REPORT 2018:05

Flood risk for investors

Are you prepared?

°CICERO
Climate Finance

Flood Risk for Investors

The Flood Risk for Investors report discusses:

How will climate change impact the FREQUENCY and INTENSITY of flooding events?

What are the TOTAL COSTS of flood events?

WHO PAYS the costs ultimately?

Report outline

Executive Summary

The **probability** of flood risk is increasing with climate change, due to more **intense and frequent extreme precipitation** events. This may lead to coastal flooding, which can have significant impacts in combination with extreme weather and sea level rise. Inland flooding can also result from major storms or from sustained periods of above-average rainfall.

Flood risk is observed in all regions of the world. To date, the focus of water risk analysis outside of the insurance industury has been on water scarcity. As flooding events become more extreme and more costly, at the same time that insurance coverage is shifting, we need to focus on the implications of flood risk. While large coastal flood events get the majority of attention, frequent water overflow or infiltration from heavy inland rain can have significant costs over time.

We examined four cases illustrating diverse types of flooding events and cost and insurance outcomes:

Case study 1: Hurricane Harvey in Houston, 2017

Case study 2: Superstorm Sandy in New York, 2012

Case study 3: Copenhagen Cloudburst, 2011

Case study 4: Regional flooding in Norway, 2012-2013

While each case is unique, lessons learned can highlight potential vulnerabilities and raise questions about preparedness.

The industry sector is exposed to direct flooding risk, but **all sectors are exposed to indirect damage via transportation, communication and supply chain disruptions**. Cities are especially vulnerable due to complicated infrastructure, yet flooding in rural areas can also have costly indirect impacts from transportation disruptions.

Up to 50% of the total flood costs can result from electricity outages and transportation disruptions. Across the four cases, indirect costs ranged from 10% to 50% of total costs, depending on the specific regional and economic characteristics.

More than 50% of the total flood costs were not covered by insurance in the cases we reviewed for this report. Indirect costs such as electricity and transportation disruptions to business operations are not always covered by insurance.

Investors and companies may not be able to rely on public policy or insurance to alleviate financial impact. A significant insurance protection gap exists and seems to be growing. Further, the insurance system is poorly equipped to effectively handle large-scale flood events. National flood programs may not be able to handle increased severity of costs. Re-insurance companies have lost profit from extreme flooding events, raising questions about potential systemic risk in the insurance industry.

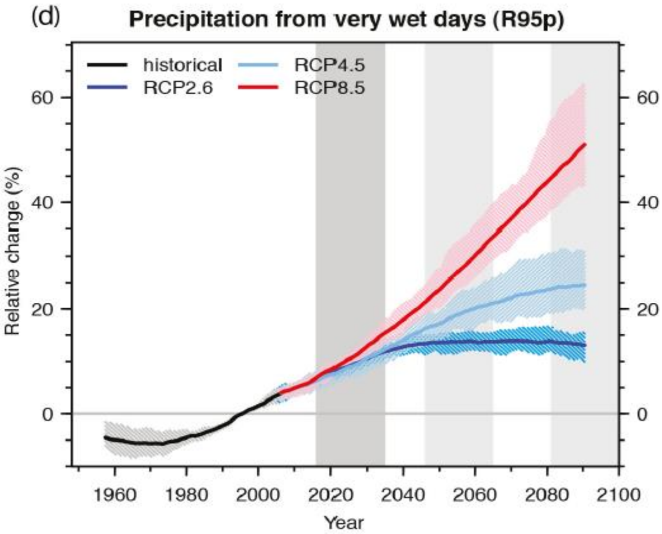
Resiliency planning in both the public and private sectors is critical to address increasing flood risk, significant costs and the increasing insurance gap. In parallel, there are several ways for investors to engage on flood risk, via **dialogue with companies** and **new investment opportunities**.

Extreme precipitation is increasing

Flooding risk, in combination with extreme weather and sea level rise, has been observed in almost all regions. In Northern Europe, increased intensity in precipitation is observed. In coastal regions of North America, stronger hurricanes and flooding events are observed. In South East Asia, higher sea level rise threatens low-lying areas in combination with hurricanes.

Looking forward, extreme precipitation will increase in intensity both in dry and wet regions across the world. Recent observations show that daily maximum precipitation increases 3 times faster than daily mean precipitation globally. Across a range of projected climate scenarios from business-as-usual to 2ºC, more intense rain is expected in Northern and Central Europe.

Precipitation on the wettest days will increase most. The number of days with precipitation will not increase, but just the intensity. Changes to hourly extremes are uncertain and may increase substantially.



Change in precipitation (historic and projected with IPCC scenarios). *Increased precipitation has already been observed, and is projected to increase across a range of results from three IPCC scenarios. The Representative Concentration Pathways (RCPs) incorporated by IPCC in the last Assessment Report, represent a broad range of climate outcomes. Extreme precipitation intensity will increase more than average change in precipitation. Source: IPCC, 2013*

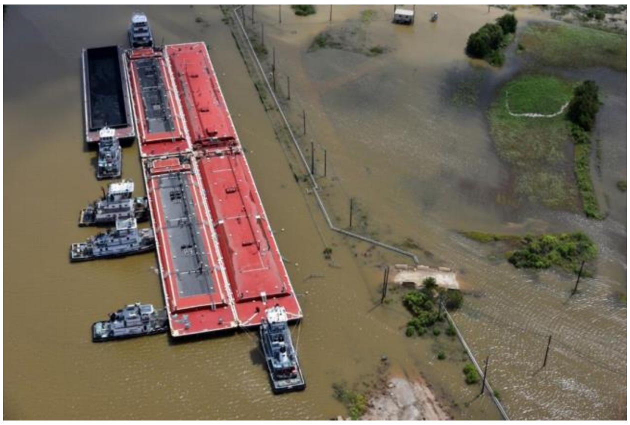
The influence of global warming on such short duration episodes of rain is still uncertain, but recent scientific findings indicate that increases in hourly maximum precipitation may be even higher than for daily extremes.

Flood risk models use historical trends to produce 1-3 year outlooks…but future outlook is driven by more extreme weather events not reflected in historical data. Downscaling from models is improving, but progress takes many years.

Region	Climate risk	Key message	Observed impacts	Projected impacts for mid-century
Europe (Northern and Central)	Extreme precipitation	High variability and greater intensity	Increases seen in some parts, especially in winter	Likely increase in intensity and frequency, especially in winter
Europe	Flooding	Flooding from precipitation patterns and snow melt	Observed increase	Increase in already wet regions
South East Asia	Sea level rise	Threat to low-lying areas in combination with hurricanes	Coastal erosion and flooding	For equator and sub-tropical regions, up to 20% higher sea level rise than global average
North America (coastal regions)	Extreme hurricanes	High risk of combined hurricane and flooding	Atlantic tropical hurricanes have become stronger but not likely they are more frequent	Coastal flooding , more damaging with sea level rise. Atlantic hurricanes likely to become stronger
North America (urban areas)	Flooding	Increases in urban drainage flooding	Likely increase in many regions	Increase in maximum daily precipitation (especially in the North)
Africa (coastal regions)	Sea level rise	Cities in coastal areas at risk	Current global observed change 3.2 mm/year	For equator and sub-tropical regions, up to 20% higher sea level rise than global average
Central and South America	Extreme flooding and landslides	Risk could be complicated by uncertainty of El Niño	Increases in many areas (decreases in a few)	Increases in Tropics, inconsistent trends elsewhere

Immediate Flood-related Risks by Region. *Impacts are already observed have a significant probability to increase regardless of scenario, from 2°C to Business-as-Usual. Source: CICERO, 2017.*

Case study 1:
Hurricane Harvey, Houston 2017



Houston port on 31 August 2017

Event parameter		
Climatic event		Flooding
		Extreme weather
Harvey made landfall in south Texas as a category 4 system, then remained near-stationary in the Houston area for several days, producing exceptionally prolonged extreme rainfall and severe flooding. An exceptional 1 539 mm of rain fell from 25 August to 1 September in Texas — the largest amount of rain ever recorded in a tropical cyclone in the United States — whilst the storm total rainfall was in the 900–1 200 mm range in much of metropolitan Houston.		
Total costs	$ 80 - 100 billion	
Indirect share of costs	N/A	
Insurance coverage	20% of household costs were covered by insurance	

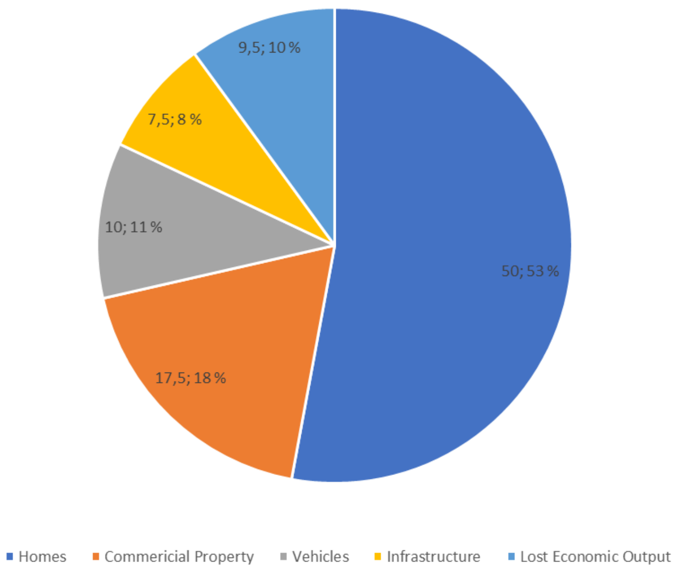
Hurricane Harvey is estimated to be **second most costly natural disaster in US history, pushing the national insurance schemes to take on additional debt**. After Harvey, the US National Flood Insurance Program (NFIP) is facing debt of USD 25 billion, and for the first time sought a reinsurance program of USD 1 billion. In 2018 NFIP purchased additional protection, transferring risk from the public to the private sector.

The event caused **significant indirect losses throughout US and beyond via supply chain disruptions**. Houston airport and port were closed for days, making the consequences of this local event felt across the world.

The **outdated flood control system** from 1940s made the damage worse: shared pipes for storm sewers and wastewater sewers allowed for raw sewage leakage into open waterways.

Urban sprawl over swamps and wetlands, due to absence of zoning regulations, limited the ability of land to absorb water.

Resiliency planning to improve how excess water is absorbed by the landscape around Houson is underway.



Total costs for Hurricane Harvey are estimated between $80–100 billion. *Half of the costs were from direct damage to homes. Source: Artemis*

Case study 2:
Superstorm Sandy, New York 2012

Manhattan blackout during Superstorm Sandy

Hurricane Sandy was the deadliest and most destructive hurricane of the 2012 Atlantic hurricane season. Sandy wreaked havoc across the Caribbean, damaging infrastructure, roads and thousands of homes. The coastline of the United States was also affected, prompting severe floods across the northeast and resulting in over 130 fatalities.

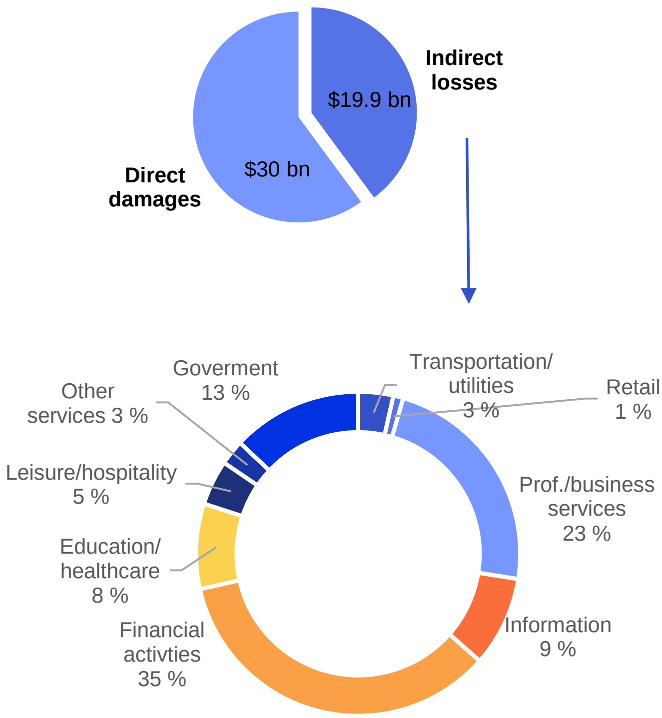
Scientists had not anticipated that warming waters could contribute to a hurricane or superstorm this far north in the Atlantic.

The economic losses impacted every key sector. Power outages led to significant losses for the financial sector, estimated at $7 billion by Moody's. Sandy was responsible for the closure of the New York Stock Exchange for two consecutive days – the last time this occurred due to a weather phenomenon was in 1888.

Lax monitoring and outdated flood maps led to massive underinsurance. Only properties in the 100-year flood zone are required to have flood insurance. At the time of Sandy, the effective Federal Emergency Management Agency (FEMA) floodplain map for New York was from 1983. By one estimate, half of the buildings inundated were outside the 100-year flood zone.

The changing climate requires more sophisticated and recent data. An increasing number of assets are expected to be in the flood plain in the coming decades.

Event parameters	
Climatic event	 Extreme weather Sea level rise
Wind speed of 80 miles (130 km) per hour; storm surge of 14 feet intensified by sea level rise and the high "spring" tide. Hurricane Sandy brought record rainfall to parts of the north-eastern region, with rainfall totals insome areas ranging from 100 mm to 230 mm	
Total costs	$ 22 – $ 113 bn
Indirect share of costs	Estimates range from 10% to 40%
Insurance coverage	40 % of losses insured



Total costs for Superstorm Sandy with breakout of indirect costs. *Indirect losses via electricity and transportation outages impacted all sectors. Source: Zandi, 2012*

Investors cannot rely blindly on insurances. There is a high occurrence of foreclosures in the Sandy flood zone. It may be hard to offload properties in the floodplain and banks may find themselves with unexpected "stranded assets".

Case study 3:
Copenhagen Cloudburst 2011

Istedgade in Copenhagen after the cloudburst

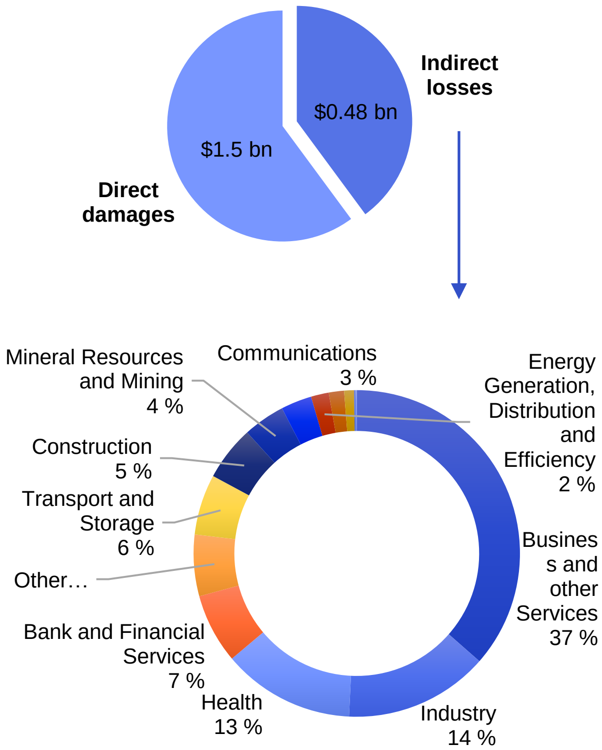
Event parameters	
Climatic events:	Extreme weather
On the 2nd July 2011 150mm of rainfall fell on the city of Copenhagen in less than three hours, inundated the city with 15 centimetres of rain, and flooding basements, train stations and key arterial roads.	
Total costs	$ 2 billion
Indirect share of costs	25%
Insurance coverage	30% of total costs (with 90 000 claims)

The Copenhagen cloudburst on 2 July 2011 showed the **vulnerability of urban structure to extreme precipitation and overflow** and brought extreme weather to the attention of politicians and the insurance sector. The cloudburst left 10,000 homes without power for up to 12 hours; 50,000 homes were without heating for one week.

All economic sectors were impacted to some degree by electricity outages, transportation disruptions and reduced revenue as a result of consumer interruption. The industry sector suffered the most direct (physical damage) and indirect losses (production disruptions).

There are less uninsured losses in the case of Copenhagen as in the previous cases thanks to the mandatory flood tax imposed on business and households by the Danish Government. Standard private insurance in Denmark has not covered floods since the 1980s. Uninsured losses possibly refer to indirect impacts of the flooding, for example, moisture impacts.

After the cloudburst, the City of Copenhagen developed **climate change adaptation and cloudburst plans** with measures to prepare the city for future extreme rainfall. The cloudburst plan includes both measures to expand the sewer network underground as well as 300 surface solutions, combining resiliency and urban innovation.



Total costs for Copenhagen Cloudburst with breakout of indirect costs. *Direct and indirect losses were highest in the industrial and manufacturing sectors. Indirect losses were estimated using input-output analysis. Source: CICERO analysis.*

Case Study 4:
Regional flooding in Norway, 2012 - 2013

Bridge in Gausdal threatened by flood, 2013

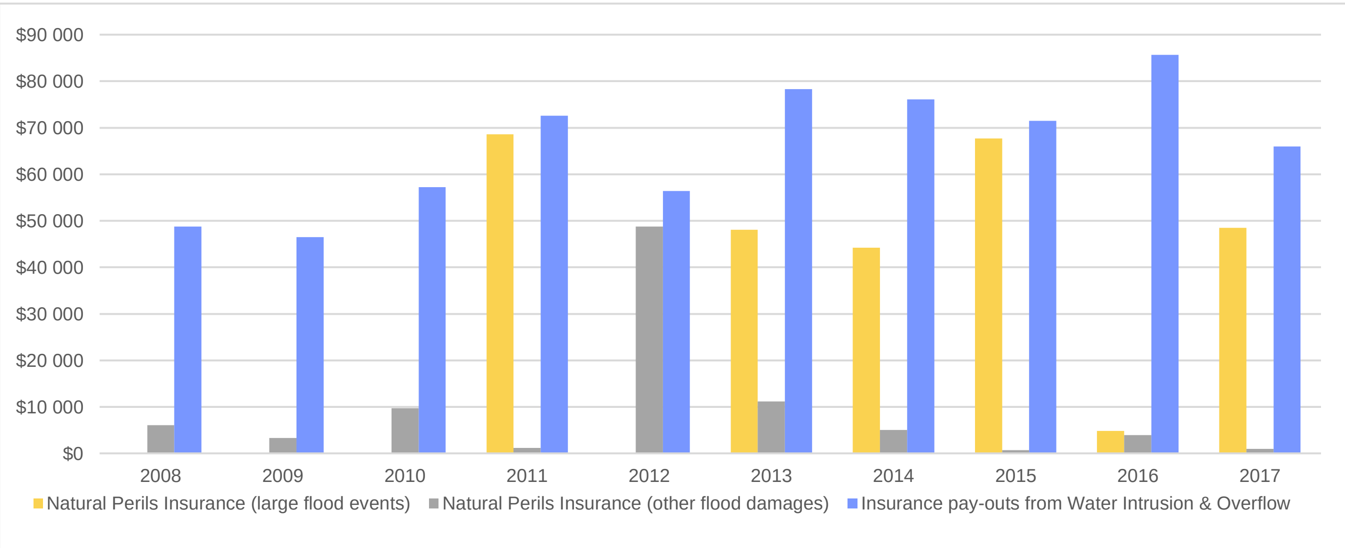
Event parameters	
Climatic events: 	Flooding
Inland regional flooding along Dovrebanen rail and E6 highway in 2013, and extreme rainfall in Buskerud county in 2012, disrupted rail transportation in Norway.	
Total costs	Buskerud: 2.6 mill USD (rail only) Dovrebanen: 49 mill USD (rail only)
Indirect share of costs	Buskerud: 53% Dovrebanen: 37%
Insurance coverage	N/A

Both regional flooding events in 2012 and 2013 and are characteristic of frequent flooding in Norway, which cause building and infrastructure damages.

Inland, rural flooding can have wide-spread supply chain impacts. In the Buskerud and Dovrebanen floods, rail transportation was disrupted. In addition to the direct costs of damages to the rail infrastructure, indirect costs were incurred including lost productivity from delays and communication break-downs.

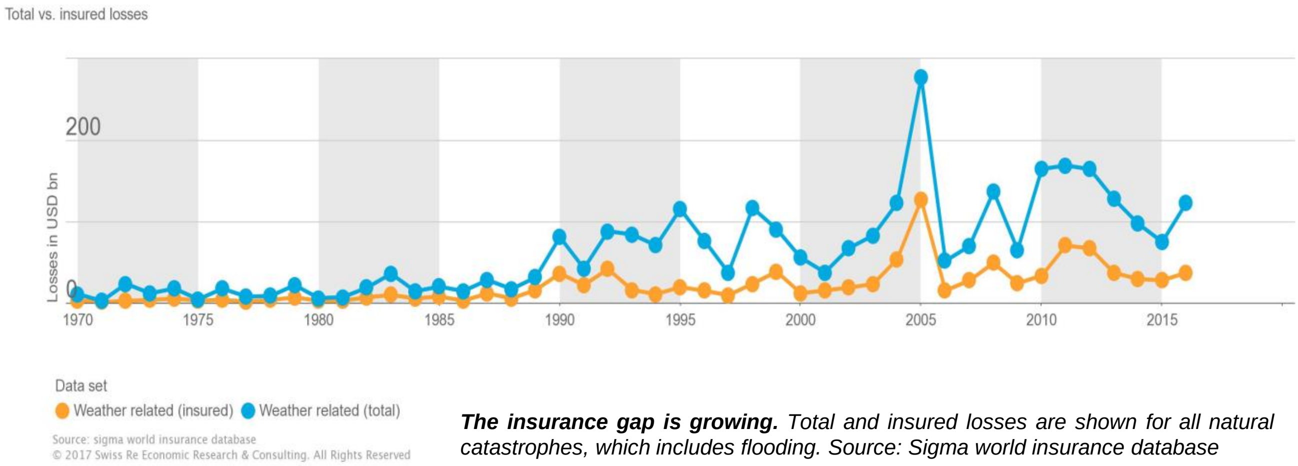
In Norway, natural hazard insurance coverage is relatively high due to the government-mandated bundling of flood and fire insurance through the Natural Perils Insurance Act. For uninsurable assets, the government has a separate natural hazard compensation scheme. Due to the mandatory insurance coverage, direct damages to property are less of a concern. However, **indirect costs from supply chain and communication disruptions may not always be covered.**

Although extreme floods get more attention, the majority of cumulative costs in Norway have been caused by frequent, less severe, water overflow events. These damages are not covered by the Natural Perils Insurance Act and directly impact the individual asset owner and insurance company. Damages from urban overflow and water intrusion are expected to rise with increased extreme rainfall in urban areas.



Insurance payouts in Norway from 2008-2016. *Large flood events are the largest share of the natural disaster insurance payouts,but are not as expensive as the insurance payouts for damages from overflow. Source: NASK and VASK, 2017*

Insurance protection gap is growing



The insurance gap is growing. *Total and insured losses are shown for all natural catastrophes, which includes flooding. Source: Sigma world insurance database*

Economic losses and insurance pay-outs after extreme weather are rising globally. 2017 was the year with the highest documented economic losses associated with severe weather and climate events.

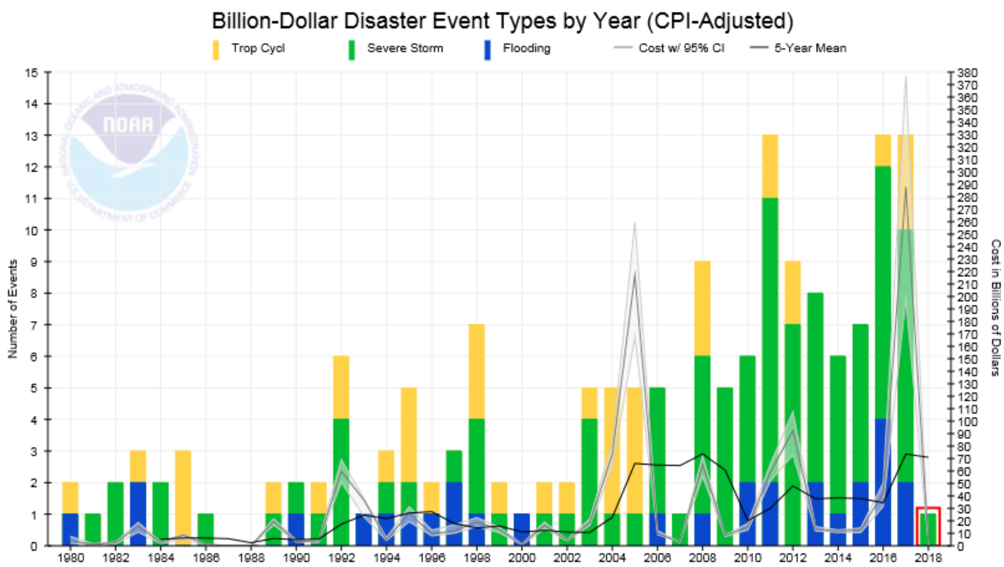
The gap between insured and total natural catastrophe losses is widening. 70% of national catastrophy losses were uninsured (2004-2014). Some national programs are capable to shoulder these uninsured losses, but increasing flood risk could push government programs to bankruptcy.

There may be systemic risk related to the insurance industry. The insurance industry manages risk, e.g. through repricing, withdrawing coverage or transferring exposure. However some of the risk previously covered by the public sector through national insurance programs is being transferred to the private sector (e.g. via NFIP purchasing reinsurance). To understand the implications of this transfer and better math price to risk, there are ongoing efforts to redesign risk classification systems. But questions about systemic risk still remain unanswered:

What happens when re-insurers pull out because of declining profits?

What is the impact on the private sector and individuals when insurance fails to cover flood risk?

Who pays for the damages if public insurance programs are financially depleted?



Billion-dollar disaster events are on the rise. *US disasters of a billion-dollar magnitude, particularly severe stroms, have increased in the past decade. Source: NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters (events as of 6 April, 2018).*

How to prepare for increased flood risk?

Resiliency planning in both the public and private sectors is critical to address increasing flood risk, significant costs and the increasing insurance gap. How flooding risk is managed by the public sector and costs are covered by the insurance sector needs to be considered in combination. As insurance coverage recedes or shifts, the public sector can consider ways to proactively manage flood risk through a combination of resiliency planning and insurance programs.

For investors, dialogue with companies can help uncover potential vulnerabilities either in resiliency planning or insurance coverage. Some example questions are suggested here.

Questions to engage with companies on flood risk:

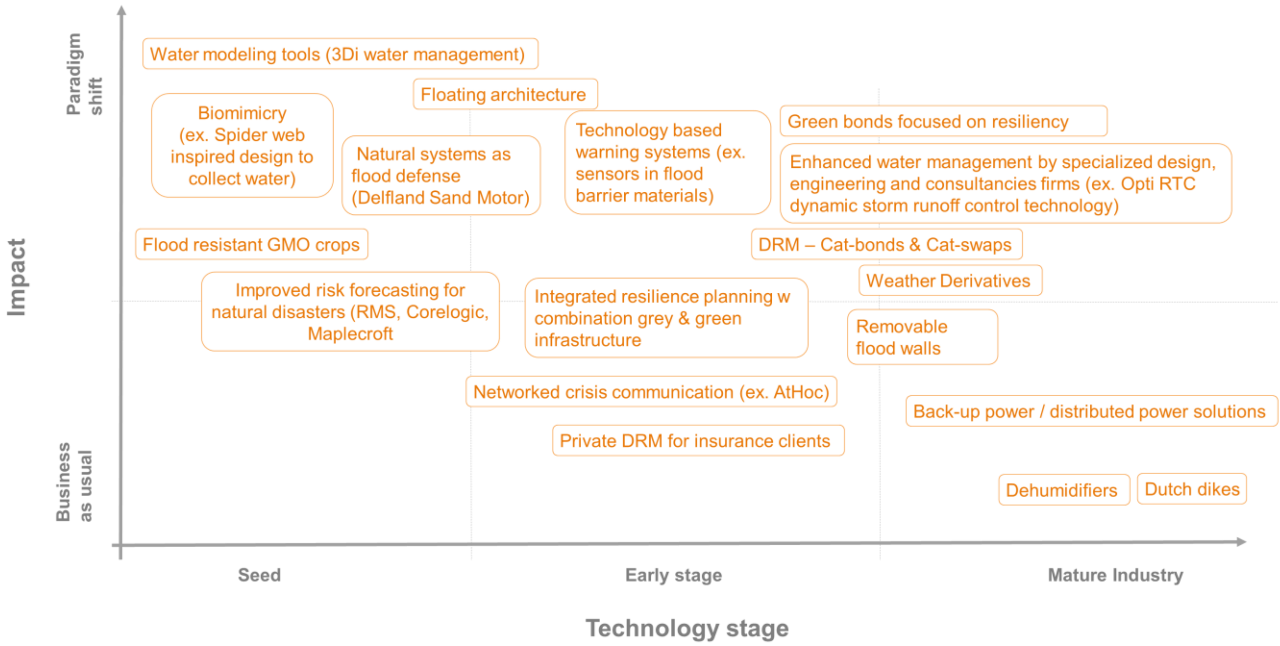
Flooding resiliency and preparedness

- What strategies are in place to mitigate vulnerability to flood risk?
- Is your company prepared for supply chain disruptions from flooding? Does your business continuity plan cover flooding risk?
- Do you know if flooding probabilities and zoning maps for areas in which you operate updated on a frequent basis? (e.g. check regional sources like NOAA storm surge data, European Environment Agency, national environment agencies)

Insurance coverage

- What types of flood risk does your insurance cover?
- Have your insurance costs/coverage changed in the past few years?

Investors can also consider new investment opportunities via technologies and services that can mitigate flood risk. A mapping of selected examples of investment opportunities is provided below, including flood barriers, floating architecture, and risk modelling services. The examples are categorized according to their relative potential for impact and the stage of development.



Mapping of investment opportunities. *Source: CICERO analysis*

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Are You Prepared?

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