementation programs were operating under the InsuResilience umbrella, with 324 projects across 108 countries.

# 4. Reinsurance and securitization through catastrophe bonds

## 4.1 Reinsurance and catastrophic risks

Reinsurance plays a key role in promoting mitigation strategies and reducing exposure to extreme events. It serves as a tool that significantly enhances geographic and institutional diversification, enabling the pooling of such risks. This mechanism is formalized through a contract in which one insurance company (the reinsurer) promises to indemnify another insurance company (the ceding company) for the losses the latter may incur as a result of the insurance contracts it has underwritten as a direct insurance company. This is an essential risk management tool in the insurance industry, allowing direct insurance companies to transfer part of their risk to other insurance companies that are authorized to enter into reinsurance contracts or pure reinsurance companies. Normally, these contracts refer to the cession of technical risks, in which is known as *traditional reinsurance,* but there are reinsurance contracts through which financial risks are also ceded (*financial reinsurance*). Sometimes, risk can also be transferred between reinsurance companies, freeing the capacity of the ceding company, which are called *retrocession contracts.*

There are several types of reinsurance contracts (see Table 4.1). One of the main ones is known as *facultative reinsurance*, in which each individual risk is negotiated and reinsured independently. There is also *treaty reinsurance*, which may be either *proportional* (in which the reinsurer assumes a percentage of the premiums and claims of the ceding insurer) or *non-proportional* (in which the reinsurer covers losses above a certain threshold in exchange for a reinsurance premium without sharing the direct insurer's premiums proportionally). Treaty reinsurance automatically covers all risks that comply with the treaty conditions, providing stability and efficiency in risk management. There are also *hybrid reinsurance* contracts, combining facultative and treaty structures. In these cases, the ceding insurer retains facultative reinsurance discretion, while the reinsurer provides treaty coverage for qualifying risks that the direct insurer chooses to cede.

Table 4.1
General types of reinsurance contracts

| Contract type | Coverage mechanism | Modalities | Risk selection | Regular use |
|---|---|---|---|---|
| **Reinsurance treaty** | Automatic coverage within agreed terms | | Automatic | Common risks, routine business |
| -Proportional | Shared premium and proportional losses | Quota share / Surplus | Automatic | Increase in capacity and technical stability |
| -Non-proportional | Covers losses exceeding the retention limit | Excess Loss / Stop Loss | Automatic | Catastrophes, major individual |
| **Facultative reinsurance** | Individual, case-by-case basis. Requires a specific agreement by both parties. | | Individual selection | Major risks |
| **Mixed reinsurance** | Optional for the direct insurer; mandatory for the reinsurer | | Individual selection | Major risks |

Source: MAPFRE Economics

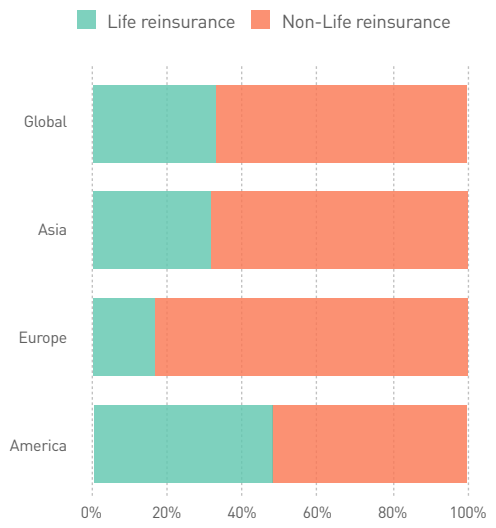
There are two different classes under *proportional reinsurance.* First, *quota share reinsurance*, through which the reinsurer assumes a fixed percentage of each risk covered by the ceding company, sharing premiums and claims in the same proportion. And, second, *surplus reinsurance*, in which a retention limit is set, and the reinsurer takes on the portion of risk that exceeds this limit. Meanwhile, in *non-proportional reinsurance*, the most common contracts are: *excess of loss* reinsurance, where the reinsurer covers claims that exceed a limit set by the ceding company. This can apply to individual claims or total claims over a given period; and *stop loss* reinsurance, where the reinsurer covers the ceding company's total loss ratio above a predetermined annual threshold.

Reinsurance is a service underwritten at the corporate level, an area in which the financial and operational strength of the counterpart with whom insurance companies do business plays a fundamental role. This shapes the very nature of the market, which requires economies of scale and is characterized by its concentration among large global players, dominated mainly by multinational groups with vast financial resources, underwriting expertise, and a high degree of specialization in their business.[63] Economies of scale and a high level of specialization are also observed among brokers and other reinsurance intermediaries, which play an important role in facilitating transactions between insurers and reinsurers, advising on risk management and program structuring, and leveraging their knowledge of the market to optimize reinsurance placement.[64]

## Global reinsurance market

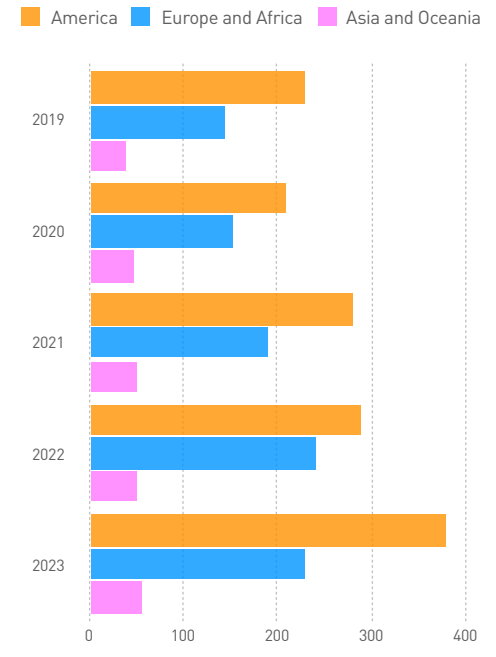
The volume of activity in the global reinsurance market has grown significantly. According to the latest data from the International Association of Insurance Supervisors (IAIS),[65] the market reached nearly 900 billion dollars in gross premiums

**Chart 4.1-a**
**Global: breakdown by line of gross reinsurance premiums, 2023**
**(%)**




Source: MAPFRE Economics (with IAIS data)

**Chart 4.1-b**
**Global: regional distribution of reinsurance premiums, net of retroceded reinsurance**
**(billions of USD)**

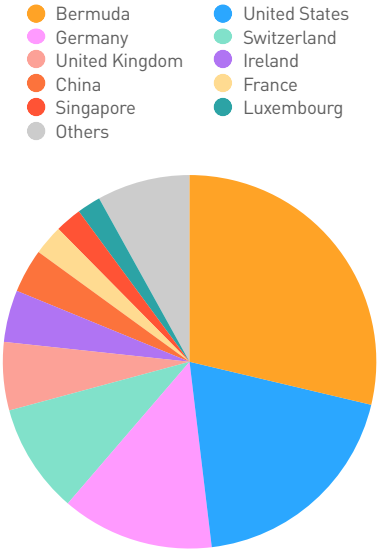



Source: MAPFRE Economics (with IAIS data)

by the end of 2023,[66] and more than 630 billion dollars in net premiums, which assumes year-over-year growth of 12% and 13%, respectively. Gross premiums are regionally distributed, with 49% allocated to risks in the Life segment, and the remaining 51% to Non-Life in the Americas,[67] and 17% to Life and 83% to Non-Life in Europe.[68] Overall, approximately 35% of reinsurance premiums correspond to risks in the Life segment, while the remaining 65% refer to reinsurance in the Non-Life segment (see Chart 4.1-a).

Meanwhile, Chart 4.1-b shows that reinsurance premiums originating in the Americas region (basically North America) are the main drivers of global growth. According to the latest IAIS data, Bermuda and the United States dominate the reinsurance landscape, accounting for 48.1% of all reported global gross reinsurance premiums, followed by Germany, Switzerland, and the United Kingdom (see Chart 4.1-c).

Chart 4.1-c
Global: gross reinsurance premium quota by country, 2023



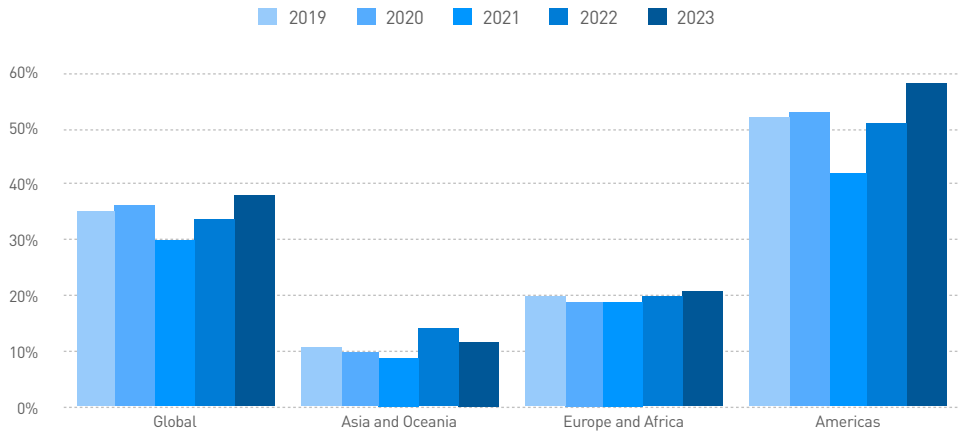

Source: MAPFRE Economics (with IAIS data)

It should be noted that Bermuda is a key market in the global reinsurance sector,[69] with a strong presence of international reinsurance companies that operate under a regulatory framework that was granted full equivalence with the Solvency II regimen in the European Union in 2016.[70] Ceded premiums have increased due to the growing demand for alternative reinsurance and Bermuda's role as a financial center. Likewise, the absence of regulatory restrictions on offshore reinsurance and the availability of tax benefits have consolidated its appeal for global reinsurance companies.[71]

In the United States, the market is dominated by reinsurance companies like Berkshire Hathaway, Everest Re, Munich Re, and Swiss Re. In 2023, ceded premiums in Non-Life reached 826.3 billion dollars. In regulatory terms, the system is still based on the legislation of each state, with a common framework provided by the National Association of Insurance Commissioners (NAIC) and the Dodd-Frank Act. The NAIC has promoted greater transparency in the regulation of cessions to offshore reinsurers, especially regarding reserve financing agreements. Since 2024, collateral requirements for Life reinsurance have been revised to strengthen the stability of primary insurance companies. The Non-Life reinsurance market has experienced an increase in the cession of catastrophic risks, with prices tightening after events like Hurricane Ian (2022) and the increase in forest fires. In 2023, the NAIC strengthened regulations concerning risk concentration and cession limits in facultative contracts.[72]

The third major market in the world due to the importance of its reinsurance companies is Germany, the home of Munich Re, Hannover Re, and General Re (which have been part of the American group Berkshire Hathaway since 1994). In 2023, 29 reinsurance companies operated in that country, with both domestic and international activity. Munich Re and Hannover Re led the market with a high concentration of proportional insurance and a high volume of industrial risk and natural

Chart 4.1-d
Global: use of retrocession between 2019 and 2023
(% of gross reinsurance premiums)

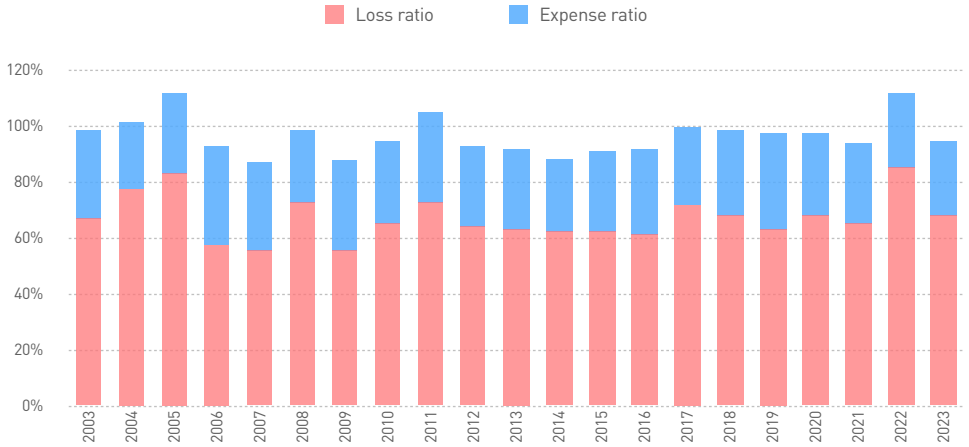



Source: MAPFRE Economics (with IAIS data)

disaster contracts. In recent years, an increase in the underwriting of non-proportional reinsurance has also been observed, especially in lines like third-party liability and automobile. The Swiss market is notably in fourth place, with one of the highest rates of insurance against catastrophes in Europe, with Swiss Re as the principal reinsurance company, which has also led catastrophe bond issues on the continent. Switzerland is a key market in the reinsurance sector, with a strong presence of international reinsurers, in which 22 reinsurance companies and 24 captives operated in 2023. The market is mainly international, with more than 90% of premiums originating abroad.

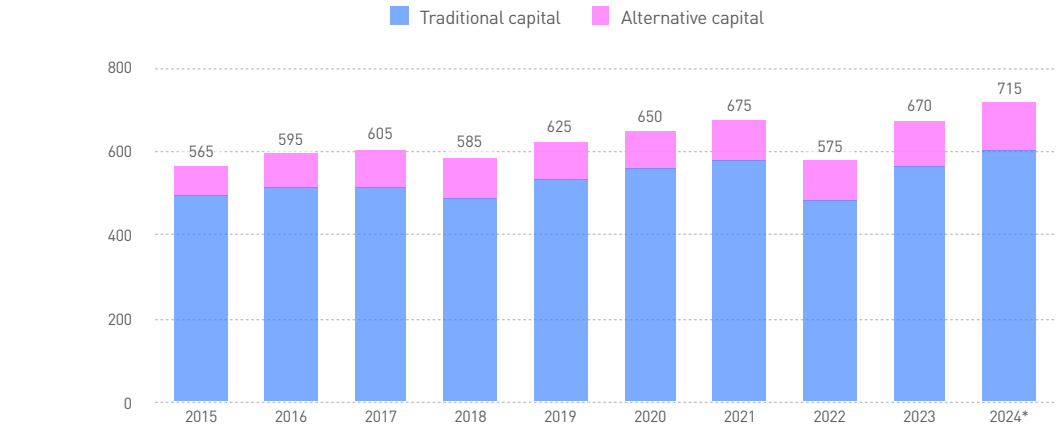
Meanwhile, by the end of 2023, approximately 39% of gross global premiums originated from retrocession contracts, where the Americas region (58%) is the main contributor to the aggregate increase (see Chart 4.1-d). The increased demand for reinsurance in recent years has driven growth in retrocession by

Chart 4.1-e
Global: combined Non-Life reinsurance ratio
(%)




Source: MAPFRE Economics (with IAIS data)

**Chart 4.1-f**
**Global: global capital of reinsurers**
**(billions of USD)**




Source: MAPFRE Economics (based on AON data)

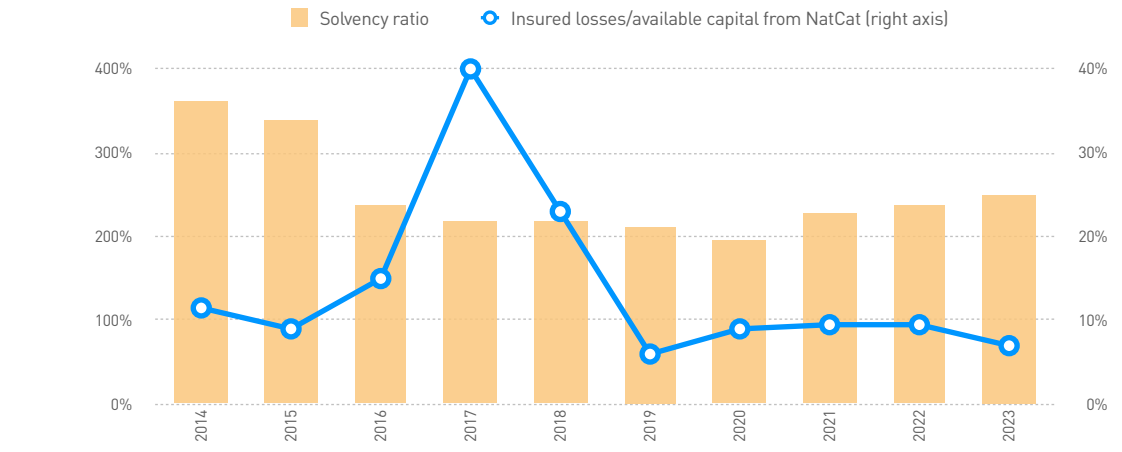
* Data as of September 2024

reinsurers lacking sufficient capacity to meet this demand and expand their operations.[73]

## Profitability and solvency of the reinsurance industry

Regarding the technical profitability of reinsurance, in 2023, the combined ratio for Non-Life notably improved, standing at 95% (see Chart 4.1-e). Notable among the worst years in which the combined ratio remained significantly above 100% (which means entering into technical losses), are 2005, mainly as a result of Hurricane Katrina in the United States, which caused 82 billion dollars in losses, and 2011, due to the tsunami disaster in Japan (which caused a nuclear leak at the Fukushima center) and the floods in Thailand. The increase in the combined ratio in 2022 was due to both the elevated insured losses due to natural disasters[74] (increasing 18 percentage points

**Chart 4.1-g**
**Global: reinsurance solvency indicators**
**(%)**




Source: MAPFRE Economics (based on data from IAIS and Swiss Re Institute)

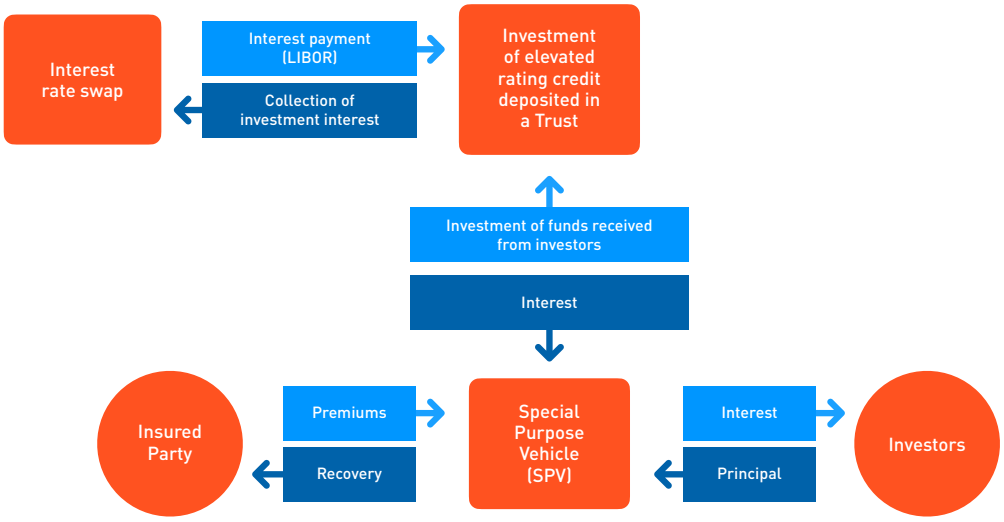
that year) and the strong and unexpected spike in global inflation in practically all of the world's economies. This was a result of ultra-expansive monetary and fiscal policies implemented to counter the economic effects of the pandemic, and the supply chain bottlenecks after the reopening process. The rise of inflation increased claim costs and other operating expenses for insurance and reinsurance companies, without these higher costs being reflected in the premiums for insurance and reinsurance, which are always calculated in advance.

Furthermore, it is worth noting the high level of capitalization of reinsurance companies in aggregate (see Chart 4.1-f). As of September 2024, the sector's global capital was 715 billion dollars, showing significant growth over the same period the year before (45 billion dollars). This rise was mainly driven by retained earnings, unrealized gains in the bond portfolio that directly contribute to capital, and new issuances in the catastrophe bond market. [75] In relative terms, it is notable that the solvency levels of reinsurance companies has dropped over the 2014-2023 period, but the sector still had a broad solvency margin, with a change in trend since 2020, when a progressive climb began until 2023 (see Chart 4.1-g).

## 4.2 Catastrophe bonds

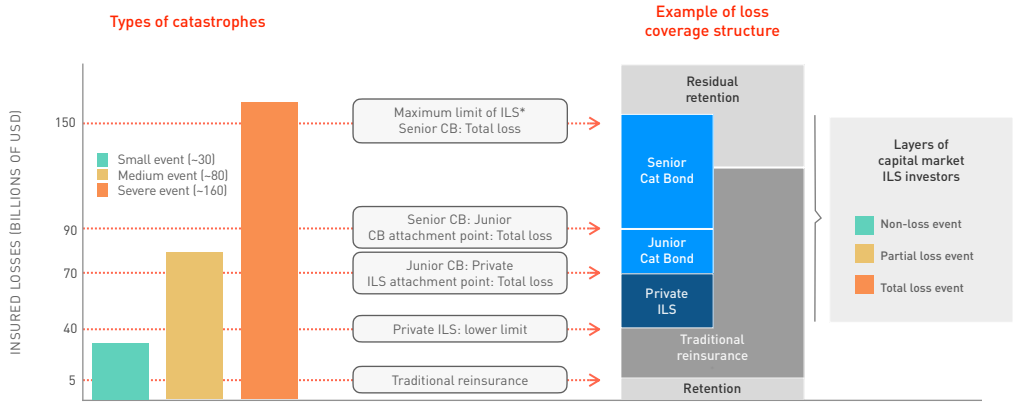
Natural disasters, such as hurricanes, droughts, floods, and earthquakes, are becoming increasingly frequent and severe, causing growing human and economic losses. These events heighten sensitivity around the balance sheets and solvency of reinsurance companies that cover these types of risks. In this context, part of the risk can be offloaded from the balance sheet through securitization, resulting in financial instruments known as *catastrophe bonds* (Cat Bonds). Catastrophe bonds arose in the 1990s, after devastating events like Hurricane Andrew in 1992 or the Northridge earthquake in 1994, which revealed the insurance industry's limited capacity to handle massive losses from disasters of that magnitude.

Chart 4.2-a
How a Cat Bond works




Source: MAPFRE RE

**Chart 4.2-b**
**Catastrophic loss coverage structure**



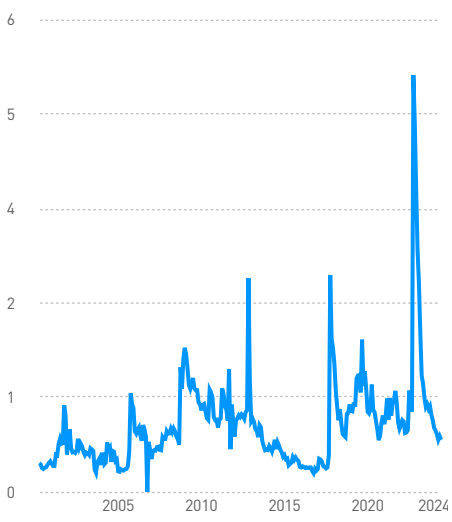

Source: MAPFRE Economics (with data from Bentley Reid)

*ILS, Insurance-Linked Securities

The structure of catastrophe bonds is based on the same dynamics as other structured products, whereby certain risks are categorized and classified as *Insurance Linked Securities*, ILS. These risks are then transferred from the insurer's balance sheet to a special purpose vehicle (SPV), turning them into unique securities for final investors due to the underlying catastrophic risk embedded in this asset class. They are issued contingent on predefined events, such as a major hurricane or earthquake, and are subject to meeting specific loss thresholds. This scheme guarantees that the funds backing the assets are sufficient to cover losses if the so-called "*trigger*" (the event or threshold that activates the losses) is activated. This means there is a potential for a 100% loss of the investment, but in exchange, these bonds offer more attractive returns than other, more conventional structured products.[76] In fact, it is common for the catastrophe bond issuer to cover part of the total risk through the issue of low bands or amounts, limits known as "*exhaustion point*" (upper limit) and "*attachment point*" (lower limit). This arrangement determines different types of catastrophe bonds based on their priority (senior, mezzanine, or junior) to offer flexibility and address the investors' various preferences and tolerances to risk[77] (see Charts 4.2-a and 4.2-b).

From the investor's perspective, catastrophe bonds are considered "zero-beta" investment products, due to their absence or low correlation with economic cycles, therefore they can be considered an adequate source of diversification. Normally, the repayment of

**Chart 4.2-c**
**Monthly weighted supply and demand index of the catastrophe bond market**




Source: MAPFRE Economics (based on Swiss RE data)

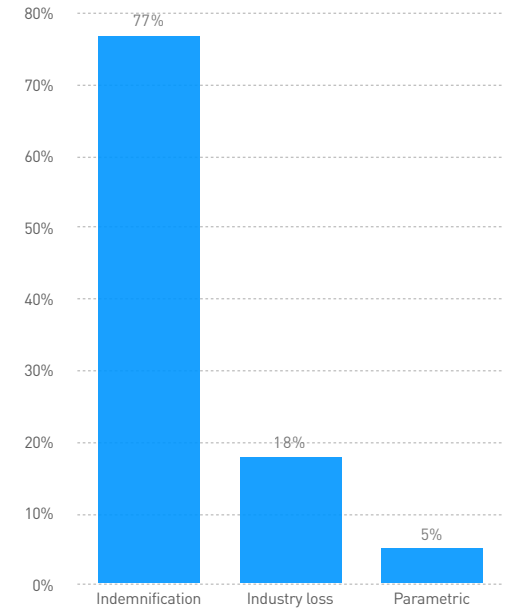
Table 4.2
Global: issuing of catastrophe bonds, by issuer and trigger type, 1997-2017

| Issuer type | Trigger type | | | | | |
|---|---|---|---|---|---|---|
| | Indemnification | Industry loss | Parametric | Multiple triggers | Unknown | Percentage of total issuing |
| Insurance company | 55 | 31 | 9 | 3 | 2 | **60** |
| Reinsurer | 12 | 57 | 21 | 9 | 1 | **25** |
| State fund | 80 | 1 | 19 | 0 | 0 | **15** |
| All | **49** | **33** | **14** | **4** | **1** | **100** |

Source: MAPFRE Economics (based on Federal Reserve Bank of Chicago data)

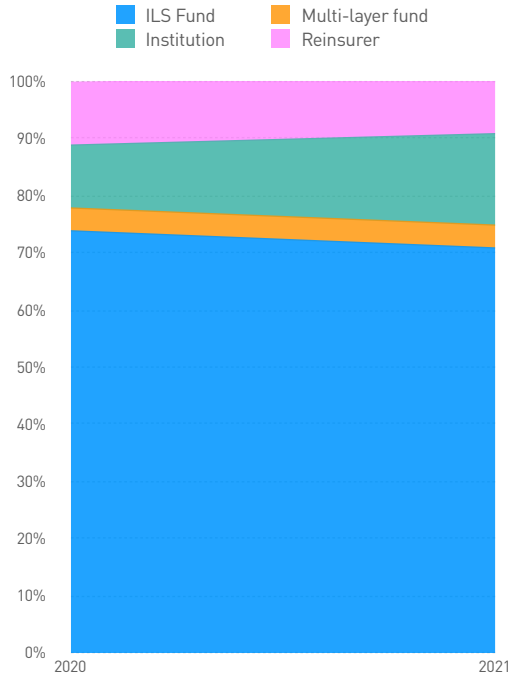
the bond's principal—or its face value—is reinvested by the SPV in government securities. These can offer floating-rate coupons and inflation-linked returns, partially eliminating reinvestment risk by establishing a structured cash flow scheme. In addition to the coupons from government securities, investors also benefit from the premium adjustments collected from the underlying reinsurance contracts. This results in an additional parametric compensation that is more closely tied to inflation risk. While in theory these instruments are classified as "zero-beta" assets, historical evidence has shown that in the face of extreme events or financial

Chart 4.2-d
Loss trigger of new catastrophe bond issues



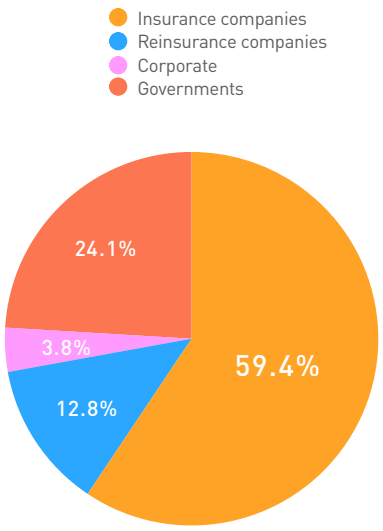

Source: MAPFRE Economics (based on AON data)

Chart 4.2-e
Investors in catastrophe bonds by category, 2020-2021



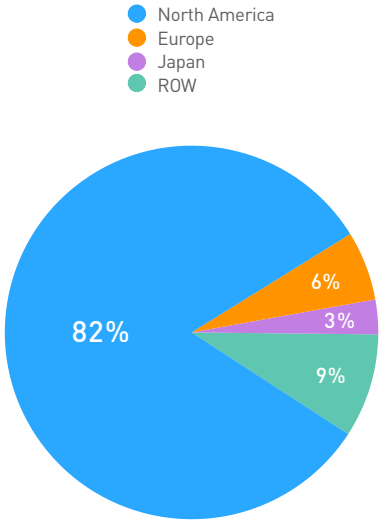

Source: MAPFRE Economics (based on Swiss RE and AON data)

Chart 4.2-f
Global: outstanding notional by type of promoter
(as of May 31, 2024)




Source: MAPFRE Economics (based on Swiss Re Capital Markets data)

Chart 4.2-g
Global: geographic distribution
of new issues
(% of issued notional)




Source: MAPFRE Economics (based on AON Securities data)

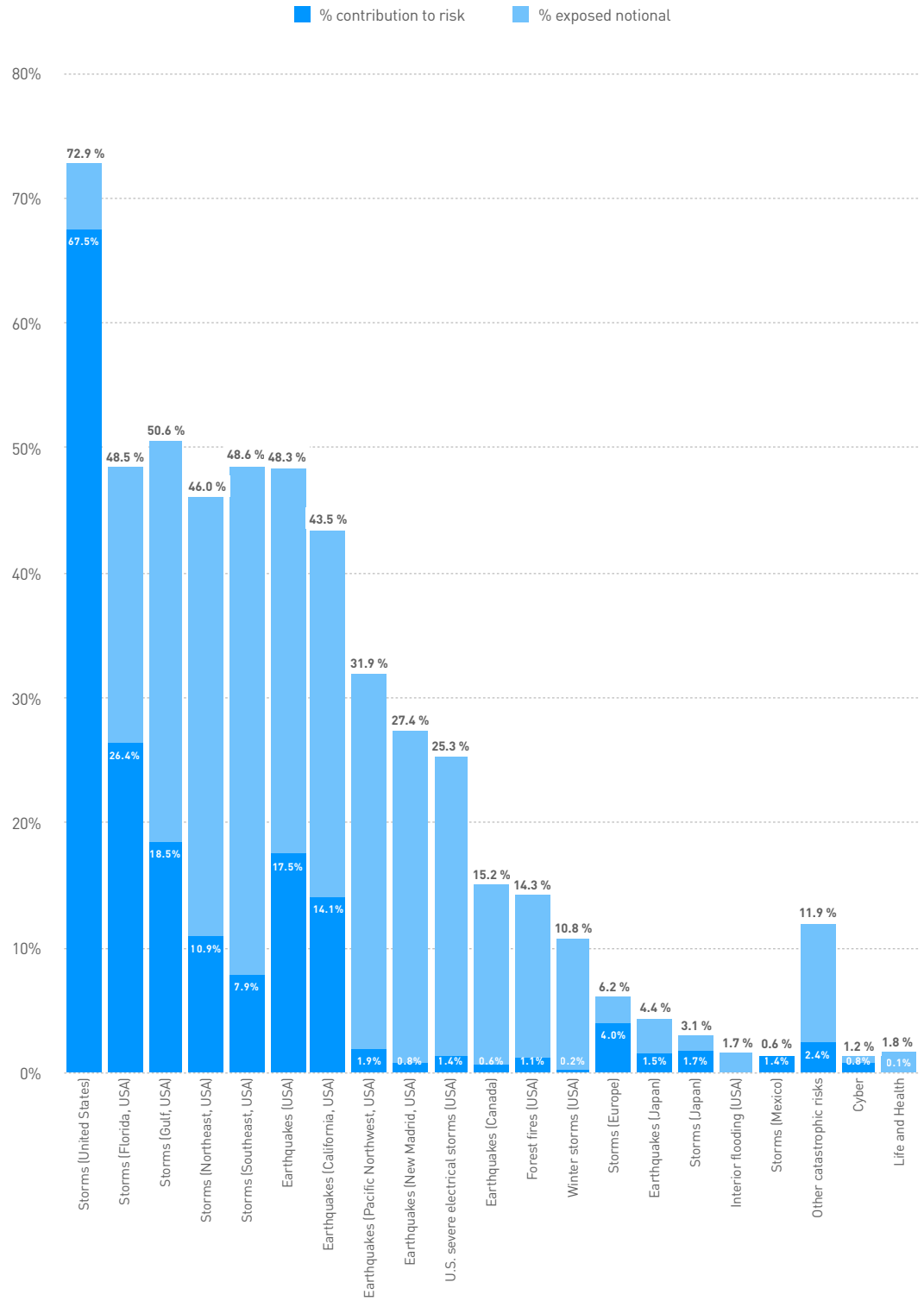
market turbulence, an illiquidity premium tends to emerge. This leads to a positive correlation with other types of risk assets, as observed during the collapse of Lehman Brothers in 2008 and the subsequent financial crisis (see Chart 4.2-c).

In this regard, one of the keys to using these bonds lies in risk modeling, which permits an analysis of the probability of occurrence, the magnitude of losses, and vulnerable regions. However, growing climate uncertainty has complicated the modeling, adding new variables that are hard to predict. The triggers that activate the use of funds can be based on actual loss indemnities, parametric indexes that reflect the magnitude of events, or on industry-wide aggregate insurance losses[78] (see Table 4.2 and Chart 4.2-d).

On the other hand, in terms of financial stability, and due to the large size and low frequency of these catastrophic events, investors should generally adopt a very long-term outlook to smooth losses during long periods. As a result, the main participants in this market are institutional investors with long investment horizons and the intention to hold these assets until maturity. However, given the growing investor appetite, the breadth and depth of this market are expanding through the marketing of more accessible products to other investor profiles through mutual funds, exchange-traded funds (ETFs) (see Chart 4.2-e).

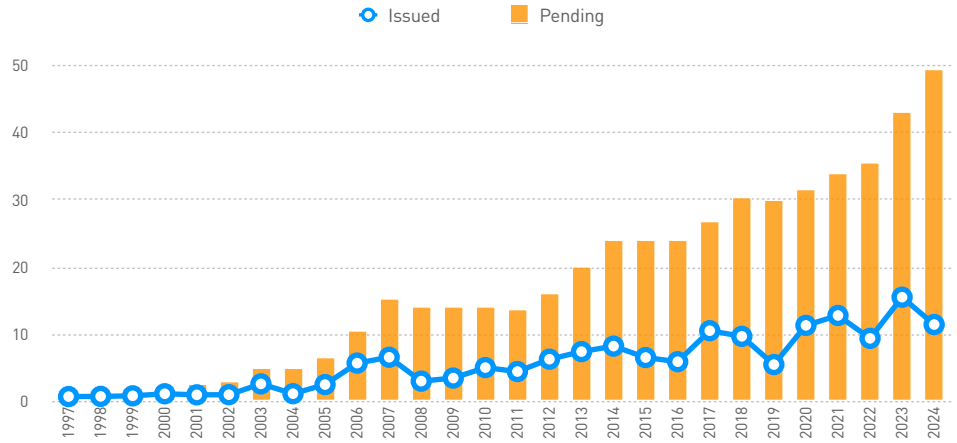
Another important aspect of catastrophe bonds is their positive social impact, as they provide liquidity to reinsurers to cover damages from climate-related events, thereby accelerating the reconstruction of affected areas. The United Nations itself has recognized the relevance of these assets in closing the gap between current adaptation financing needs and future needs; that is, they offer a promising structure to confront the more immediate challenges while investing in future resilience. In fact, this mechanism falls

## Chart 4.2-h
## Global: exposed notional vs. contribution to risk by risk type
(as of May 31, 2024)




Source: MAPFRE Economics (based on AON and Swiss Re data)

Chart 4.2-i
Global: new issues and outstanding balance of catastrophe bond market
(billions of USD as of May 31, 2024)

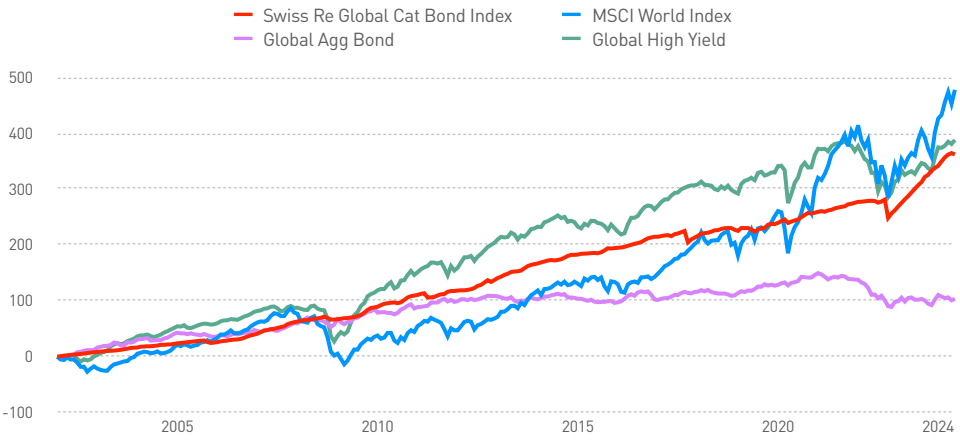



Source: MAPFRE Economics (based on Swiss Re Capital Markets data)

within the framework of the World Bank program, through the International Bank for Reconstruction and Development (IBRD), and is supported by the Insurance and Risk Financing Fund, under the United Nations Development Program (UNDP). This is reflected in the categorization of active issues based on the sponsors of the securitizations, with a significant share promoted by governments themselves (see Chart 4.2-f).

In summary, as natural disasters intensify, insurers and reinsurers are increasingly turning to catastrophe bonds to diversify and transfer these risks to the capital markets. The most common pools are broadly distributed geographically and cover an ever more extensive number of events, which allows them to generate benefits of diversification for the investor while reducing concentration and counterpart risk for the issuer (see Charts 4.2-g and 4.2-h).

Chart 4.2-j
Global: reference indexes in the catastrophe bond market




Source: MAPFRE Economics (based on Swiss RE and Bloomberg data)

Thanks to this favorable dynamic, the catastrophe bond market reached a new record in 2024, with 17.7 billion dollars in new issues and a cumulative balance that reaches 49.5 billion dollars. This represents a 15% increase over the previous year and more than double the size of the market over the past decade. At the same time, the yield offered this past year reached 17.3%, showing that the balance between supply and demand remains attractive, leaving ample room for further growth in the future (see Charts 4.2-i and 4.2-j).

# 5. Climate change and insurance companies' investment portfolios

## 5.1 Investment risks related to climate change

The insurance industry is doubly exposed to climate risks, as it can be affected not only through the insured risks underwritten in insurance policies, but also through the risks embedded in its investment portfolios. These risks can be classified into three categories: *physical, transition, and liability risks. Physical risks* refer to direct damages caused by extreme weather events; *transition risks* arise from changes in policies and technologies that must be implemented to reduce emissions (with certain sectors more exposed due to the need for large-scale investments in clean energy sources and infrastructure to manage an orderly transition); and *liability risks* are those related to potential legal claims and lawsuits for damages caused by the company's activities that may be related to environmental deterioration and climate change.

*Climate risks* arising from insurance policies refer to losses stemming from incorrect pricing, primarily due to the challenges in modeling losses linked to natural phenomena, as well as unexpected increases in the frequency, severity, and geographical concentration of claims—including legal risks from potential litigation and reputational risks. *Investment portfolio-related risks*, meanwhile, include credit risks that may arise from the loss of counterparties' credit quality due to holdings in fixed-income securities or other

Table 5.1
Risk outlook and climate change decisions for reinsurers and Property & Casualty and Life insurance companies (asset side)

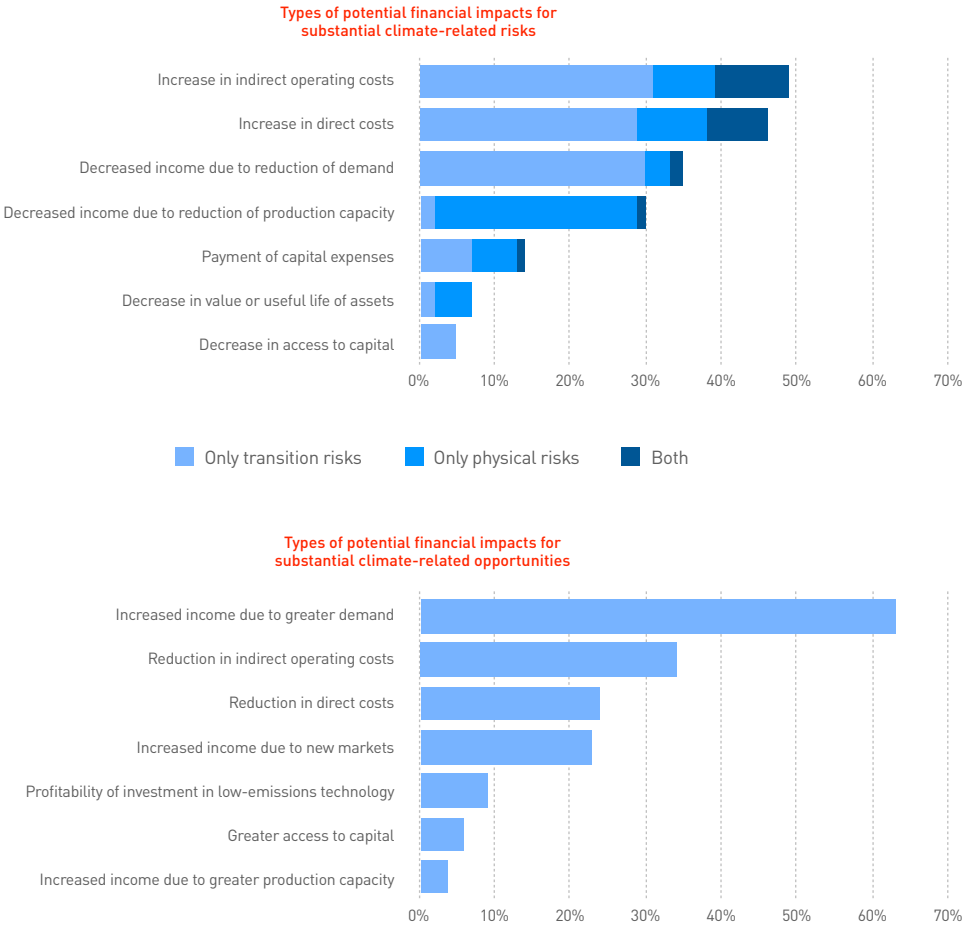
| | Physical risks | | Transition risks | | | |
|---|---|---|---|---|---|---|
| | Chronic | Acute | Politicians | Litigation | Market | Technological |
| **Risk landscape over the business planning horizon: 2020-2030 (short term)** | • Insurance companies are exposed directly through investments in real assets (e.g., buildings, infrastructure) and indirectly through investments in companies (e.g., equity, debt) that are themselves exposed to such risks.<br>• Although assets may increasingly be affected by more frequent and severe natural disasters, losses can be offset by insurance protection (e.g., property insurance on real estate). | | • The extent to which transition risk impacts reinsurers and insurers' investment portfolios will depend on the speed and scale of developments across this spectrum.<br>• Significant actions or developments could result in sudden losses in the value of the investment and promote faster actions by reinsurance companies. | | | |
| **Risk landscape over the strategic planning horizon: 2030-2050 (long term)** | • As the effects of climate change accelerate, certain investments and sectors may become less attractive ("stranded assets"), for example, real estate in coastal communities or shares in fossil fuel companies if renewable energies become viable on a large scale.<br>• Renewable energies and the greening of other key sectors are expected to grow significantly, along with investment in resilient and ecological infrastructure.<br>• New technologies (clean, ecological, and carbon capture and storage) will continue to arise, bringing new opportunities.<br>• Other considerations. | | | | | |

Source: Geneva Association

credits; market risks, due to losses from fluctuations in the prices of equity portfolios and real estate investments; and liquidity risks that may cause difficulties obtaining cash flows or financing, as a result of a combination of financial stresses triggered by natural disasters (see Table 5.1[79]).

An additional layer of losses is linked to the secondary effects of catastrophic events that may involve a potential threat to the stability of the financial system as a whole. This is due to the fact that their impacts often occur simultaneously rather than as isolated events, potentially triggering a cascade of events that could affect the financial sector and the real economy with systemic effects.[80] According to the Financial Stability Board (FSB),[81] among the seven types of potential financial impacts most frequently estimated by companies,[82] the most common was the increase in indirect operating costs (such as supply chain disruptions, the need for investments to adapt processes, or higher insurance premiums), reported by 49% of firms. This was followed by an increase in direct costs (for example, immediate physical damage to assets), cited by 46%. Both of these impacts are directly linked to companies' financial performance (see Chart 5.1).

**Chart 5.1**
**Global: types of estimated potential financial impacts for material issues**




Source: Financial Stability Board, Task Force on Climate-related Financial Disclosures

Currently, the assessment and management of climate risks require the use of models by institutional investors—including banks and insurance companies—within the framework of Enterprise Risk Management (ERM) and the Own Risk and Solvency Assessment (ORSA), to evaluate and address climate-related risks. Supervisory authorities also rely on such models, employing risk quantification techniques such as stress testing and scenario analysis to assess exposures to climate change-related risks. These models are based on mathematical analyses, historical climate data, and future scenario projections.

The aforementioned models include four main components:

- *Catastrophe models.* They simulate the probability and intensity of extreme events in specific areas. They also map exposed assets (buildings, infrastructure, crops) in the areas of interest, and assess how those assets will react to different levels of impact.[83]

- *Models based on climate projections.* Global climate models (GCM) and regional models (RCM) are integrated with financial analysis tools to predict the long-term impacts of climate change. These models evaluate chronic risks, such as rising sea levels or changes in temperature and precipitation patterns.[84]

- *Transition models.* The ClimateWise Transition Risk Framework uses a scenario-based focus to model the impacts of the transition toward a 2°C economy, analyzing how infrastructure portfolios and energy assets are affected by regulatory and technological changes.

- *Scenario-based models*. The TCFD (Task Force on Climate-Related Financial Disclosures) encourages the use of scenario analyses to evaluate the way climate policies could impact insurance companies' portfolios under different economic trajectories.

It is worth noting that the U.K.'s prudential regulation authority (PRA) has an open source tool that allows users to introduce their investment exposures to different sectors and calculate the effect of the climate resistance test on the value of their portfolios.[85]

## 5.2 Global initiatives on sustainability criteria in investments

The first organization to involve the financial and insurance sector in sustainability issues was the United Nations (UN), through the program of financial initiatives for the environment (UNEP Finance Initiative or UNEP FI), created in 1992. For more than 30 years, this initiative has connected the UN with financial institutions worldwide to shape the sustainable finance agenda, helping the financial sector achieve goals, address risks, and identify business opportunities by adopting a responsible sustainability approach in banking and insurance.

Within this initiative, and under the United Nations Global Compact, the Principles for Responsible Investment (PRI) were established in 2006, and the Principles for Sustainable Insurance (PSI) in 2012. These principles defined the rules for sustainable finance, serving as a foundation for setting standards and ensuring that the private financial sector can play its role in achieving the 2030 Agenda for Sustainable Development and the Paris Agreement on Climate Change. Currently, this initiative encompasses an extensive list of adhering banks and insurance companies, including 172 large global insurance groups affiliated with this program.[86]

The Net-Zero Asset Owner Alliance (NZAOA), promoted by the UN, is also notable. This initiative is led by institutional investors committed to transforming their investment portfolios to reach net-zero greenhouse gas (GHG) emissions by 2050, aligning themselves with the goal of limiting the rise in global temperature to 1.5ºC. This means

investment management in the insurance industry that follows *"best in class with minimal rating"* criteria (investing in those that best meet environmental, social, and corporate governance criteria, ESG), measure the climate impact of investments, and set decarbonization targets. It also involves avoiding investments in sectors such as coal, gas, and oil that do not have a reinforced energy transition plan, thus strengthening the reduction of environmental impact.

## 5.3 Green bonds and sustainability bonds

*Green bonds* and *sustainability bonds* are two instruments designed to advance the fight against the effects of climate change related to investment portfolios. Their goal is to mobilize private capital toward specific projects with a positive environmental impact, such as renewable energies, clean transportation, energy efficiency, sustainable agriculture, and ecosystem conservation. By directly financing low-carbon-emissions activities, or those that reduce GHG, they accelerate the energy transition and support climate change adaptation to combat global warming. These types of bonds (and loans) adhere to standards proposed by institutions like the International Capital Market Association (ICMA) and, more recently, the Taxonomy of the European Union, to increase market confidence, reducing the risk of *"greenwashing"* and strengthening the alignment between private investments and international sustainability goals, especially those established in the Paris Agreement.

The aforementioned ICMA is an international association that brings together financial institutions and investors, whose goal is to promote standards, rules, and best practices in the international capital markets. It was founded in 1969, with headquarters in Zurich, Switzerland. It originally arose as the Association of International Bond Dealers (AIBD), for the purpose of improving transparency, stability, and efficiency in the global debt markets. It is currently recognized for establishing international standards widely used in sustainable markets, like the Green Bond Principles (GBP), the Social Bond Principles (SBP), and the Sustainability-linked Bond Principles (SLBP), trying to thus strengthen the integrity and credibility of sustainable financing on a global level. Meanwhile, the European Union (EU) has created its own mandatory standards (EU Green Bond Standard, EUGBS), based on its Taxonomy, seeking to add transparency and rigor in the fight against *"greenwashing"* for emissions originating in the EU.

### Main concepts

A *green bond* is a fixed income financial instrument issued specifically to finance or refinance projects with a positive environmental impact, such as renewable energies, energy efficiency, clean transportation, or biodiversity conservation. Its origin dates back to 2007, when the European Investment Bank (EIB), and later the World Bank, issued the first bonds of this type in response to the growing demand for sustainable investment. This established a market that has since grown exponentially at a global level and has been consolidated thanks to international standards, such as the GBP and, more recently, with specific regulatory initiatives such as the EU Taxonomy.

Meanwhile, a *sustainability bond* is a fixed income financial instrument issued to finance or refinance projects that simultaneously generate environmental and social benefits, thus combining ecological objectives (renewable energy, clean transportation, environmental conservation) and social goals (education, health, affordable housing). These bonds arose in 2014, promoted by the growing global interest in investments that align social impact with environmental targets. They were consolidated with the creation of the Sustainability Bond Guidelines by the ICMA in 2017, establishing clear standards that improve transparency and reduce the risk of *"greenwashing"* in the international financial markets.

A relevant trend is the growing appeal of instruments classified as sustainable (sustainable bonds and loans), which have been displacing the use of green bonds and loans in recent years in terms of issuing. This shift can be explained by the greater flexibility they offer: the debt servicing conditions of the former depend on achieving predefined environmental impact targets, whereas—according to the ICMA definition—the latter are linked to broader performance-based impact objectives. In this case, payment conditions are tied to achieving a wider range of goals and therefore rely on a reporting and impact verification mechanism that is not connected to a specific investment project, but rather to an incentive contract and measurable impact outcomes.

## General market view

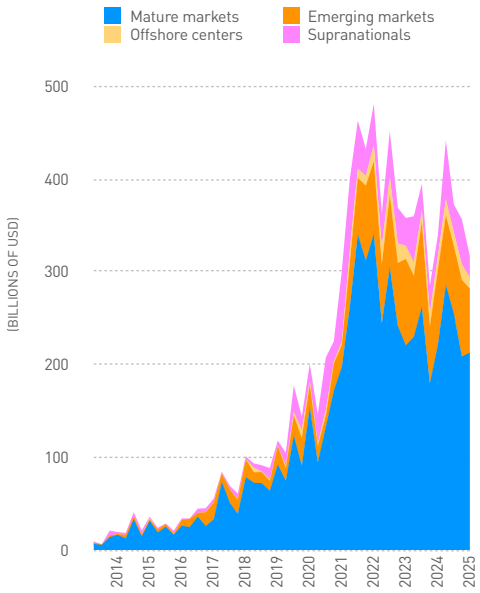
Issues of this type of product are still led by developed markets and, to a lesser extent, by emerging markets and supranational entities (see Chart 5.3-a). Thus, the current balance of debt market issues classified as sustainable (bonds and loans) reached 7.3 billion dollars as of January 2025 (20% more than in January 2024), with the breakdown by asset category shown in Chart 5.3-b.

It is worth noting that while ESG-rated bonds and loans remain the most common funding instrument, they still represent a small fraction of global bond markets (see Chart 5.3-c). In the specific case of the EU, the figure is also low, in the range of 3.0% to 3.5%, according to estimates made for the European Parliament.[87]

## Insurance industry sustainable investments

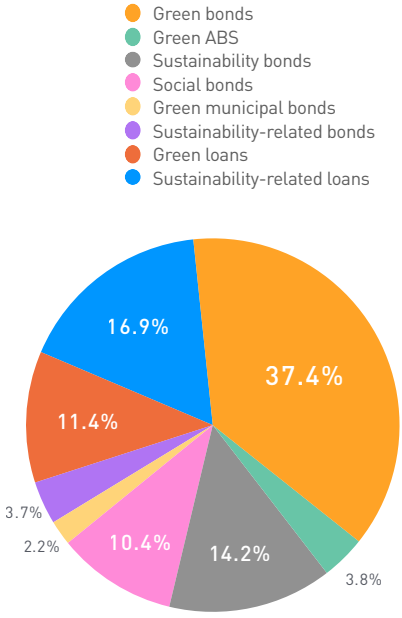
The GIMAR 2024 report by the International Association of Insurance Supervisors (IAIS)[88] presents an estimate of the proportions of different types of climate-related investments held by the insurance industry. This estimate ranges from approximately 22% to 45% of total investments (see Chart 5.3-d), of which approximately 49% corresponds to equity

**Chart 5.3-a**
**Global: sustainable debt issues**
**(bonds and loans)**



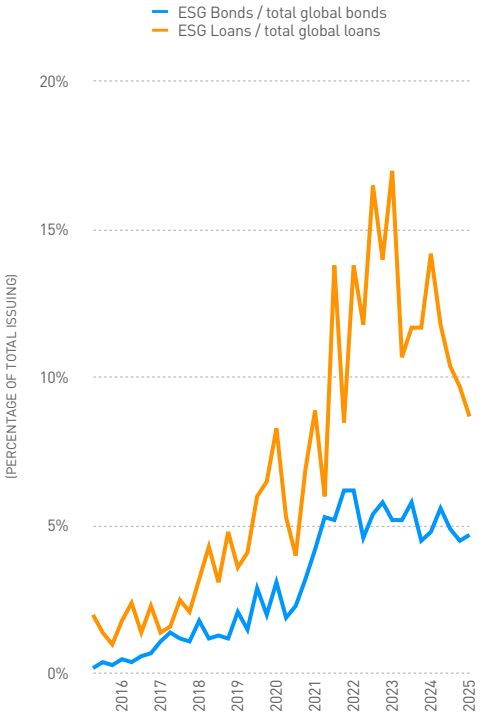

Source: MAPFRE Economics (based on IIF data)

**Chart 5.3-b**
**Global: valid issued balance by product type**
**(%)**




Source: MAPFRE Economics (based on IIF data)

Chart 5.3-c
Global: ESG issues
(bonds and loans)




Source: MAPFRE Economics (based on IIF data)

investments, 37% to loans, and the remainder to corporate debt. However, as the study itself highlights, data availability remains a challenge due to the heterogeneity of climate-related information across different regions.

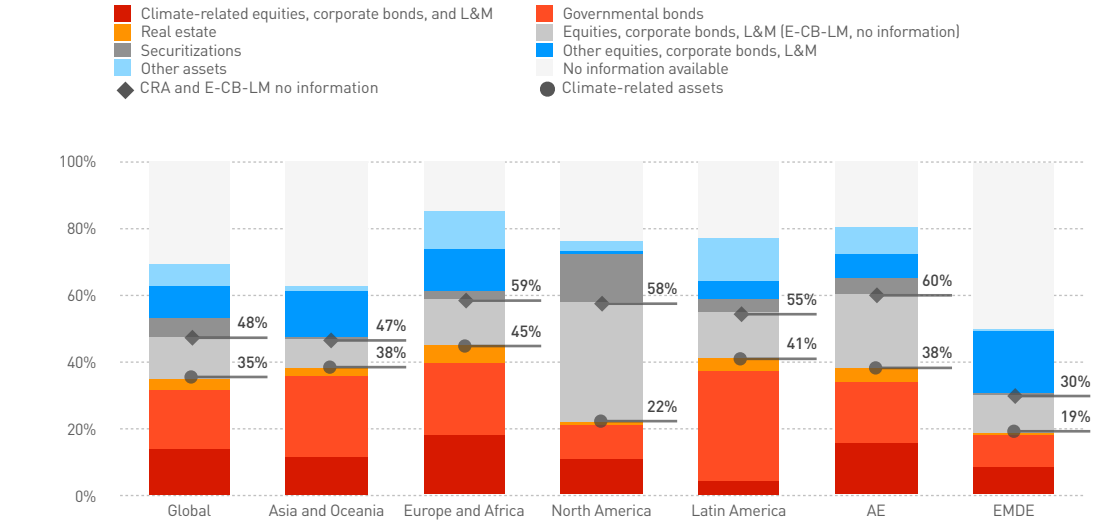
## 5.4 Initiatives in the European Union

In addition to the initiatives developed within the UN framework, the European Union (EU) has been very active, adopting a robust and complex regulatory framework to integrate climate change into investment decisions. The aim is to promote sustainability under various regulations, both in the area of disclosure for investors participating in the financial markets, and in substantive regulation that goes beyond disclosure obligations. Such regulation governs due diligence processes, including rules on third-party liability and penalties.

### Initiatives related to due diligence

On July 5, 2024, Directive (EU) 2024/1760 of the European Parliament and of the Council of June 13, 2024, on corporate sustainability

Chart 5.3-d
Global: asset composition by climate sensitivity, 2023
(%)




Source: MAPFRE Economics (with data from IAIS SWM 2024 and IIM 2024)

due diligence,[89] known as "CS3D," was published in the Official Journal of the European Union. This Directive establishes standards to promote sustainable and responsible business conduct with respect to human rights and the environment, concerning the company's own activities, those of its subsidiaries, and the activities of their business partners within their value chains.

It also sets out rules on third-party liability arising from non-compliance with these obligations, as well as the need to adopt and implement a climate change transition plan, with a global warming limit of 1.5ºC, in line with the Paris Agreement. The plan must prevent, mitigate, and minimize potential adverse impacts and remedy existing adverse impacts, monitoring the effectiveness of the company's policy and due diligence measures. Member States must require companies to retain documentation relating to actions taken to meet their due diligence obligations to demonstrate compliance, including supporting evidence, for at least 5 years from the time such documentation was submitted or obtained.

This Directive will apply progressively to companies established under the laws of a Member State, with an average of more than 1,000 employees and a worldwide net turnover exceeding 450 million euros in the last fiscal year for which annual financial statements have been approved, and to companies that do not meet these thresholds but are the ultimate parent company of a group that did meet them in the last fiscal year. It will also apply to companies established under the regulations of a third country that generate a net revenue in excess of 450 million euros in the EU, among others. The entry into force is scheduled to take place progressively between July 26, 2027, and 2029, depending on the size of the company, with the largest companies being the first to comply. The Directive must be transposed into the national legal framework of each Member State, which may lead to specific variations depending on the terms of its implementation.

Among the important definitions contained in the Directive is the definition of the *value chain*, which encompasses the activities of a company's business partners involved in the upstream links related to the production of goods or provision of services, such as design, extraction, sourcing, manufacturing, transport, storage, and supply of raw materials, products, or product components, as well as product or service development. It also includes activities of business partners involved in the downstream links related to distribution, transport, and storage of the product when these partners carry out such activities for or on behalf of the company. For regulated financial entities, the term *value chain* should not include business partners involved in the downstream links of the chain who receive the services and products. Therefore, in relation to regulated financial entities, the Directive only applies to those upstream in their value chain, and not downstream.

## Initiatives related to sustainability disclosure

There are three main standards in the EU regulatory framework related to sustainability disclosure requirements in the market: (I) The Sustainable Finance Disclosure Regulation (SFDR); (ii) the Corporate Sustainability Reporting Directive (CSRD); and (iii) Regulation 2020/852 on the establishment of a framework to facilitate sustainable investment (commonly known as "The Taxonomy Regulation"). These regulations are complemented by numerous additional implementing rules in the form of delegated regulations and technical standards for implementation, resulting in a complex regulatory framework. Currently, the European Commission has proposed an Omnibus Directive aimed at simplifying this framework.

### Sustainable Finance Disclosure Regulation (SFDR)

First and foremost, the Sustainable Finance Disclosure Regulation (SFDR) requires participants in the financial market to disclose how they integrate sustainability risks into their investment decisions. The SFDR is a European regulation that mandates financial entities to classify their investment products into three categories based on their level of sustainability: products that do not consider ESG risks or that are expressly declared non-sustainable (Article 6), products that promote environmental and social characteristics along with traditional financial objectives (Article 8), and products with explicit sustainability goals, that is, those that seek sustainable investments with a specific purpose (Article 9).

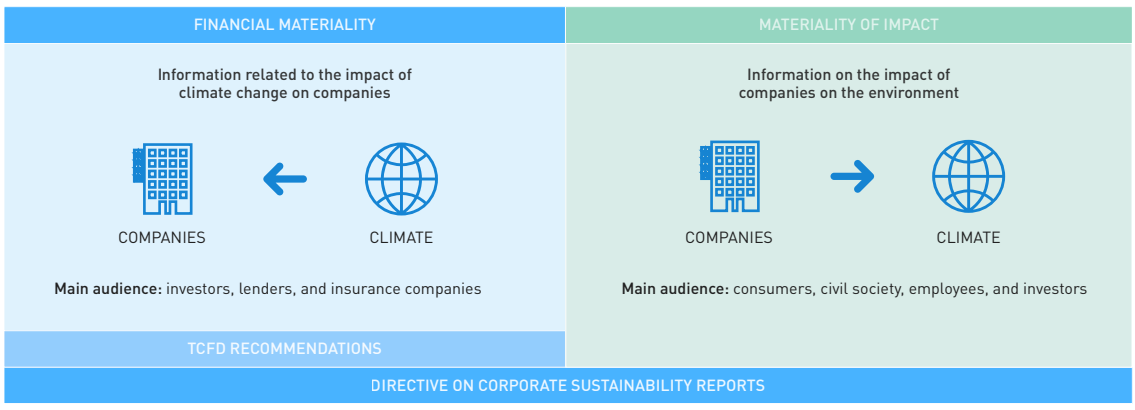
### Corporate Sustainability Reporting Directive (CSRD)

Secondly, and in line with the European Green Deal of December 2019, this standard seeks to move private capital toward sustainable activities, ensuring that financial decisions consider climate risks and opportunities. Thus, the Corporate Sustainability Reports Directive (CSRD) requires companies to provide detailed information about their climate impacts, risks and sustainability strategies, from a perspective known as *double materiality* (see Chart 5.4-a).[90] According to this directive, companies must report the information necessary to understand their respective developments, results, and positions (*financial materiality*), as well as the impact of their respective activities on environmental, social, and labor matters, respect for human rights, and the fight against corruption (*impact materiality*). The sustainability information established in the CSRD must be published according to some standardized rules (ESRS), drafted by the European Financial Reporting Advisory Group (EFRAG), which must be adopted through the corresponding delegated Regulations in order to be binding in the EU.

### European Union Taxonomy

Finally, the EU Taxonomy is a classification system introduced by Regulation 2020/852, which establishes a list of economic activities that can be considered environmentally sustainable based on six objectives: (i) climate change mitigation; (ii) climate change adaptation; (iii) the sustainable use and protection of water and marine resources; (iv) the transition to a circular economy; (v) pollution prevention and control; and (vi) the protection and restoration of biodiversity and ecosystems.[91]

Chart 5.4-a
Financial materiality of climate change and materiality of its impact



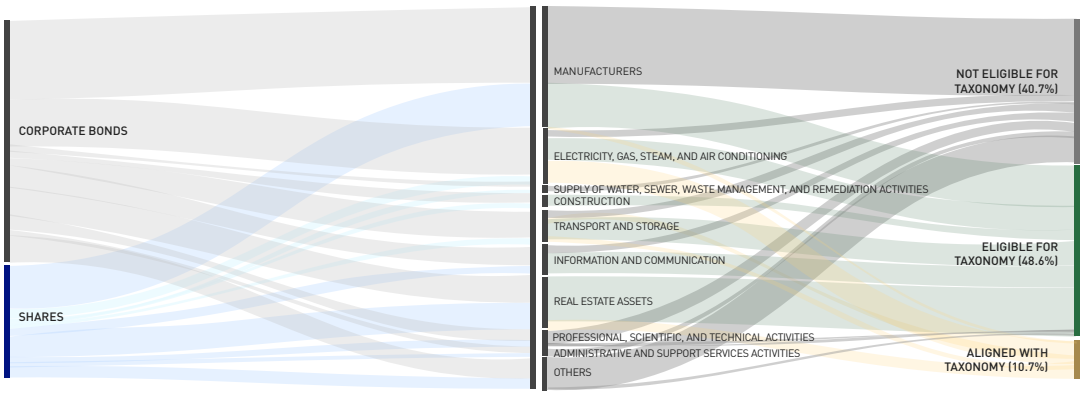

Source: Financial Stability Board, Task Force on Climate-related Financial Disclosures

The latest analysis published by the European Insurance and Occupational Pensions Authority (EIOPA) about green investments of insurance companies in 2024[92] (based on the EU Taxonomy of sustainable activities, under the framework of the NACE and focused on direct investments by insurance companies in corporate bonds and stocks that, jointly, represent about 29% of total investments) concludes that 4.5% of direct investments by insurance companies in corporate bonds and stocks adhere to this criteria. Considering only non-financial exposures, the proportion of investments that adhere to the Taxonomy stood at 10.7% in 2024 (compared to 5.7% in 2022). A more detailed analysis shows that about 20.5% of direct investments in corporate bonds and stocks, and 48.6% of non-financial exposure, are directed toward sectors that do not qualify as aligned, but that are considered eligible for the Taxonomy (see Chart 5.4-b).

The eligibility of investments under the Taxonomy refers to compliance with the requirements of Regulation (EU) 2020/852, dated June 18, 2020, on the establishment of a framework to facilitate sustainable investments, and the European Commission Delegated Regulation supplementing the EU Taxonomy Regulation. This Delegated Regulation sets out the technical selection criteria to determine the conditions under which an economic activity qualifies as a substantial contributor to climate change mitigation or adaptation to climate change, and to determine whether said economic activity does not cause significant harm to any of the other environmental objectives. It should be noted that, until December 31, 2023, companies were only required to disclose information about the eligibility of their activities, but not their full alignment with the EU Taxonomy.

Thus, both underwriting and investments must be aligned with the EU Taxonomy and its system, which rates economic activities as sustainable from an environmental perspective, including climate change adaptation and mitigation. According to the European Taxonomy Regulation 2020/852, insurers and reinsurers must report eligibility indicators and alignment related to their underwriting activities in Non-Life insurance and reinsurance. In addition, according to the EU Taxonomy Regulation, insurance companies must disclose the percentage of their investments that are eligible under the Taxonomy since fiscal year 2023, showing their alignment through two key performance indicators (investment KPI[93]).

**Chart 5.4-b**
**Taxonomy alignment of non-financial corporate bond and equity holdings of insurance companies in the European Economic Area**




Source: EIOPA

Table 5.4
Major European insurance groups by income volume from insurance service, 2023

| | Groups | ESG (S&P Ranking) | ESG Investments EU Taxonomy | Exposure to ESG funds |
|---|---|---|---|---|
| 1 | Allianz | 98 | 75% | 2,618 |
| 2 | Axa | 98 | 74% | 2,708 |
| 3 | Zurich | 85 | N/A | 1,963 |
| 4 | Generali | 99 | 67% | 1,714 |
| 5 | Talanx | 69 | 100% | 1,025 |
| 6 | Covéa | N/A | 41% | N/A |
| 7 | MAPFRE | 95 | 45% | 346 |
| 8 | Aviva | 96 | N/A | 1,488 |
| 9 | Ergo | N/A | N/A | N/A |
| 10 | Aema | N/A | N/A | N/A |
| 11 | Groupama | N/A | 71% | N/A |
| 12 | Crédit Agricole Assurance | N/A | N/A | N/A |
| 13 | R+V | N/A | N/A | N/A |
| 14 | Sogecap | N/A | N/A | N/A |
| 15 | Legal & General | 90 | N/A | 1,398 |
| 16 | CNP | 74 | 67% | 10 |
| 17 | VIG | 67 | 64% | 276 |
| 18 | Nationale-Nederlanden | 92 | 100% | 1,585 |
| 19 | Aegon | 89 | 96% | 1,030 |
| 20 | Anipol | 94 | 55% | 809 |
| 21 | Swiss Life | 81 | 78% | 1,270 |
| 22 | Sampo Group | 87 | N/A | 1,613 |
| 23 | BNP Paribas Cardif | N/A | N/A | N/A |
| 24 | Mutua Madrileña | | 78% | |
| 25 | Ageas | 81 | 69% | 1,331 |
| 26 | RSA | 78 | N/A | 4 |
| 27 | M&G | 89 | N/A | 1,040 |
| 28 | Lloyd's | N/A | N/A | N/A |
| 29 | Intesa | 98 | N/A | 2,280 |
| 30 | Poste Vita | 100 | 32% | 1,398 |

Source: MAPFRE Economics

After analyzing the information published in the annual reports of the major European groups for 2023, figures similar to the investments reported under the Taxonomy criteria in the previous section can be observed (see Table 5.4). This underscores the significant role that companies and the insurance industry as a whole can play in strengthening the pillars of resilience and sustainability. In this regard, a positive evolution is expected in the future, leading to clearer disclosure standards for EU Taxonomy-related products and greater consistency in reporting requirements.

# 6. Climate change and the carbon emission trading market

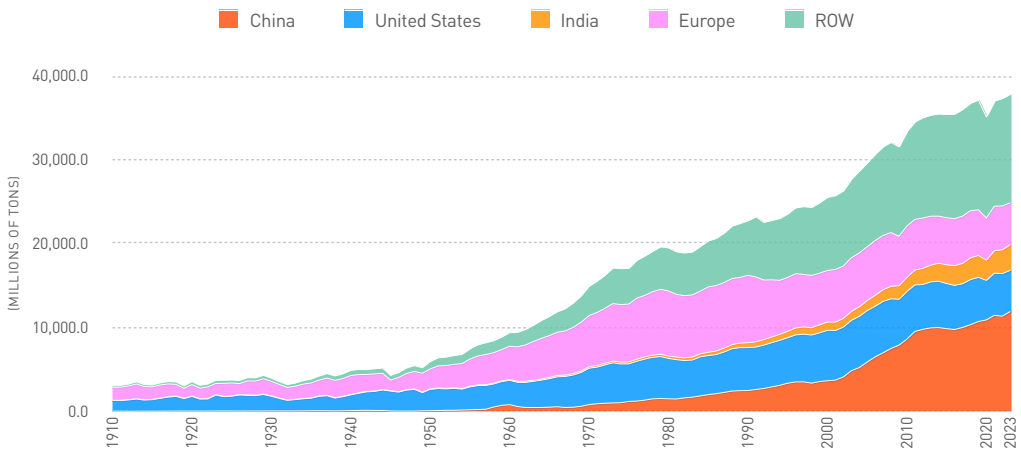
## 6.1 Greenhouse gas emissions

The onset of industrialization marked a turning point in greenhouse gas (GHG) emissions driven by human activity. The burning of fossil fuels to power steam machines, and later combustion engines and electricity generators (mainly coal and oil), released large amounts of carbon dioxide into the atmosphere (see Chart 6.1), a phenomenon that has been accompanied by gradual warming since the pre-industrial era, as highlighted in the first chapter of this report.

Since the 18th century, $CO_2$ and other greenhouse gas emissions have increased progressively, although awareness of global warming and its potential climate consequences was limited at the time. However, the period after World War II led to economic growth and an unprecedented increase in energy consumption. The reliance on fossil fuels intensified, leading to an exponential rise in GHG emissions. In recent decades, there have been increasing efforts to curb emissions, but the surge in industrial activity and energy consumption in both developed and emerging economies has partly offset these efforts.

The main greenhouse gas is carbon dioxide, primarily generated by the burning of fossil fuels, in addition to what is emitted by other phenomena like wildfires. However, there are other gases also associated with human activity, such as methane ($CH_4$) and nitrous oxide ($N_2O$), which originate from livestock farming, intensive agriculture, the use of fertilizers, and the decomposition of organic waste. Among the initiatives dedicated to trying to reduce GHG emissions is the COP ("Conference of the Parties"), the supreme decision-making body of the United Nations Framework Convention on Climate Change (UNFCCC). COP meetings are held annually and bring together representatives from signatory countries, international organizations,

Chart 6.1
Global: annual $CO_2$ emissions




Source: MAPFRE Economics (with Global Carbon Budget 2024, with major processing by Our World in Data)

experts, and members of civil society to debate, negotiate, and evaluate the progress in the fight against climate change. These conferences aim to reach global consensus on specific measures to reduce GHG emissions, to strengthen adaptation to the effects of climate change, and to guarantee the necessary financing and international cooperation to achieve these goals.

Key agreements have been adopted during these meetings, such as the Kyoto Protocol in 1997 and the Paris Agreement in 2015. The latter is an international treaty adopted under the framework of the UNFCCC, with the central goal of limiting global warming to below 2ºC above preindustrial levels, making efforts not to exceed 1.5ºC. To that end, it establishes voluntary commitments by signatory countries (Nationally Determined Contributions, NDC) to reduce their GHG emissions, promote measures to adapt to climate change, and mobilize climate finance toward the most vulnerable countries. It also considers a periodic review mechanism to progressively increase the ambition of the parties' climate commitments.

At the 2023 Climate Summit (COP28[94]), it became evident that the private sector plays a fundamental role in achieving global climate goals,, where its involvement is very important. The summit concluded that, in order to limit global warming to 1.5ºC, the agreement establishes that global GHG emissions must be reduced by 43% by 2030, and 60% by 2035, in relation to 2019 levels, thus reaching net-zero carbon dioxide emissions by 2050. This commitment was reinforced at COP29 held in 2024, where, in addition, the need to secure the necessary financing for developing countries to reduce their emissions was discussed, ultimately agreeing that developed countries will provide support amounting to 300 billion dollars annually until 2035.[95]

It is important to highlight another key initiative aimed at reducing GHG emissions: the creation of carbon markets, where emission allowances (carbon credits) are bought and sold. In this way, the sellers generate income by offsetting the emissions of buyers, facilitating a transition toward a low carbon economy and reducing the environmental footprint.

## 6.2 Greenhouse gas emission allowance trading systems

Two major categories can be distinguished in greenhouse gas emission trade systems: regulated and voluntary. The most prominent are the regulated systems, which set mandatory limits for specific emitters of $CO_2$ and other greenhouse gases. These typically include companies in sectors such as power generation, oil and gas, mining, cement, steel, chemicals, aviation, and other heavy industries, depending on the scope of each market. These systems allow participants to trade their emission rights with each other or with other actors ("cap and trade"). The voluntary systems are still in an early phase of development, and are much more limited in relation to their volume compared to the regulated systems.

### 6.2.1 Regulated emission allowance trading systems

Regulated emission allowance trading systems (Emission Trading Systems, ETS[96]) are designed to reduce GHG emissions and are created through a state or supranational regulation. They establish a regulatory maximum limit for the total amount of emissions permitted within a specific area ("Cap"), which may be, for example, a country or a region. Thus, what are called "emissions allowances" are created, where each allowance is normally equivalent to a ton of $CO_2$ permitted, and these allowances are distributed to polluting companies or entities, either free of charge or through auctions (primary emission allowance market). Companies that manage to reduce their emissions below their allocation can sell their surplus allowances to those that exceed their allowance on a regulated secondary

trading market where these allowances are bought and sold, thus establishing a price for carbon emissions ("trade"). The main goal is to create incentives for reducing emissions, as companies face a cost for each ton of $CO_2$ they emit.

According to data from the World Bank,[97] although there is still a long way to go between the commitments countries have assumed and the final policies implemented, global revenues arising from the price of carbon in 2023 reached 104 billion dollars, where carbon taxes and the Emission Trading Systems (ETS) cover about 24% of global emissions. It should be noted that, currently, there are 75 carbon pricing instruments operating worldwide[98] (see Chart 6.2.1-a).

## United States

In the United States, two major mandatory regional carbon markets are currently in operation: California's Cap-and-Trade program and the Regional Greenhouse Gas Initiative (RGGI), which covers several states in the Northeast. However, the United States does not have a mandatory regulated carbon market at the federal level and is not expected to create one in the near future. This is largely due to the decision by the country's new federal administration to withdraw from the Paris Agreement, thus abandoning the previous administration's commitment to reducing emissions by 50-52% by 2030. The current policy direction favors deregulation and opposes carbon pricing mechanisms.

### California "Cap-and-Trade"

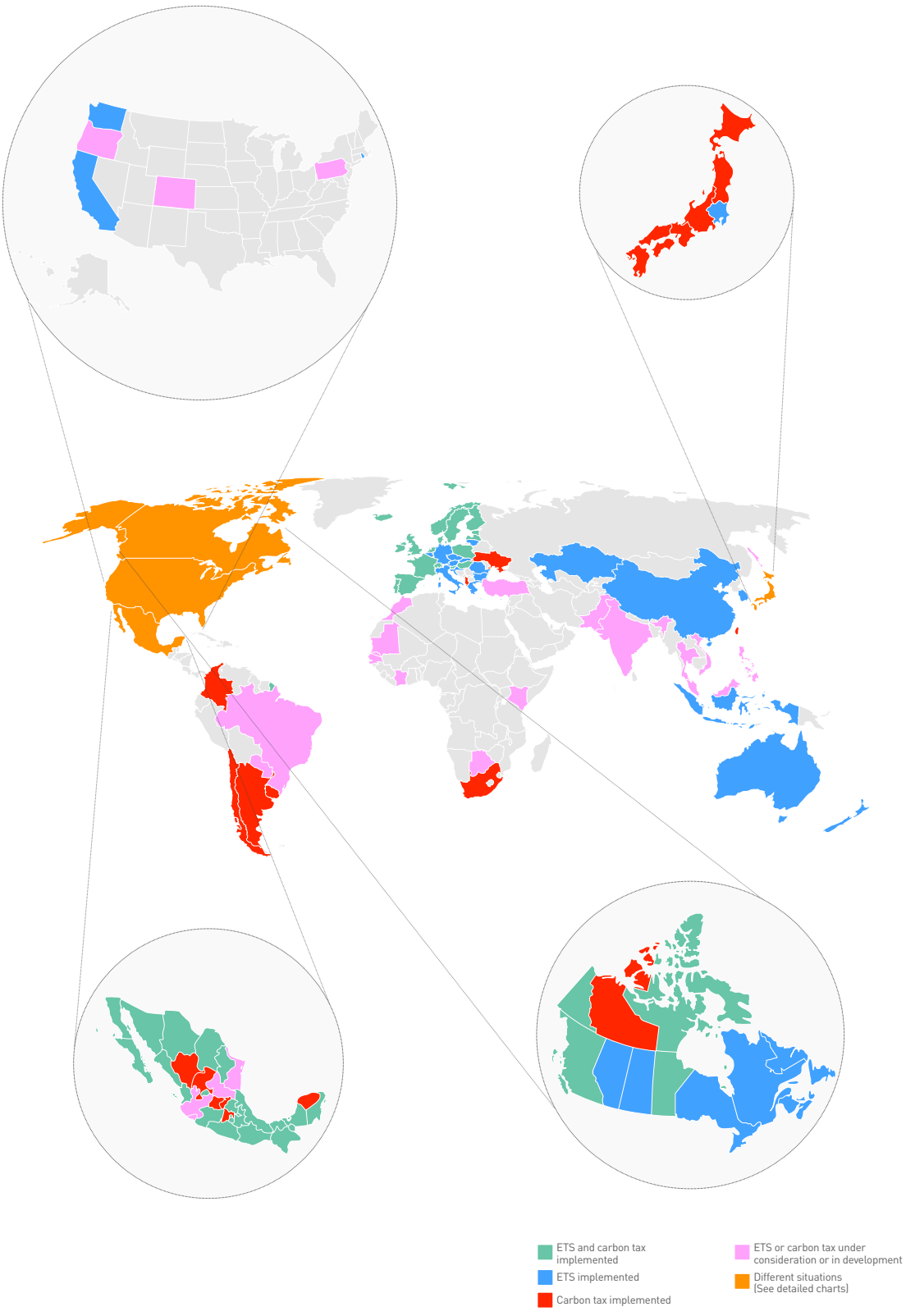
The California "Cap-and-Trade" market was established in 2013 and covers approximately 85% of emissions in the state of California,[99] including energy generation, large industries, and transportation fuels. Participants in the U.S. carbon trading markets are predominantly electric utilities, power generators, fuel distributors, and industries based in California.[100] Around 450 regulated entities are covered, including oil refineries, cement plants, and gas importers, which must purchase allowances or use limited offsets for any emissions exceeding their free allocations. Key companies subject to emissions caps, which normally act as buyers of emissions allowances in this trading system, include companies like Pacific Gas and Electric Company (PG&E) and Southern California Edison (SCE), refineries like Chevron and Valero, and cement companies, among others.

Financial entities or investment fund managers can acquire emissions allowances and resell them, although their scale is smaller compared to other similar markets. Overall, institutional investor participation in U.S. carbon markets is slowly growing through specialized funds and Exchange-Traded Funds (ETFs), but they are still largely dominated by companies subject to emissions caps, with relatively less participation by banks and investment funds than in the European Union market, which currently stands out as the most developed globally.

### Regional Greenhouse Gas Initiative

The Regional Greenhouse Gas Initiative (RGGI) is a cooperative emission trading system (ETS) among eleven states of the Northeast and Middle Atlantic of the United States, including Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, Vermont, and Virginia (although the latter state is planning to withdraw). This emission allowance trading market has been operating since 2009, generally with lower prices than the California market. In the RGGI, public service companies that operate fossil fuel energy plants are the main buyers in the quarterly auctions. There, too, financial institutions and investment fund managers can buy permits at auctions and resell them, but the scale is smaller than the California "Cap and Trade" emissions allowance market.

Chart 6.2.1-a
Global: map of carbon taxes and emissions trading systems (ETS)




Source: MAPFRE Economics (based on data from the World Bank)

## Canada

Canada does not have a unified carbon market, but rather a heterogeneous range of carbon price fixing systems, mainly carbon-linked taxes applicable in numerous provinces and some systems of caps on emissions along with an emissions trading system or ETS.[101] The most notable ETS is in the province of Quebec, which is linked to California's Cap-and-Trade Program, sharing administrative infrastructure and harmonized standards. Together, they operate a joint emissions market ("Cap and Trade") allowing cross-border trade of emissions allowances. This joint initiative is also known as the "Western Climate Initiative" (WCI). The main participants in these Canadian systems include public service companies (like Hydro-Quebec), industrial and oil companies and, increasingly, the financial sector, as carbon prices rise. In the province of Nova Scotia, a small cap-and-trade system is in place, while Alberta and Ontario have used "output-based pricing systems" (OBPS) for industry, which are voluntary benchmark and credit programs rather than fixed emission limits. Ontario briefly joined the WCI in 2017, but withdrew in 2018 after a change of government, highlighting the political vulnerability of carbon markets.

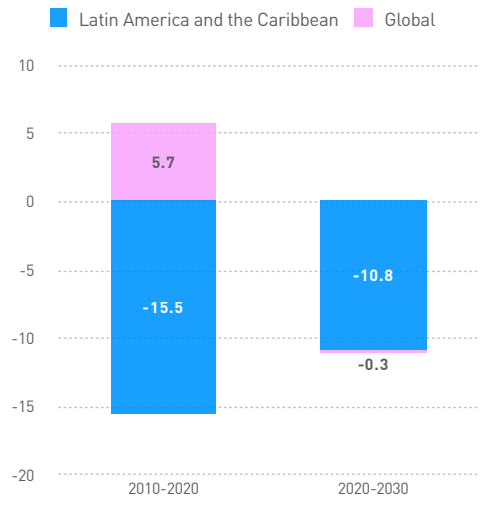
At the federal level, Canada's approach has been to impose a national carbon price floor, requiring provinces to implement a system that meets or exceeds a set price (80 Canadian dollars/ton in 2024, increased to 170 dollars by 2030). Some provinces comply through a tax; others, through trading systems for large emitters that apply mainly to the oil and gas industry, with the goal of achieving net-zero emissions by 2050.

## Latin America

Throughout history, developed countries have had a greater responsibility for greenhouse gas (GHG) emissions, contributing 45% of the total, compared to 11% by Latin America and the Caribbean. A report on this subject published by the Development Bank of Latin America (CAF)[102] reveals the need to reduce the environmental footprint through energy strategies. Globally, the register of Nationally Determined Contributions (NDC) shows that this decrease would be less than 1%, greater in Latin America and the Caribbean, who have committed to reducing their emissions 11% by 2030 (see Charts 6.2.1-b and 6.2.1-c).

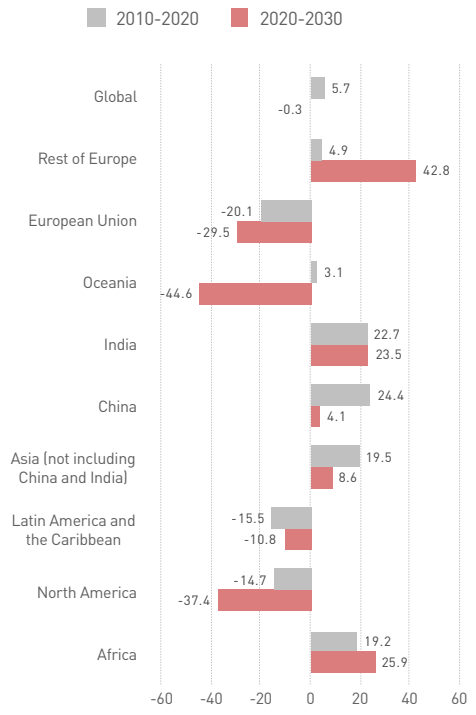
The emission allowance trading systems in the region seem to be consolidating as one of the most effective tools to reduce GHG. According to the ICAP (International Carbon Action Partnership),[103] the promotion and implementation in some emerging economies are especially notable, particularly in Brazil, which approved Law No. 15,042 to establish a regulated carbon market in the country and to set caps for GHG emissions.[104] For its part, after several years of implementation, Mexico culminated the SICEM (*Sistema de Comercio de Emisiones en México*, Emission Trading System in Mexico) project in February 2025,

**Chart 6.2.1-b**
**Latin America: variation of GHG emissions**
**(greenhouse gases, %)**




Source: MAPFRE Economics (with data from CAF, Development Bank of Latin America and the Caribbean)

Chart 6.2.1-c
Global: variation in GHG emissions
(%)




Source: MAPFRE Economics (with data from CAF, Development Bank of Latin America and the Caribbean)

with the support of the German Government (German Sustainable Development Cooperation, GIZ), developed under the framework of IKI (International Climate Protection Initiative),[105] and it is expected to be fully operational in the near future.

## European Union

In the European Union, the emissions allowance trading system (EU Emissions Trading System, EU ETS) was the first carbon market in the world, and today is one of the largest globally, contributing to the reduction of global emissions.[106] This market covers approximately 40% of the total greenhouse gas emissions in the European Union, encompassing a wide range of companies and sectors. These include the energy generation sector (power plants and other combustion installations producing electricity and heat), other energy-intensive sectors (oil refineries, iron and steel production facilities, cement, glass, ceramics, paper manufacturing, and chemical industries), the aviation sector (airlines operating flights within the European Economic Area), and, starting in 2024, the maritime sector (large ships operating routes within and outside the European Union). It is also expected to gradually include road transport and buildings.

To reduce GHG emissions, a limit is set on the total amount of gases the sectors covered by the system can emit ("Cap"). The maximum cap is expressed in emissions allowances, in which one allowance is equivalent to one ton of $CO_2$. The price of these allowances is set by the European Union carbon market, operating under regulatory oversight. Companies that emit less than their stipulated allowances can sell their emission allowances to other companies that exceed their permitted emissions ("Trade"). The price of emission allowances is determined by the balance between supply—set by the European Commission through a cap on the total number of allowances to meet emission reduction targets—and demand, which reflects the needs of sectors required to surrender allowances for their greenhouse gas emissions.[107]

This market began operating in 2005 through Directive 2003/87/CE of the European Parliament and the Council, for which a GHG emissions allowance trading regimen was established in the Community. In the initial phase, under the National Allocation Plan (NAP) that each Member State was required to develop, the total number of emission allowances to be allocated during the period was agreed upon, along with the method of allocation. In phase two (2008-2012), the total volume of emission allowances remained constant, and later, in the 2013-2020 period, the auction was introduced as a method to allocate emission allowances and establish the allocation of allowances at the community level; therefore the National Allocation Plan of each country disappeared.[108] In the current phase, it is expected that

the free allocation will be gradually reduced, and other sectors will be incorporated, such as building and road transport, among others.[109]

In its early phases (2005-2012), excessive free permit allocation led to a significant drop in prices. However, the 2017-2018 reforms addressed this surplus by establishing the Market Stability Reserve to restrict supply.[110] Meanwhile, since their classification as financial instruments in 2018, banks and investment funds have also become active in this market, improving liquidity. Today, the leading oil and energy companies, steel works, cement producers, and airlines are among the major buyers, while some public service companies also sell surplus emissions allowances. Financial intermediaries, investment funds, and carbon-focused hedge funds are playing an increasingly important role in taking positions and creating a market. In particular, hedge funds have treated carbon emission allowances in the European Union as an investment asset, betting that the strictest climate goals could drive prices upward. According to the European Commission and the European Securities and Markets Authority (ESMA), the price increase has been largely driven by market fundamentals and the adjustment policy implemented (see Chart 6.2.1-d). In general, the carbon market has consolidated as a deep and liquid market, dominated by the European Union ETS, which represented approximately 87% of the global carbon market value in 2023, according to that organization's estimates.[111]

The regulatory scope and changes have expanded the EU ETS and will continue to affect emission allowance prices. In its fourth phase (2021-2030), the annual reduction rate of the cap will be more stringent to align with the goal of net-zero emissions by 2050. The European Union is also launching a separate ETS II for buildings and transport fuels in 2027. Meanwhile, free allocation for industries is gradually being phased out. Overall, the future outlook of the EU ETS

**Chart 6.2.1-d**
**European Union: emission allowance estimates**
**(EUR by tons of $CO_2$)**


Source: MAPFRE Economics (based on Bloomberg data)

points to a tightening supply and broader coverage, which could lead to higher prices over time, barring temporary downturns in economic cycles and with significant risk from regulatory uncertainty, among other factors.

Among the latest regulations approved is the so-called European Climate Legislation, contained in EU Regulation 2021/119 of the European Parliament and the Council, which establishes the framework for achieving climate neutrality.[112] This regulation is intended to ensure that all EU policies contribute to the goal of achieving a neutral economy and society by 2050 ("net-zero GHG emissions" for the EU countries as a whole). To this end, an intermediate target is to reduce emissions by at least 55% by 2030, compared to 1990 levels.

Moreover, the Carbon Border Adjustment Mechanism[113] (CBAM) was created through EU Regulation 2021/119 of the European Parliament and the Council, with the objective of establishing a fair price for carbon emitted

during the production of carbon-intensive goods entering the European Union, in order to promote clean production in non-EU countries. Its transitory phase began in October 2023, and the definitive regime will be implemented in 2026.

### United Kingdom

Following Brexit, the UK left the EU ETS and launched its own emission trading system in January 2021, similar to that of the EU, covering energy, heavy industry, and aviation within the UK, with an initial cap 5% tighter than that of the EU. In its first two years, the UK carbon price largely followed the EU price, and since then it has been more volatile, so the UK government may be considering adjusting the cap and possibly linking it to the EU ETS in the future, which could harmonize prices. Otherwise, the operation of this market bears strong similarities to that of the European Union.

### China

After launching regional pilot markets in seven provinces starting in 2013, China inaugurated its national carbon market in July 2021. In its initial phase, China's national ETS covers just over 2,000 electric companies, encompassing 4.5 billion tons of $CO_2$, which is approximately 40% of China's emissions.[114]

Unlike the traditional cap-and-trade system, China's design began as a system based on state-owned electric companies, primarily coal and gas-fired power plants, many of which initially received extensive free allowances based on carbon intensity benchmarks (tons of $CO_2$ per MWh). As a result, allowance prices have been moderate and traded in a narrow band, so while it is large measured in terms of emissions volume, it is still a modest market in terms of prices. Companies that exceed their benchmarks (emitting less $CO_2$ per unit of energy) can sell their surplus allowances, while those that emit more must buy. Meanwhile, the Chinese government has only gradually allowed financial institutions to participate and, during the pilot phases, some markets (such as Guangdong) experimented with institutional investors. However, participation in the national market remains largely limited to the covered companies—currently, mainly large state-owned power producers (such as Huaneng, Datang, and others), which are the key players on both the buying and selling sides. In this context, the price of carbon in China remains well below that of Europe, reflecting its current oversupply and the size of the sector, although it is expanding coverage to gradually include the steel, cement and, aluminum industries.[115]

### Other Asian markets

Japan has launched an emission trading system (GX-ETS),[116] with a first phase of voluntary participation by companies, intended to encourage them to lead the transition to carbon neutrality, which will become mandatory after 2026. Countries such as South Korea and New Zealand also have a system in place, with the latter having a long-standing ETS (since 2008) covering most sectors. Meanwhile, after revising its climate regulation system, Australia[117] will also ask large GHG emitters to reduce their emissions, within the framework of a credit trading system.

## 6.2.2 Voluntary carbon markets

Voluntary carbon markets allow companies and other organizations to purchase carbon credits to offset their GHG emissions outside of any regulatory requirements. Although this market is small, it has been growing in recent decades, albeit with fluctuations,[118] offering a private financial ecosystem that facilitates its operation, continues to expand, and is becoming increasingly sophisticated.[119] Supply in the voluntary market is generated by developers who design and implement carbon reduction or removal projects, for example,

reforestation initiatives, renewable energy facilities, methane capture, or improved distribution of direct air capture facilities, among others.[120]

These projects generate carbon credits (each typically representing one ton of $CO_2$ reduced or removed) that can be sold. Credits must be certified by independent standards to ensure that they meet quality criteria (actual, additional, permanent, and verified emission reductions). In this regard, the main standards are Verra's VCS (Verified Carbon Standard), Gold Standard, and the American Carbon Registry (ACR), together with Climate Action Reserve (CAR), Verra being the largest by volume worldwide. Gold Standard (backed by WWF) is known for its emphasis on sustainable development benefits, while ACR and CAR, both based in the United States, also certify various types of projects. These standards, meanwhile, not only certify projects, but also maintain records that track the issuing and removal of credits to ensure that there is no double counting. The major companies and financial players remain committed and are even increasing their involvement in high quality credits, although scrutiny over their actual effectiveness is growing more rigorous to ensure that climate targets are genuinely being met.

On the demand side, the main buyers in the voluntary market are corporations with climate or sustainability commitments. This includes companies in the technology, finance, consumer goods, and energy sectors. For example, large tech companies (Microsoft, Google, Meta) have been active buyers of offsets to address unavoidable emissions; Microsoft even set a goal of being carbon negative by 2030 and is investing heavily in carbon removal credits. Large oil and gas companies (Shell, BP, Total) have also purchased large volumes of nature-based offsets to compensate for a portion of their product emissions, or to offer carbon-neutral LNG and gasoline to customers. Airlines (Delta, United, British Airways) purchase offsets to neutralize flight emissions (especially as part of CORSIA, the aviation industry's carbon offsetting program). Retail and consumer brands (Nike, Disney, Starbucks, among others) have also used offsets for specific products or events. Notably, in 2024, some of the main buyers were Shell and Microsoft, which emerged as the largest buyers of voluntary credits.[121]

Meanwhile, financial institutions and intermediaries are playing an increasingly prominent role by facilitating transactions, connecting buyers and sellers, and in some cases, taking positions in credits themselves (e.g. Hartree Partners, Macquarie's carbon desk, SCB Group). Dedicated carbon trading platforms have also emerged: exchanges such as Xpansiv CBL, AirCarbon Exchange, and Climate Impact X, which offer electronic marketplaces for offsets, improving transparency and liquidity. There are also aggregators and retailers that bundle credits for smaller buyers and offer products certified as "carbon neutral." Lastly, although still in its early stages, some investors are also using tokenization (conversion of credits to blockchain tokens) to create new trading avenues.

Overall, the voluntary carbon market ecosystem now includes project developers, third-party verifiers, standard-setting bodies, brokers, exchanges, investors, and end buyers.[122] This ecosystem is striving to mature by improving standardization and trust. In this regard, efforts are being made to establish reference prices for different types of credits (e.g., nature-based vs. technology-based removals) and futures contracts for offsets. As a result, corporate interest in offsets remains, especially for "hard-to-abate" emissions and net-zero strategies post-2030. Moreover, the implementation of Article 6 of the Paris Agreement (international trade), as of 2021, means that some voluntary projects may be eligible to transition into compliance-grade international credits, which could even blur the boundaries between these markets and regulated markets.

# 7. A public policy analysis

## 7.1 Current trends

Closing the insurance protection gap for natural and anthropogenic catastrophic risks is a *public policy challenge that must be addressed from a multi-faceted perspective*. This requires coordinated action by insurers and other stakeholders with all levels of government at the local, national, and international levels.[123] Insurance and reinsurance companies can make a substantial contribution to managing the impacts of such disasters by providing timely funds for recovery and encouraging risk reduction. However, without adequate measures, climate risks may become uninsurable or unaffordable, which not only fails to reduce the protection gap but may actually widen it.[124]

Therefore, public administrations must collaborate, and even take the initiative, to adopt proactive policies to maintain the viability of insurance markets while at the same time leveraging insurance mechanisms to promote climate adaptation and loss prevention. In this context, this chapter analyzes four key aspects of public policy measures to address the climate disaster insurance protection gap:

- *Public-private insurance partnerships for climate disasters*. Development of collaboration frameworks between public administrations and the insurance industry to manage and share disaster risks.

- *Incentives for prevention and risk reduction of adverse climate events*. Use of insurance as a tool to incentivize risk reduction, and integration of insurance into broader climate adaptation and disaster risk management efforts, early warning systems and their transfer to the capital market.

- *Measures for the collection and management of catastrophic loss data*. Improved risk data, modeling, and pricing strategies.

- *Measures aimed at expanding coverage through parametric solutions*. Coverage expansion through combinations of parametric (index-based) insurance solutions, along with conventional insurance.

Chart 7.1
Key aspects of public policies to address the climate disaster insurance protection gap


Source: MAPFRE Economics

## Public-private insurance partnerships for climate disasters

Catastrophic natural disasters (geological or weather-related) are sometimes too large and potentially systemic for the private market or the public sector to deal with on their own, resulting in insurance coverage gaps. Therefore, cooperation is needed to broadly distribute this type of risk, taking advantage of the insurance industry's experience and aligning incentives to reduce these protection gaps. Public-private partnerships (PPPs) between government authorities and the insurance industry can be a key element in jointly managing disaster risk, as demonstrated by the experience of countries where such arrangements are in place.

Generally speaking, PPPs can take various forms, such as government-backed insurance pools, government-subsidized coinsurance programs, government reinsurance for private insurers, or joint financing schemes to ensure affordable coverage. Many countries have successfully used PPPs to address disaster insurance market failures, especially when private insurers alone charged unaffordable premiums or excluded high-risk areas. This section describes how policymakers can initiate and develop PPPs over time, in collaboration with the insurance industry, as a strategy to close the insurance protection gap.

To ensure the success of PPP schemes, broad participation is essential. Given the nature of the risks being covered, the larger and more diverse the pool, the more stable and affordable the coverage will be. Participation in the scheme could be made mandatory for *all* insurers operating in certain lines (e.g., property insurance such as home, auto, business, homeowner associations, life insurance, or personal accident insurance, among others), requiring them to transfer a portion of premiums and losses to the pool. Similarly, policyholders would be included on a mandatory or automatic basis, so that the fund would not be made up of only the highest risks, thus avoiding adverse selection. An analysis of the main PPPs currently in operation, as discussed in Chapter Three of this report, reveals a wide variety of partnerships in terms of the specific catastrophic risks they cover and, accordingly, of the variety of insurance lines on which some type of surcharge is imposed to constitute the funds necessary for their operation.

For example, the UK's Flood Re collects a premium from household insurance policies whose flood risk is ceded to the pool, in addition to a mandatory annual contribution from all insurers with such coverage, based on their market share. Meanwhile, France's Nat Cat is financed by a mandatory surcharge on damage insurance policies, while the Insurance Compensation Consortium (*Consorcio de Compensación de Seguros*) in Spain assumes the extraordinary risk of natural catastrophes by charging a mandatory surcharge on practically all insurance policies, with only a few small exceptions. These three systems are reference models for other countries that are considering creating a coverage fund to offset these catastrophic risks. Even in systems with broad catastrophe risk coverage under a PPP, there are some specific risks that are excluded due to their unique treatment. These include catastrophe risks affecting the agricultural sector or nuclear accident risks, which are covered by mechanisms specifically designed for them, normally within the framework of a holistic industry policy that considers all public policy measures for that sector, with catastrophe risk coverage being just one component of that broader framework.

Establishing or enhancing such collaborations is not a straightforward process and requires representatives from finance ministries, insurance regulators, large insurers, reinsurers, and consumer groups to work together to design PPP solutions for climate

risks. As noted by the International Association of Insurance Supervisors (IAIS), insurers have an interest in this regard and are always "ready to engage in a constructive dialog with public authorities" on the coverage of extreme events.

In this regard, the European Union (EU) is currently discussing a public reinsurance arrangement at the EU level to support national schemes for megadisasters.[125] This would allow a multi-layered funding structure to be put in place ensuring that claims can always be paid without destabilizing either insurance companies or public finances. In any case, governments should ensure that PPP-based schemes have access to adequate funding for major disasters, which may involve building reserves during low-loss years and securing backup funding, such as contingent lines of credit or reinsurance for the pool. For example, a national flood insurance pool could purchase reinsurance on the international market for events that exceed a certain threshold. In the case of emerging countries or regions, authorities might negotiate a permanent contingent loan with an international financial institution, to be used in case reinsurance capacity is exhausted. Likewise, public policies could allocate funds or guarantees for these purposes.

Establishing permanent structures with sufficient capital would help avoid having to make ad hoc decisions in the aftermath of catastrophic events—such as when insurers withdraw from the market, as occurred in California with wildfire coverage. In that case, a state-run "FAIR Plan" now acts as an insurer of last resort for homes at high wildfire risk when private coverage is unavailable. Similarly, this avoids the need for measures like temporary premium subsidies or tax incentives to persuade insurers to stay in the market.

As PPP-based schemes are implemented, governments must establish processes to evaluate their performance and make any necessary adjustments. In this regard, a medium-term measure is to establish an independent board or oversight body for PPPs, including members from government, the insurance industry, consumer advocates, and technical experts, to periodically review the financial health of the scheme, coverage levels, claims payments, and the impact on the protection gap. If certain regions remain underinsured, or if the scheme is accumulating too much risk, the supervisory board or body could recommend changes, such as adjusting premium rates, adding new risks (such as including drought coverage to a flood insurance scheme or hail coverage for severe convective storms), or improving procedures for receiving and paying claims. This *adaptive management*, which could be required in the scheme's founding legislation, means that PPP can evolve with the climate and market conditions, rather than being static.

Based on its performance, public policy should aim to transition any temporary arrangement into a stable, well-funded entity with clear governance, offering long-term certainty to citizens and markets that coverage will remain available even as climate risks evolve. Ultimately, a mature PPP fulfills a similar function to that of a public service company, duly regulated, partially public, but efficiently managed with private sector participation, providing affordable disaster coverage as a public good.

**Leveraging existing insurance infrastructure**

Many households and small and medium-sized enterprises (SMEs) already have some form of insurance that may have natural catastrophe coverage built into existing policies by law, for a surcharge. This approach is used in countries such as France and Spain, where by law all property policies include disaster coverage backed by a public reinsurer. These measures can drastically reduce the protection gap in the short term by expanding the risk pool to which everyone contributes via a small

premium, ensuring broad coverage without relying on voluntary uptake.

In such a model, private insurers would underwrite the insurance contracts and service the policies, but most of the catastrophic risk would be reinsured by a public entity, taking control of claims in such cases, potentially with a broad government guarantee for truly extreme losses. Premiums could be risk-based, but with a degree of cross-subsidization (solidarity), as in the French model, where a uniform surcharge finances the scheme. Implementation requires capitalizing the fund (through budget allocation or taxation), formalizing operational agreements between the government and insurers, and conducting a broad public outreach campaign so that people understand the new protection being offered.

**Public-private coordination for recovery and reconstruction**

In the long term, collaboration between government authorities and private insurers can be expanded beyond the financial aspect to operational collaboration in disaster response. In this regard, public policies can formalize various roles; for example, coordinating claims payments under the PPP scheme with governmental aid programs to maximize efficiency. One long-term measure could involve establishing a unified platform or "one-stop shop" for disaster victims, where insurance claims under the PPP scheme and government aid applications are processed jointly, simplifying and streamlining the recovery process. Ideally, private insurance companies and the government should also share post-event data to improve underwriting and future planning. One notable example is the close collaboration between New Zealand's Earthquake Commission (EQC—a PPP-like entity), private insurers, and the government in managing claims and repairs following earthquakes, effectively functioning as a single recovery program.

**Climate change adaptation in the design of public-private partnerships**

In the long term, PPPs will require flexibility to adapt to shifting patterns of climate risk, and the policies that establish these schemes must ensure that built-in mechanisms are in place to manage evolving trends. This may include the periodic recalibration of covered risks or the reclassification of high-risk regions as new climate data emerges. A PPP might also expand its membership; for example, initially national, but eventually connected to the schemes of other neighboring countries for greater diversification if the climate impacts are correlated. Ongoing discussions within the European Union on pooling disaster risk among Member States exemplify a forward-looking approach to expanding the scope of public-private partnerships.[126] Despite the inherent challenges in reaching stable, multilateral, cross-border agreements, it would be desirable to work toward a regional or federal PPP that shares cross-border risks, a logical evolution if extreme weather events continue to intensify.

**Global and multinational linkages between public-private partnerships**

Given the global nature of climate risks, countries could benefit from connecting their insurance pools and sharing reinsurance reserves. International public policies, through treaties or organizations (such as the G20, the Financial Stability Board, or the United Nations), could facilitate a network of national PPPs that provide mutual support. For example, if a catastrophe depletes one country's fund, others could contribute under predefined conditions, knowing that next time, the situation could be reversed. This situation would be similar to how certain regional reinsurance agreements function, but on a greater scale. Undoubtedly, establishing such linkages would be complex, but over time, trust and the successful track record of national schemes could make them

feasible. Essentially, a "coalition of insurance funds" could share reinsurance or issue catastrophe bonds collectively, achieving better prices and diversifying the climate risk at a global level.

Additionally, countries with a limited private insurance capacity could resort to schemes like the World Bank's Catastrophe Deferred Drawdown Option (Cat-DDO). This is an instrument structured as a contingent credit line that provides immediate liquidity to member countries of the International Bank for Reconstruction and Development (IBRD) and the International Development Association (IDA), after the occurrence of a natural catastrophe or a public health emergency caused by a biological event.[127] In any case, the International Monetary Fund (IMF) and the World Bank advocate for risk layering, maintaining certain reserves while relying on insurance mechanisms for extreme events.[128]

In the short term, institutions like the multilateral development banks or export credit agencies can support public-private partnerships (PPPs) by acting as a backstop to strengthen the insurance industry's capacity to absorb disaster risk, while the necessary funding is gradually built up. This approach encourages insurers to underwrite new risks in areas traditionally considered uninsurable. In any case, public policies should address matters of equity and moral risk, ensuring that the support does not discourage local risk reduction, possibly requiring recipient countries to invest in their own adaptation as a condition for subsidized coverage.

## Incentives for prevention and risk reduction of adverse climate events

### Prevention measures

Promoting preventive and mitigation measures to reduce damage caused by events related to catastrophic risks and, in particular, with natural catastrophes derived from an adverse weather event, is a responsibility that falls to public administrations at all levels. It requires the development of appropriate plans and infrastructure, including public goods and services aimed at minimizing harm to the population. Within these efforts to adopt measures for the prevention and mitigation of catastrophic risks, the insurance industry can provide valuable support to public authorities. Insurance not only offers post-disaster compensation but also serves as a powerful tool to influence behavior before disasters strike—ranging from the modernization of buildings to withstand floods or fires, to discouraging construction in high-risk areas, and promoting infrastructure that reduces risk.

*The role of insurance in climate adaptation and loss prevention*

Insurance companies have extensive data on risks and experience that can inform planning for climate resilience.[129] Public policies should integrate insurance considerations into broader climate adaptation efforts, like investments in infrastructure, land use planning and early warning systems, and taking advantage of the insurance industry's experience in reducing long-term risk. In this way, insurance mechanisms (premium incentives, terms of coverage, eligibility criteria) can serve as economic indicators that orient behavior toward risk awareness, prevention, and adaptation to extreme weather events. Many insurance companies already do this voluntarily. For example, discounts for homes with reinforced roofs in areas susceptible to hurricanes or for companies with advanced fire extinguishing systems.

*Expanding public-private partnerships to include prevention*

Without this being a central role, a solid strategy of schemes based on public-private partnerships (PPP) could also help in this regard, focusing not just on paying claims derived from the occurrence of these types of extreme weather events, but also helping

the bodies of the public administrations responsible for actively promoting risk reduction. In the medium term, the politicians responsible could incorporate certain commitments into partnership agreements, having the government finance risk mitigation projects and offering potential discounts on premiums or expanded coverage to customers who adopt catastrophic risk reduction measures.[130]

Public policies can be strengthened in this regard, providing frameworks or even subsidies for such discounts, and keeping a list of certified resilience improvements. In addition, public administrations can implement or expand grant programs to help owners to finance resilience measures, on the condition that the owner maintains an insurance policy against the specific risk they are trying to reduce, and that the insurer agrees to a potential premium discount (owner, insurer, government), thus ensuring that everyone participates.

*Integrating insurance into building codes and land use planning*

The trend in building code approval and stricter zoning regulations in many places seeks to share in the effort of addressing and mitigating climate change. For example, a coastal region may adopt a code that establishes that all new buildings must be raised over a certain flood level. In addition, the insurance companies could refuse standard coverage for any building that does not comply with these codes, or charge a higher premium for noncompliance. In this way, the availability and price of insurance becomes leverage for imposing safer construction requirements or smart land use. Land-use policies could also prohibit development in high-risk areas (such as relocating communities away from eroding coastlines or out of floodplains) by denying new insurance policies for new constructions in those zones.

Along the same lines, public policies could aim to reduce insurance premiums in neighborhoods or whole cities that meet certain risk reduction milestones. For example, if a city creates a buffer zone to protect it from forest fires or invests in better drainage (cities like Tokyo, Los Angeles, or New York are paradigms), insurance companies could reduce rates for all property owners in that jurisdiction. In the long term, it would be desirable to extend these requirements to various environments, such infrastructure projects and large-scale residential developments, and even to demand that local governments insure critical assets as a requirement to obtain state or federal funding. It is also common for government buildings or infrastructure to be uninsured against climate-related risks. Ensuring that critical services (such as public utilities or transportation networks) have insurance or contingency coverage means faster recovery and continuity after a disaster, reducing secondary economic losses.

**Loss reduction measures: integration of early alert systems**

Public entities must ensure that early warning system infrastructure—such as radars, sensors, and alert protocols—is robust and reaches the last mile. The synergy lies in the fact that alerts are only useful if people act accordingly; therefore, insurance policies could include conditions or benefits linked to this behavior. As part of this infrastructure, insurance programs could be integrated with early warning systems to enhance loss prevention, with insurers supporting the dissemination of alerts—for example, by sending SMS warnings to policyholders when a severe weather alert is issued (as some already do). Insurance companies could also offer potential reduced premiums or benefits in their customer loyalty programs for those who register in community alert programs and show an emergency response plan.

*Transfer of extreme risk to the capital market*

Countries prone to mega disasters should consider the implementation of alternative instruments to compensate for losses, such as "catastrophe bonds," as part of a risk layering strategy,[131] including the creation of a regulatory framework for their issuance, with tax incentives or public co-sponsorship, in order to tap into global capital when domestic insurance alone proves insufficient. Another focus would be the issuance of "resilience bonds," a variant of catastrophe bonds where the bond income finances a specific resilience project and the terms are structured so that, if a disaster occurs, the bond may pay out less (because the project reduced the resulting losses). For example, a city may issue a resilience bond to finance a seawall, with the insurance companies perhaps sponsoring it or agreeing to reduced premiums once the wall is built. In this way, the public policy can facilitate their issuance by providing partial guarantees or covering the initial development costs.

*Insurance industry's commitment to sustainability*

It is reasonable to expect that many insurance companies are still working on or joining the commitments made across all productive sectors to support climate goals, as many of them have already done through the United Nations' Principles for Sustainable Insurance. This may translate, among other aspects, into investment considerations regarding issuers of financial assets that actively promote low-carbon technologies, as explained in Chapter Five of this study, investing only in low-emissions companies or those with a transition plan toward the use of renewable energies or greenhouse gas-neutral energy sources.

Such commitments could include refraining from insuring activities that exacerbate climate risk (such as deforestation or the destruction of wetlands that serve as natural barriers), as well as promoting nature-based solutions that help reduce the risks and losses from natural disasters—such as the conservation of reefs, mangroves, or forests to protect against flooding (already tested with coral reefs in Mexico's Yucatán Peninsula). In this way, communities or governments insure a natural asset so that, if it is damaged, there are funds available to rapidly restore it, keeping its protective function intact. Policymakers in coastal and rural areas can draw on the expertise of insurance companies to facilitate—and even subsidize—these schemes, as they essentially deal with public goods.

## Measures for the collection and management of catastrophic loss data

Accurate data for risk pricing and the establishment of technical provisions for obligations assumed under insurance and reinsurance contracts form the foundation of a sound insurance system. Climate change is complicating actuarial models in an environment in which past averages cannot predict future losses with historical disaster data.[132] The problems with the data include gaps in the risk and loss information, not enough granularity, a lack of prospective climate information, and fragmentation. Thus, pricing challenges revolve around balancing risk-based premiums with coverage affordability.

In this regard, it would be desirable for public policies to also be oriented toward improving the exchange of data, helping to incorporate the climate perspective into current pricing. This would facilitate advanced, dynamic modeling that contributes risk-based pricing, considering that this is a global challenge. In the long term, greater cooperation on data and modeling is therefore necessary, enhancing and promoting initiatives such as the Coupled Model Intercomparison Project (CMIP[133]). Public policies could prompt international standards for catastrophe risk data (similar to financial reporting standards), so that risks in any country can

be assessed consistently, which would enable global reinsurance and risk transfer solutions. Other initiatives, like the Global Risk Modeling Alliance of the Insurance Development Forum (IDF[134]), are also a step in that direction, creating open models for developing countries.

Governments and regulatory authorities can contribute to increasing the availability of high-quality data, updating and disseminating risk maps (flood zones, forest fire risk areas), and the creation of centralized loss and disaster exposure databases.[135] In this regard, the authorities could mandate the reporting of insured and economic losses from all major events to build a comprehensive dataset, supporting open data platforms or dashboards (such as EIOPA's Insurance Protection Gap Dashboard) to ensure access for insurers, researchers, and the general public. Establishing rapidly implemented collaborative platforms where insurance companies, meteorological agencies, and emergency management organizations share data in real time would be key actions on this objective. Even simple measures, like sharing flood sensor data or wildfire propagation models with insurance companies could improve risk underwriting and pricing accuracy in the short term.

### Improving catastrophe risk modeling

Regulators in various jurisdictions have started requiring insurance companies to conduct climate stress tests or scenario analysis (as the Bank of England does biannually, or the European Union with the Solvency II reform), to have a long-term analysis of climate scenarios in the Own Risk and Solvency Analysis (ORSA) that integrates climate outlooks in insurance risk assessments and pricing. Public policymakers should also support the development of improved catastrophe models that incorporate climate change trends. This could involve partnerships with the academic world and industry, in order to develop open source risk modeling tools and use new technologies (i.e. satellite images, data provided by advanced sensors, or AI for a more granular risk assessment). Financing climate scenario analysis pilot projects (e.g., modeling a 1-in-100-year flood under future climate conditions) can help insurers price long-term risk more accurately. Regulators could also encourage insurance companies to use common data standards and share modeling results, which reduces duplication of effort and improves the general understanding of the risk.

Creating national and regional risk data centers could also generate metrics and risk maps for use by all insurance companies, thus reducing the asymmetry of the information. At the regional and international level, countries could cooperate to share data, for example, with a pan-European natural disaster data platform.[136] The consistency and high quality of data in all jurisdictions would facilitate the pooling of risk and development of regional insurance solutions.

## Measures aimed at expanding coverage through parametric solutions

*Parametric insurance* pays a pre-established amount based on a *triggering factor*, such as the wind speed of a hurricane or a drought index, among others, and could play a significant role in closing the protection gap alongside traditional indemnification insurance (which indemnifies real losses), as shown in a recent study prepared jointly by members of the Financial Stability Institute (FSI) of the Bank for International Settlements (BIS) and the International Association of Insurance Supervisors (IAIS).[137] Although still in early stages of development, pilot tests have been implemented in some emerging countries, such as India and Kenya, with parametric coverage to protect farmers against the effects of extreme rainfall, demonstrating their effectiveness.

At the sovereign level, governments could acquire parametric disaster insurance for their own emergency needs. Instruments like the Caribbean Catastrophe Risk Insurance Facility Segregated Portfolio Company (CCRIF) and the African Risk Capacity (ARC) already allow countries to purchase coverage that pays out within days after a catastrophe, which provides crucial funds to provide alleviation before international aid arrives. Countries that still do not participate in this type of scheme should consider joining or forming similar risk funds. For example, Pacific Island states recently partnered with development agencies to create a parametric disaster risk transfer vehicle.[138]

The support of public policies for these sovereign parametric insurance solutions can ensure that governments have immediate liquidity after extreme events, thereby improving resilience and reducing the debt load derived from the occurrence of disasters. Urban parametric coverage could also quickly compensate municipal governments for extreme precipitation, financing the flood response to protect consumers, noting that payments are made regardless of actual loss (reducing basis risk through sound design).

Some insurers have introduced parametric add-ons (such as an initial payment that policyholders can receive immediately after a triggering event), while awaiting adjustment of their full claims. Regulators could accelerate the approval of these products, and even permit their purchase through mobile apps or platforms for greater speed and accessibility. Participation in the technology sector (fintech, insurtech), through innovation challenges or initial financing, could generate creative solutions that combine traditional and parametric insurance for a greater scope.

Public administrations, in collaboration with the insurance companies and their organizational associations, could implement campaigns and advisory services, especially in high-risk regions, to explain how insurance works and why it is crucial. Often, protection gaps persist because people underestimate the risk and are not familiar with insurance products that allow for such losses to be offset.[139] For marginalized populations, especially in developing regions or among low-income groups, micro-insurance with parametric coverage programs could be launched or expanded. Their advantage is that the premiums for this type of insurance are small in relation to the potential payouts, but they require a broad base of policyholders, so the option of marketing them in the form of micro-insurance can be a good solution, especially in countries where these products are well developed.

Meanwhile, groups of countries with similar risks are increasingly grouping more risks, like the aforementioned CCRIF in the Caribbean (for hurricanes and earthquakes) and the ARC in Africa (for droughts). Public policymakers should continue to support these regional funds, as they provide profitable coverage through diversification among countries.[140] In addition, initiatives like the InsuResilience Global Partnership[141] (the purpose of which is to extend climate risk insurance to hundreds of millions of people in vulnerable countries) should continue receiving political and financial support. The goal would be significantly greater international coverage for developing countries, which is an important step to closing the protection gap on a global scale.

## 7.2 European Central Bank Initiative

Catastrophic risk coverage for events related to an adverse climate, along with other types of natural and anthropogenic disasters, have been a permanent object of concern and debate in the European Union (EU), but no consensus has been reached among the Member States to develop a joint initiative. In

this regard, more than a decade ago, the European Commission developed a proposal that culminated in the Commission's Green Book of April 16, 2013, on natural and anthropogenic disaster insurance, in the framework of the EU's climate change adaptation strategy (COM(2013)0216).

However, this proposal did not pass the debate in the European Parliament. Its Resolution of February 5, 2014, on natural and anthropogenic disaster insurance (2013/2174[INI]), argued that it did not see a distortion in the market that would justify a Europe-level intervention and, therefore, it did not consider a universal solution to be viable. It also found that a flexible natural disaster insurance market allows insurance companies to adapt products to different conditions, and that a non-mandatory framework for Member States was the best way to develop products adapted to the natural risks of a given geographical area—while also emphasizing that the state or regional authorities must recognize the importance of risk prevention and make it a core pillar of their investment strategy.

## European Central Bank Initiative and the European Insurance and Pensions Authority

Given the persistent increase in the frequency and severity of extreme weather events, in April 2023, the European Central Bank (ECB), in coordination with the European Insurance and Occupational Pensions Authority (EIOPA), published a discussion paper reintroducing some initiatives to address the growing climate insurance protection gap. The document highlights that, between 1981 and 2023, natural disasters caused around 900 billion euros in direct economic losses in the EU (one fifth produced in just the last three years) and that, historically, only about a quarter of losses due to extreme weather and climate events in the EU were insured —with some countries insuring less than 5% of such losses.

Since the publication of the paper, further devastating natural catastrophes have occurred, such as severe floods that struck various countries in Central and Eastern Europe, as well as Spain, in September and at the end of October 2024, respectively. These events once again drew attention to the impact of natural disasters on Member States, the relevance of solutions to improve insurance coverage, and the increasing burden on public finances to compensate for the materialization of such risks. Although the EU has increased the Solidarity Fund budget, its resources remain insufficient to significantly contribute to reconstruction efforts after a large natural disaster. This is due to the fact that the fund is not designed to respond to specific disasters, is not available for all EU Member States, and neither the Cohesion Funds nor the Solidarity Fund itself include mechanisms to ensure that Member States address the risk of natural disasters systemically and preventively.

The insurance protection gap is expected to widen even further due to the growing risk posed by climate change. Europe is the fastest-warming continent in the world, and if pertinent measures are not implemented, the increasing climate risk is likely to have implications for both the supply and demand sides of the insurance market. As the frequency and severity of climate-related events increase, insurance premiums and the cost of reinsurance are expected to rise, making insurance less affordable, especially for low-income households. Climate change also heightens the unpredictability of these phenomena, which could lead insurance companies to stop offering catastrophe insurance in high-risk areas.

Evidence highlights the economic relevance of this insurance protection gap, including its implications for the macroeconomy, the financial system, and public finances. A lack of insurance can slow economic recovery, increase the banking system's exposure to

credit risk, and weaken governments' fiscal positions when they intervene to cover non-insured losses. To help bridge this gap, a phased approach to natural catastrophe insurance was advocated, calling for a multidimensional approach involving both the private and public sectors, at both national and EU levels, emphasizing that the private sector cannot manage this risk alone.

The joint ECB and EIOPA report reviews 12 national natural catastrophe insurance systems existing in the EU, as well as how they combine private and public funding to bridge the protection gap. It concludes that the existence of such schemes correlates with higher levels of insurance coverage in European countries. These schemes typically function by establishing risk-based insurance and reinsurance structures that involve coordination between the public and private sectors across multiple risks (for example, flooding, droughts, fires, and windstorms).

Based on this analysis, the paper outlines a possible solution at the EU level structured around two pillars. A *first pillar* would consist of an *EU public-private reinsurance scheme*, aimed at increasing insurance coverage against natural catastrophe risks in areas with low coverage. This system would pool private risks across the EU and across different perils, in order to further increase the benefits of diversification at the regional level, while promoting and safeguarding national-level solutions. This pillar could be funded through risk-based premiums from insurers, reinsurers or national systems, considering the possible implications of risk-based pricing for market segmentation. Access to the system would be voluntary, and it would act as a stabilization mechanism over time to achieve economies of scale and diversification for risk coverage similar to an EU public-private partnership.

Meanwhile, *the second pillar* would consist of an *EU-level public catastrophe financing fund.* Its objective would be to improve public disaster risk management within Member

**Chart 7.2**
**European Union: two-pillar system to improve resilience against natural disaster risks**

| PILLAR 1: EU REINSURANCE SCHEME | | PILLAR 2: EU CATASTROPHE FUND |
|---|---|---|
| Expansion of insurance coverage and supply | Objective | Incentivize risk mitigation and limit public expenditure |
| Insurance companies, reinsurance companies, and national schemes | Participants | Governments |
| Public-private | Configuration | Public |
| Voluntary | Enrollment | Required |
| Premiums based on participants' risks (capital market financing, including catastrophe bonds) | Financing | Risk-adjusted government contributions (and potential debt issuance) |
| Payouts according to contractual terms | Payouts | Event-calibrated payouts, conditional on implementation of national plans |

Source: MAPFRE Economics (with data from the European Central Bank and the European Insurance and Pensions Authority)

States. Fund disbursements would support post-disaster reconstruction initiatives involving major losses, subject to prudent risk mitigation policies, including risk adaptation measures and attention to the effects of climate change. The EU fund would be financed by contributions from Member States, adjusted to their respective risk profiles. Disbursements from the fund would be conditional upon the implementation of specific risk mitigation actions, as outlined in pre-agreed national adaptation and resilience plans.

This two-pillar system would improve resilience to natural catastrophe risks at both national and EU levels, limiting associated costs. It would be firmly grounded in a multi-layered approach (see Chart 7.2). Both pillars would complement and be consistent with existing national initiatives to reduce the natural catastrophe insurance gap by addressing specific market failures, in line with the EU principle of subsidiarity. Moreover, it would allow both the private sector and Member States, especially those currently lacking national solutions, to increase their insurance coverage capacity, invest in more resilient infrastructures, and adopt preventive measures.

It is worth noting that both pillars include strong risk mitigation incentives in their contribution structures, ensuring that moral hazard is reduced at all levels, thereby promoting adequate disaster preparedness. In addition, this system would leverage the benefits of pooling and risk-sharing beyond the national level, allowing for broader risk diversification. Finally, the debate surrounding a possible EU-level solution could drive new initiatives aimed at risk mitigation and adaptation, such as the use and development of open-source tools, models, and data to improve risk understanding, also considering other types of measures, such as promoting the development of catastrophe bond markets.

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# Index of tables, charts, and boxes

## Tables


Table 1.2.1 Global: major catastrophic weather events since records began . . . 21
Table 2.1 Global: economic losses, insured losses, and protection gap . . . 26
Table 2.2 Global: global protection gap (NatCat Gap) . . . 30
Table 4.1 General types of reinsurance contracts . . . 55
Table 4.2 Global: issuing of catastrophe bonds, by issuer and trigger type, 1997-2017 . . . 62
Table 5.1 Risk outlook and climate change decisions for reinsurers and Property & Casualty and Life insurance companies (asset side) . . . 67
Table 5.4 Major European insurance groups by income volume from insurance service, 2023 . . . 76


## Charts


Chart 1.1.2 Increase of the global surface temperature over pre-industrial levels . . . 18
Chart 2.1-a Global: losses due to natural disasters . . . 25
Chart 2.1-b Global: insured losses, cost of major event, and number of catastrophes by year . . . 26
Chart 2.1-c European Union: economic losses and number of natural disaster events . . . 27
Chart 2.1-d European Economic Area: evolution of catastrophe risk . . . 28
Chart 2.1-e Global: insured catastrophic losses, 2024 . . . 29
Chart 2.2-a Global: accumulated losses, 2000- 2024 . . . 29
Chart 2.2-b Global: catastrophic losses by climate-related event . . . 30
Chart 2.2-c Global: insured and total losses caused by tropical cyclones and protection gap . . . 31
Chart 2.2-d Global: global losses due to floods (2013-2022) . . . 31
Chart 4.1-a Global: breakdown by line of gross reinsurance premiums, 2023 . . . 56
Chart 4.1-b Global: regional distribution of reinsurance premiums, net of retroceded reinsurance . . . 56
Chart 4.1-c Global: gross reinsurance premium quota by country, 2023 . . . 57
Chart 4.1-d Global: use of retrocession between 2019 and 2023 . . . 58
Chart 4.1-e Global: combined Non-Life reinsurance ratio . . . 58
Chart 4.1-f Global: global capital of reinsurers . . . 59
Chart 4.1-g Global: reinsurance solvency indicators . . . 59
Chart 4.2-a How a Cat Bond works . . . 60
Chart 4.2-b Catastrophic loss coverage structure . . . 61
Chart 4.2-c Monthly weighted supply and demand index of the catastrophe bond market . . . 61
Chart 4.2-d Loss trigger of new catastrophe bond issues . . . 62

| | | |
|---|---|---|
| Chart 4.2-e | Investors in catastrophe bonds by category, 2020-2021 | 62 |
| Chart 4.2-f | Global: outstanding notional by type of promoter | 63 |
| Chart 4.2-g | Global: geographic distribution of new issues | 63 |
| Chart 4.2-h | Global: exposed notional vs. contribution to risk by risk type | 64 |
| Chart 4.2-i | Global: new issues and outstanding balance of catastrophe bond market | 65 |
| Chart 4.2-j | Global: reference indexes in the catastrophe bond market | 65 |
| Chart 5.1 | Global: types of estimated potential financial impacts for material issues | 68 |
| Chart 5.3-a | Global: sustainable debt issues | 71 |
| Chart 5.3-b | Global: valid issued balance by product type | 71 |
| Chart 5.3-c | Global: ESG issues | 72 |
| Chart 5.3-d | Global: asset composition by climate sensitivity, 2023 | 72 |
| Chart 5.4-a | Financial materiality of climate change and materiality of its impact | 74 |
| Chart 5.4-b | Taxonomy alignment of non-financial corporate bond and equity holdings of insurance companies in the European Economic Area | 75 |
| Chart 6.1 | Global: annual $CO_2$ emissions | 77 |
| Chart 6.2.1-a | Global: map of carbon taxes and emissions trading systems (ETS) | 80 |
| Chart 6.2.1-b | Latin America: variation of GHG emissions | 81 |
| Chart 6.2.1-c | Global: variation in GHG emissions | 82 |
| Chart 6.2.1-d | European Union: emission allowance estimates | 83 |
| Chart 7.1 | Key aspects of public policies to address the climate disaster insurance protection gap | 87 |
| Chart 7.2 | European Union: two-pillar system to improve resilience against natural disaster risks | 97 |


## Boxes


| | | |
|---|---|---|
| Box 3.1 | Coverage of extraordinary risks for agriculture | 40 |

# Other reports from MAPFRE Economics

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