

UNDERSTANDING PHYSICAL CLIMATE RISKS



Episode #1 Flood or floods?

KEY FIGURES AND INSIGHTS

Floods are among the most damaging natural phenomena, representing more than **20% of the natural disaster losses** worldwide.

Flood risks arise from different physical processes (**coastal, fluvial, pluvial**). Each of those will affect urban areas in a different way.

In **Amsterdam, Berlin, Copenhagen, London, or Paris**, both the flood extent and the average flood depth are projected to **increase** in the absence of additional **adaptation measures**.

Annualised damages from river floods alone could reach **€100bn by 2100 in Europe**.

Understanding the types of floods is vital to **prevent and adapt**, especially as the impact of climate change on the different types of floods varies across Europe.



Why does it matter?

Every year, images of flooded cities appear in the news. At first sight, they all look similar: submerged streets, floating cars, or roofs barely above water. Yet, **each event is driven by a specific physical cause**. While the result seems identical, i.e., **water is present where it should not be**, the underlying weather and climate processes, as well as the appropriate prevention and adaptation measures, can differ significantly. Understanding the distinct causes of these supposedly similar events is essential to **design effective strategies** to reduce risks, improve readiness, and adapt to future events.

Floods are among the most damaging natural phenomena, with **damages amounting to over US\$ 320bn** over the past five years and representing more than **20% of the natural disaster losses worldwide**¹. For example, in 2021, the devastating floods in the Ahr valley, in Germany, caused aggregate losses of almost US\$ 60bn², making this disaster the costliest in Europe for decades.

In Europe, annualised damages from river floods alone could reach **€100bn by 2100**, while **400 000 Europeans could lose their homes** to sea level rise and coastal floods in the second half the century³.

What is flooding?

In the previous paragraph we defined “flood” in layman’s terms as “the presence of water where water is not supposed to be”. Obviously, it is much more complex than that. Some of the challenges in flood prevention arise from the complex physical nature of floods.

A flood can be caused by multiple physical processes:



Riverine Flood

Riverine flood is defined as the “overflowing by water of the normal confines of a watercourse or other body of water⁴”. In practice, these slow-onset floods are often due to **prolonged rainfall over a river catchment**, leading to a saturation and an overflowing of the water system into the floodplain, where it can stay for days or weeks. This leads to large-scale, long-lasting **impacts on circulation, production, as well as potential health issues** due to stagnant waters.



Pluvial Flood

Pluvial floods can happen **anywhere**, even if there is no body of water nearby. They are related to **intense rainfall events** causing sudden overflow of the water drainage system or torrential flows of water (flash floods), especially in **urban environments**. Flash floods are dangerous and destructive events, often causing more destruction and casualties than fluvial events due to the force of water and debris swept up in the flow.



Coastal Flood

Coastal floods are usually associated with **storm surges**, when strong winds and a drop of atmospheric pressure raise seawater levels and push **seawater onshore**. The magnitude of the threat is linked to the tide, with high tides exacerbating (or even causing) coastal events. Coastal floods are intense events causing **large physical damages** that can propagate broadly inland in low-lying areas.

Each type of flood will **bring specific impacts**: while **riverine floods** are usually **slow** onset events impacting **large areas** in a floodplain, **pluvial floods** can occur **anywhere** and are usually more **sudden**, often causing more casualties. Moreover, compound events can be devastating, when extreme rainfalls cause first flash floods in urban environments but also lead to the overflowing of surrounding bodies, inducing both sudden and long-lasting impacts. Coastal floods are also a sudden and violent phenomenon, but their impact is increased by their association with intense storms or cyclones.

How does it impact us?

The physical nature of the different flood types means that **the impact of climate change on each of those is variable**. While the **frequency of intense rainfall events is expected to increase in most of Europe** (figure 1), leading to more frequent and/or intense pluvial floods, changes in river discharges and associated riverine floods⁵ are more difficult to assess^{6,7}. These general trends hide **sub-regional hydrological discrepancies**. While river discharge is projected to increase in the Elbe, lower levels are expected in the Danube for example.

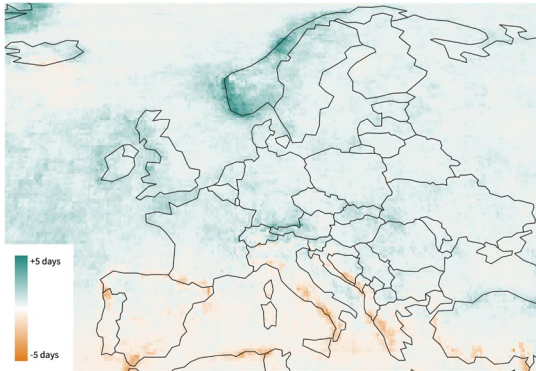


Figure 1 - Evolution of the frequency of heavy precipitation days (> 40mm/day) in Europe by 2050 (SSP585 scenario – source Altitude). Overall, heavy precipitation days are projected to increase over most Europe, increasing the likelihood of pluvial flooding. In Southern Europe, while the frequency of these heavy precipitation days might decrease, on average, the most intense events (e.g., cold drops, Mediterranean events) are projected to become more likely.

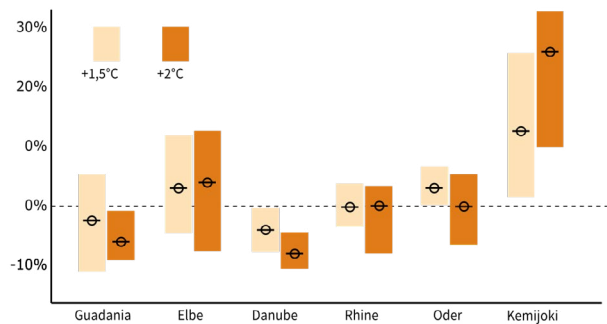


Figure 2 - Evolution of the mean river discharge for a subset of European rivers, according to +1.5 and +2°C scenarios⁸. The impact of climate change on the mean discharge of major European river systems varies across the continent.

These climate evolutions lead to diverse flood contexts in European urban areas. In the subsets of European cities analysed in this paper (see figure 3 for all results), **an increase in pluvial flood risk can be observed in most locations**. In Amsterdam, Berlin, Copenhagen, London, or Paris, both **the size of the area** affected and the **average flood depth** are projected to **increase** in the absence of additional adaptation measures (figures 3c and 3d).

The spatial footprint of fluvial floods is more limited and the future evolution is less significant. However, water levels reached are significantly higher than those expected during pluvial events, leading to **potentially longer-lasting and more impactful events on activities and infrastructures** (figures 3e and 3f).

Coastal flooding is a wholly different process, linked to storm surges and sea-level rise. **Most low-lying coastal cities are facing increasing coastal risk**. In **Copenhagen**, the frequency of the most extreme floods (i.e., 1-in-1000 yr events) is **expected to increase tenfold**⁹. In **Amsterdam**, up to **10% of the city could become at risk** without any adaptation measures (figure 3a).

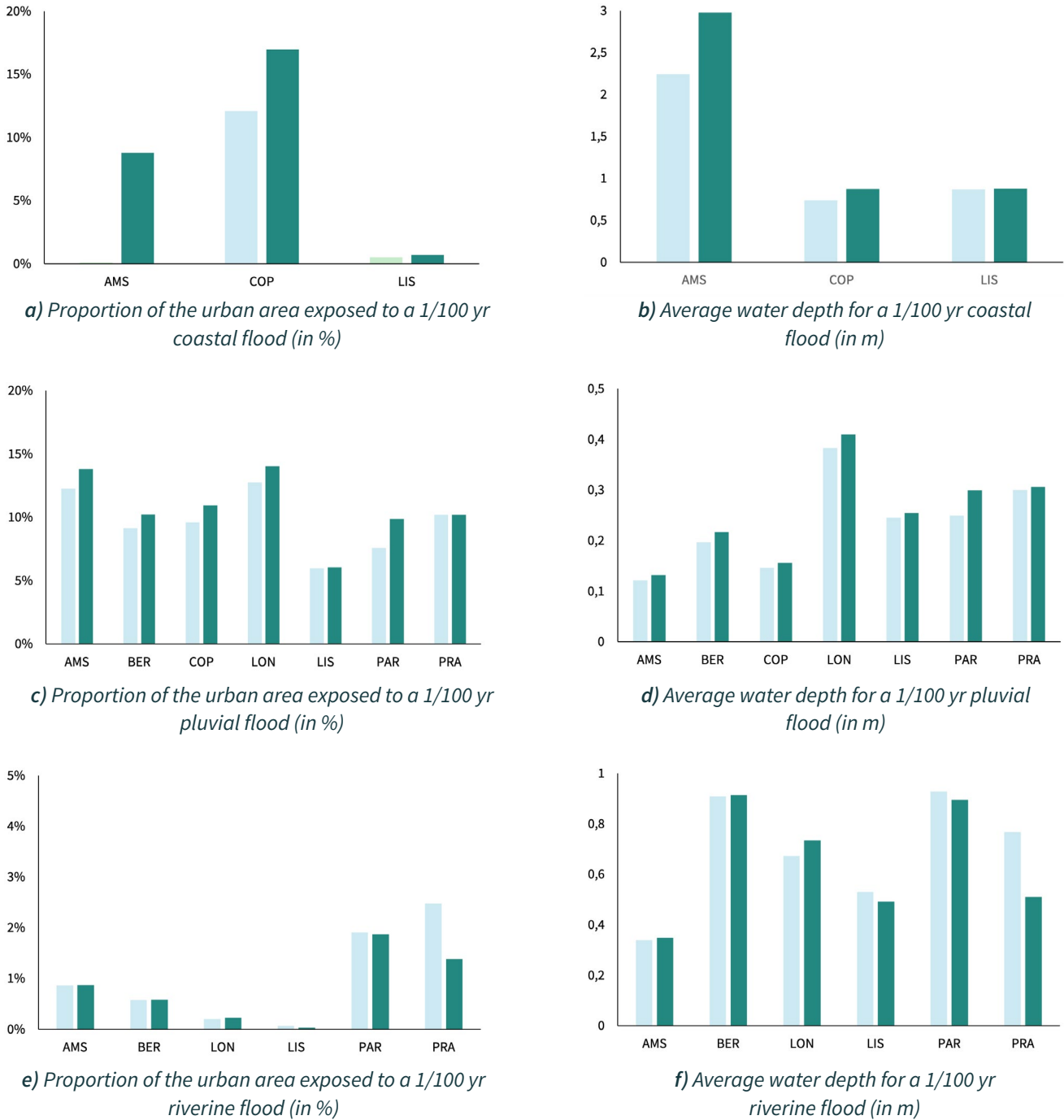


Figure 3 – Left panel : Proportion of urban areas at risk of flooding for a 1/100yr coastal (top), pluvial (middle) and riverine event (bottom) for a subset of European cities. Right panel : Average water level (in m) within the flooded areas (light green : baseline – dark green : SSP 585, 2050)

The complexity of flood processes makes them highly difficult to simulate.

This is the reason large scale flood analyses (such as the data described here) often rely on hydraulic modeling. While these models (1, 2 or 3-dimensional) are far from perfect, they remain a vital source of information for current and future flood risk assessment. One cannot simply look at precipitation patterns to identify future flood-prone areas.

How do we adapt as investors & corporates?

Climate change on the one hand, and **urbanisation** on the other, contribute to an **increase in flood risk** across large parts of **Europe**. In response, various adaptation strategies have been developed at national, regional, and local levels.

In the **Netherlands**, the **Delta Plan for Flood Risk Management** aims to strengthen flood defences for all inhabitants by 2050¹⁰.

In **London**, the **Thames Barrier** is a retractable barrier system designed to protect Greater London from exceptionally high tides and storm surges.

In **Paris**, a **real-life simulation of a Seine River flood** was conducted in October 2025¹¹, with the objective of better anticipating extreme flood events.

However, recent events, such as the 2024 Valencia floods that caused 232 fatalities, or the several billions of euros in damages recorded in Germany that same year, show that **existing protections are still insufficient** in many urban areas.

To mitigate the increasing risk of flooding, local and asset-level adaptation strategies are needed to complement the national or regional plans that are being implemented. **Asset owners, risk managers, local authorities or individual homeowners need to better understand and assess the flood risks they face**, as generic information is not enough to efficiently protect assets.

The investors perspectives

Beyond technical solutions, scaling up flood adaptation requires mobilising capital towards measures that can effectively reduce future physical risks. **For investors**, this means moving beyond stand-alone projects and supporting systemic approaches to resilience.

Several financing levers can contribute to this shift:

- Investing in nature-based solutions (NBS)

Nature-based solutions, such as bioretention area, blue roofs or coastal ecosystem restoration, can significantly reduce the effects of flooding while providing biodiversity, cooling and carbon benefits.

When well designed, these projects can attract public funding and, in some cases, generate carbon-related revenue flows, improving their overall return.

- Using dedicated debt and resilience financing for asset adaptation

Public and private debt vehicles can finance the modernisation of buildings, industrial sites and infrastructure to adapt them to future flood conditions, thereby reducing long-term physical risk and potential losses.

- Investing in businesses that promote resilience

The development of SMEs that develop flood-resistant materials, drainage systems, monitoring tools or early warning services can accelerate adaptation across territories and value chains.

From a corporate perspective

For corporates, adapting to flood risks requires moving beyond general awareness towards site-specific risk assessments, identifying critical assets and exposure points. To start, the practical path for companies is to select from a wide range of measures, while tailoring choices to each location and adopting a systemic approach that anticipates full disruption scenarios. This logic can be illustrated through a cost impact adaptation matrix.

Below is an example of practical steps that can be taken.

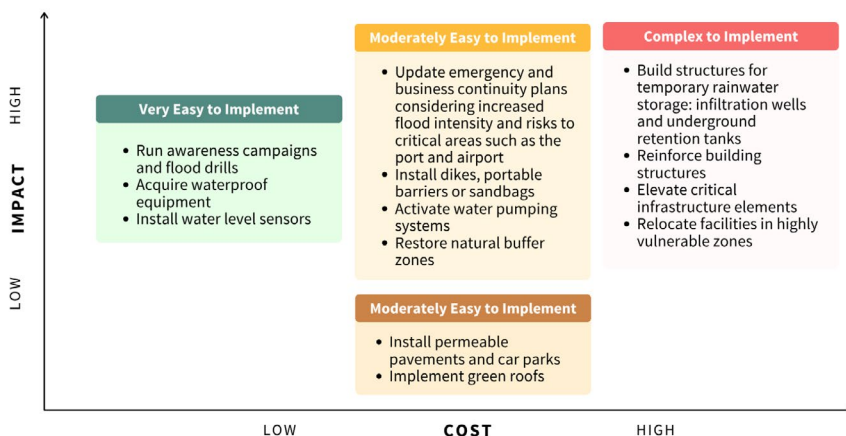


Figure 4 : Example of a non-exhaustive adaptation matrix for an industrial company in the event of an extreme flood.

Source: AXA Climate, Fundación AXA



Credit: Port of London Authority, <https://pla.co.uk/navigating-thames-barrier>



Credit: reconnect project, demonstration sites of Nature-Based Solutions with the potential for upscale, Odense Municipality, Denmark

Conclusion

Understanding climate risks is also very important to **prevent maladaptation and counterproductive measures**. For example, green roofs might be an efficient solution to reduce flash flood risks during heavy rainfall. Acting as a buffer for rainfall, these roofs can delay the arrival of excess rain to the drainage system and prevent it saturation. However, they will offer little to no protection against river overflowing due to intense, long-lasting rains upstream in the catchment. Installing concrete-made, waterproof protections against fluvial or coastal floods might make the surface more impervious and increase the risk of pluvial flooding.

In short, financing adaptation means transforming knowledge about climate risks into investment decisions, directing capital towards solutions that measurably reduce future losses and make resilience a driver of long-term economic value, rather than a cost.

From national governments to local homeowners, from listed companies to local shops, **adaptation needs to be at the centre of every decision**. This requires being able to access, use and understand the relevant climate information.

The complexity and the diversity of flood processes illustrate the need for economic actors to better understand the risks they are and will be facing. Further collaboration between climate scientists and economic actors is needed to improve knowledge and facilitate the transmission of relevant climate risk information to every link of the value chain.



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Sources

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⁹ Altitude

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