Climate risk assessment in global real estate investing

This paper is written by: Munich Re and PGGM

Introduction

Climate change is affecting the mindset of investors globally in a multitude of ways. A term originally defined for companies in the coal and oil industry 'stranded asset risk', is increasingly part of the broader investment vocabulary and linked to climate change. As a result of increasing awareness but also the Paris Climate Agreement, more and more real estate investors are taking climate-related financial risks into account. From a real estate perspective, properties are unlikely to become truly stranded as could happen with an oil well, but they do run the risk of becoming obsolete if they are no longer capable of generating rental income. In our view climate change related factors could cause property obsolescence through two partially related channels. The first is due to a lack of adherence to local regulation which forbids landlords to lease space and as such generate income. The second is because of an absolute absence in tenant demand for a specific location as no company or family wants to be housed at that particular location. The first type of risk is also known as transition risk and affects all properties in a jurisdiction while the latter depends on the climatologic characteristics of a specific location.

Transition risk is largely manageable by the asset owner through retrofitting the building in line with requirements but could create the necessity for large unanticipated investments and therefore disappointing returns. The path of changes in requirements is uncertain as these are driven by policymakers and regulators. This keeps investors in the fog whether they do too much or too little from a purely financial return driven point of view.

Transition Risk
Impacts all assets in a jurisdiction that align with government requirements

Physical Risk
Impacts all assets in different ways depending on location

Asset Level Characteristics
Potential mitigants driven by structural quality

Physical risk could be mitigated by reinforcing the structure of the building in order to withstand more frequent extreme weather events such as storms or occasional flooding but this type of protection has its physical and financial limitations. In the long run, physical asset risk could lead to a full write-off of not just the physical structure but also the land. This would be a novelty for real estate investors. However, climate change does not have to lead to a full write-off to have negative impact on returns. Increasing insurance costs, energy consumption for cooling, capital expenditures to improve resilience and a drop in tenant and investor demand lead to a competitive disadvantage for buildings in high risk areas. From a timing perspective it is likely that transition risk is more urgent but as a long-term investor in a less liquid asset class, the physical risk cannot be neglected.

In this paper we introduce the work that PGGM Private Real Estate team has been doing in partnership with Munich Re on incorporating climate related risks to its portfolio optimization process with a focus on measuring the physical risk.

PGGM Private Real Estate
Invests in private real estate markets across the globe on behalf of several Dutch pension funds. Currently EUR 14 billion in assets under management with exposure to approximately 4000 properties with a combined asset value of over EUR 160 billion.

Increasing awareness of climate risk

Waterfront, lakeside and sea view have for good reasons been long time sought after characteristics of homes, hotels and offices with the associated price premiums. Besides the aesthetic attractiveness of close proximity to water there is also the transport related positive impact that settlement near water offers resulting in concentration of industrial space. As such it is no surprise that large portions of the global real estate stock is constructed in cities built around natural harbours. Apart from occasional storms there has always been limited downsides and mainly comforts associated with coastal living. However times are changing.

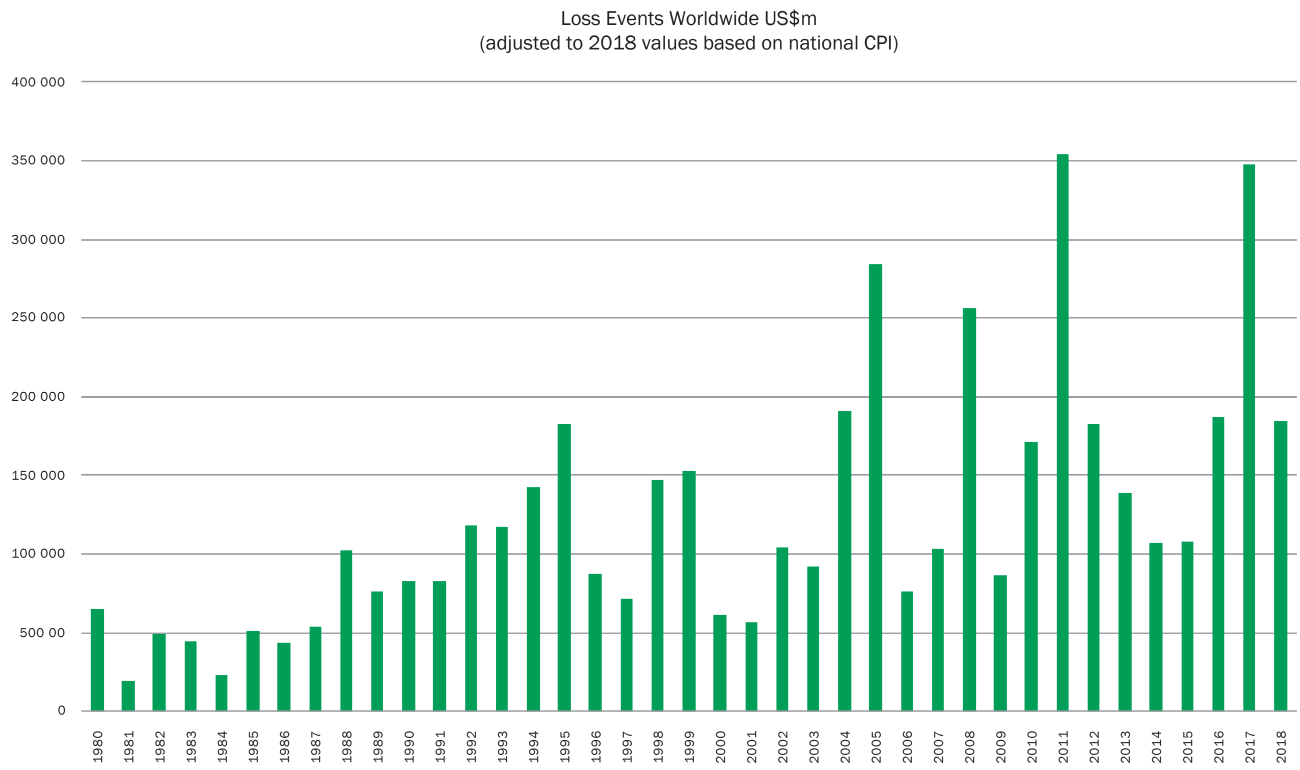


Figure 1: Loss events worldwide 1980–2018.

The expected increase in extreme weather events as a potential result of global warming and an expected gradual but hardly stoppable rise in sea-level might eventually turn the waterfront premium into a mid-water discount. As with all major trends a potential drop in the attractiveness of specific locations as a result of climate-related changes does not happen overnight. Although these changes might not even be fully visible in a lifetime, the change in awareness of the potential impact of weather-related events on the attractiveness of locations and as such pricing is clear.

According to a forthcoming paper in the Journal of Financial Economics by Bernstein, Gustafson, and Lewis (2018) 'houses in the US exposed to sea level rise already trade at a 7% discount to similar homes at another nearby location.'[1] While sea-level rise related risk receives a lot of attention, there are also other natural hazard risks potentially affected by climate change. More frequent and extended periods of hot and dry weather are leading to more droughts. These in turn reduce the livability of affected areas and in certain cases might increase wildfire risk.

On the flipside there is also an expectation of the increased occurrence of extreme precipitation, leading to soil erosion and an increase of various types of flooding. While climate change is expected to increase the future occurrence of extremes on both ends of the weather spectrum, there is increased evidence that some recent weather extremes can be partly attributed to climate change. Munich Re has been tracking natural hazard related loss events since 1980 and shows an inflation adjusted increase in loss events and a rise in calendar years with particularly costly losses.

As noted in a recent article in The Economist (Climate change and the threat to companies - Feb 21st 2019) insurers paid out $135bn in natural hazard related compensations with $195 billion in damage uninsured in 2017. In the same year Houston suffered from its third '500-year flood' in less than 40 years while wildfires occurred on an unprecedented scale across the globe in 2018 (The Economist, 2019). The most recent version of The Global Risks Report published by the World Economic Forum shows proof of an increased awareness for physical climate risk as environmental risks dominate the results of the latest annual Global Risks Perception Survey (GRPS). In 2018, for the first time, three environmental related risks accounted for three of the top five risks by likelihood and four by impact whereas before 2011 there was a complete absence of climate related risks.

Munich Re
Munich Re is one of the world's leading providers of reinsurance, primary insurance and insurance-related risk solutions. The company offers customers financial protection when faced with exceptional levels of damage—from the 1906 San Francisco earthquake through to the 2017 Atlantic hurricane season and to the California wildfires in 2018. Munich Re possesses outstanding innovative strength, which enables it to also provide coverage for extraordinary risks such as rocket launches, renewable energies, cyberattacks, or pandemics renewable energies, cyberattacks, or pandemics

Partnership PGGM and Munich Re

Generating a reliable view on climate risk should be part of prudent portfolio management and investment due diligence. However this is easily said but hard to do and therefore hardly done. Analysis of climate risk exposure in a meaningful way requires precise knowledge of locational attributes of a real estate portfolio which is hard to acquire for international real estate investors. Knowing that a portfolio has 4% exposure to Japan, or 2% exposure to Tokyo, or even more specific like 1% to the Marunouchi submarket, has for a long time been an adequate level of detail for portfolio analytics in real estate investment management. However, the local nature of climate risks requires more granular knowledge as a location on a cliff above the sea has totally different flooding risk qualifications than an adjacent building along the shoreline. Failing to incorporate these differences implies failing to make meaningful analyses. A cooperation between PGGM, its sixty external private real estate managers and real estate big-data firm Geophy made it possible to gather exact longitude/latitude information for every asset to which we have exposure across over eighty different vehicles (with a NAV of more than EUR 14 billion the PGGM Private Real Estate Fund is indirectly invested in EUR 160 billion worth of assets).

Possessing this detailed location information is necessary but needs to be supplemented with exact climate risk metrics for precisely those locations. Climate-related risk analyses are mostly available on a country or continental basis. Only few offer global insights in combination with detailed location specific insights. The search for a partner with appropriate climate risk information on a global scale led to Munich Re where, because of the

1 Bernstein, Asaf and Gustafson, Matthew and Lewis, Ryan, Disaster on the Horizon: The Price Effect of Sea Level Rise (May 4, 2018). Journal of Financial Economics (JFE), Forthcoming. Available at SSRN: https://ssrn.com/abstract=3073842 or http://dx.doi.org/10.2139/ssrn.3073842

nature of their business, natural hazard risk assessment has been embedded in the DNA of the company for decades.

Specifically, Munich Re is a pioneer in the field of individual location level natural hazard risk scoring with the NATHAN® service. NATHAN® provides maps of natural hazard risk and building loss potential as risk scores, across 12 perils. In addition, Munich Re has since the 1980's collected information on natural catastrophes to create an extensive database on economic and insured losses from natural hazard events globally.

As a long-term investor PGGM takes its fiduciary role by examining investment risk from a wide range of angles—both cyclical and structural. Physical climate risk is one of these structural risk factors. The Munich Re NATHAN® service combines global coverage, necessary for PGGM's globally diversified portfolio, with the granularity needed for meaningful analysis.

Munich Re provides natural hazard and risk scores for Real Estate Climate Risk Assessment

Munich Re's global risk scores are built up from 12 different natural hazards with potential impact on properties, (see Appendix for a description of risk factors). The existing risk metrics are based on information on historic events and a scientific understanding of natural hazards. It is generally expected that an increase in extreme weather events will occur in areas already frequently influenced by natural hazards rather than in areas that are historically less affected. In this way, past performance is indicative for expected future performance.
By relying on high-quality Munich Re natural hazard expertise it is possible to perform efficient exposure analyses of individual risk locations or even entire portfolios. In addition to the overall risk score, three subcategories of Risk Scores with a numeric risk index are available, as shown in Table 1.

NATHAN Single Risk Assessment Report

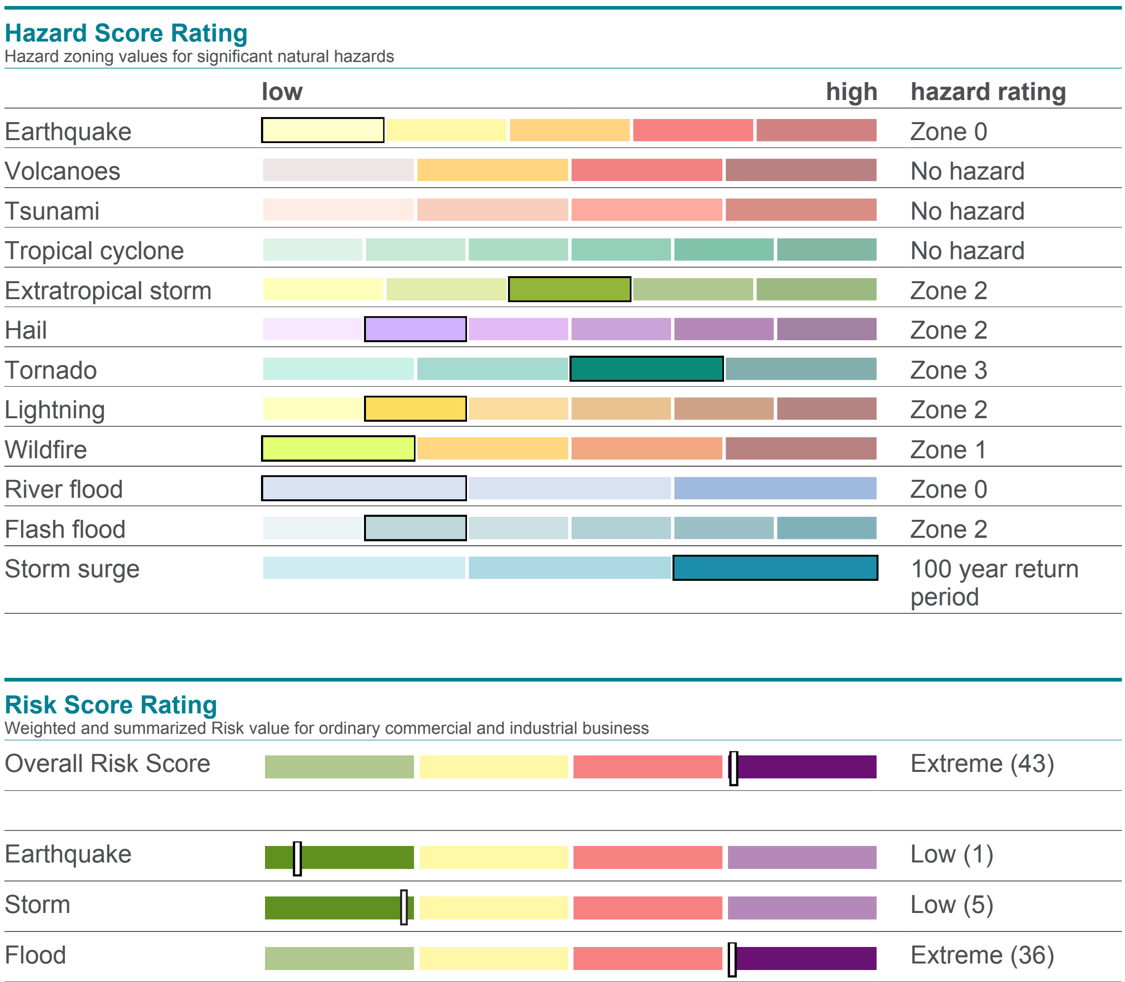


Table 1: Overview of Munich Re natural hazards and risk factors – example property.

The objective of the partnership between PGGM and Munich Re is to measure the current risk landscape and combine this risk level with forward looking climate scenarios. This enables investors with globally diversified real estate portfolios to pinpoint potential risks stemming from climate change with a level of detail and rigor that used to be impossible.

The Munich Re NATHAN® service focuses on the full spectrum of natural hazard risks but not all of these are climate related. Nine hazard scores and two risk scores are climate related while the others are unrelated to any potential climatological changes. Earthquakes, volcanos and tsunamis, while potentially devastating, are not impacted by climate change and fall out of scope for this analysis. Other natural hazard risks, like hail and lighting, are important for sectors like agriculture, but are unlikely to be material to real estate investment return expectations. As a result the analysis is confined to the set of climate related natural hazard risks with potential investment return implications for real estate as shown in the last column of Table 2.

Analysis of PGGM Private Real Estate Fund

The quantification of climate-related risks for the whole portfolio is enabled by combining climate risk assessments with financial exposure information, both at the asset level. Table 3 shows risk indications for each country in PGGM's real estate portfolio on two climate related risk scores; flooding and storm. The numerical values are created by PGGM based on Munich Re risk scores by rebasing all hazard and risk scores to values between 1 and 5.

Risk Category	Climate related risk	Real Estate Risk	Included in analysis
Earthquake	✗	✓	✗
Volcanoes	✗	✓	✗
Tsunami	✗	✓	✗
Tropical cyclone	✓	✓	✓
Extratropical storm	✓	✓	✓
Hail	✓	✗	✗
Tornado	✓	✓	✓
Lightning	✓	✗	✗
Wildfire	✓	✓	✓
River flood	✓	✓	✓
Flash flood	✓	✓	✓
Storm surge	✓	✓	✓

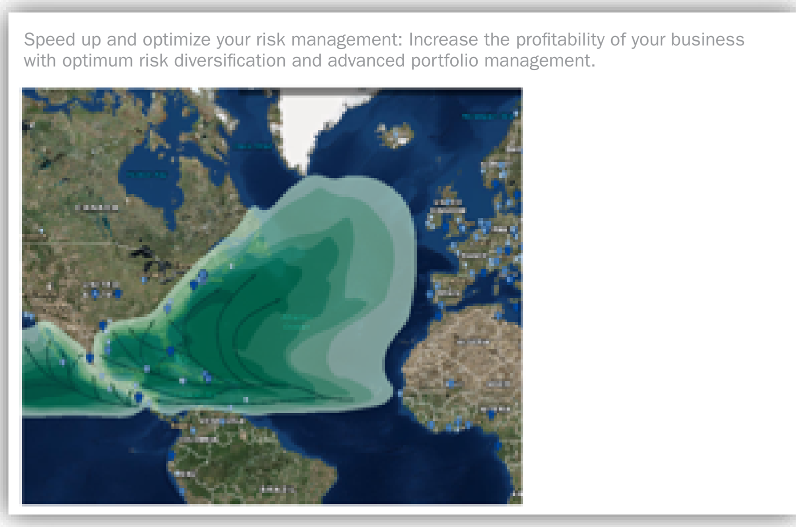
Table 2. Overview of Munich Re natural hazard risk factors included in the analysis.

This method keeps the underlying relativities between scores in place but improves comparability between risk categories. Any result presented in this paragraph at the country or city level is based on the specific portfolio of PGGM Private Real Estate Fund. Therefore it might not fully reflect the risk of the particular market since the result is based on the specific location of the buildings in the portfolio and their exposure values.

As previously mentioned, accurate climate related risk assessment needs to be performed at the individual building level. Subsequently it can be aggregated to the country or region level. However, it is very informative to know which countries are the top drivers for climate risk for the portfolio. Table 3 provides an overview of the climate risk exposure for the portfolio at the country-level. The country with the highest euro weighted average physical climate risk in PGGM's portfolio is Japan. Especially the risk of flash floods and tropical cyclones is estimated to be high at the locations where PGGM properties are located in Japan. As stated in the introduction, there can be mitigants of this risk at the asset level depending on the structural characteristics of the property and/or location. This type of analysis is out of scope for the global climate risk project but would be part of further assessment for those assets with a high risk profile.

	Composite Score Flooding	Composite Score Storm
Japan	2.9	5.0
Hong Kong	2.0	5.0
China	3.5	2.4
United States	2.4	2.7
South Korea	2.5	2.5
Germany	1.9	2.3
Netherlands	1.8	1.6
Poland	1.7	1.6
France	1.8	1.5
United Kingdom	1.9	1.3
Australia	1.6	1.4
Spain	1.3	1.6
Malaysia	1.6	1.3
Italy	1.5	1.3
Portugal	1.3	1.3
Singapore	1.3	1.3
Brazil	1.3	1.1

Table 3: Climate risk overview for the portfolio at the country-level.
Note: numbers are based on PGGM portfolio weights of assets in each country and PGGM's rebasing of underlying hazard and risk scores.



When looking for key drivers at the city level (Table 4) we can see that Marrero (Louisiana), Savannah (Georgia) and Palm Harbour (Florida), all coastal cities in the United States, rank as the top three of cities with the highest climate related risks in PGGM's global portfolio. At the individual property level, 4 out of the top 5 assets with the highest risk are located in Miami, Florida as these properties are particularly exposed to riverflood, storm surge, tornado, and tropical cyclone risk.

Table 3 and 4 show average risk scores at the country and city level, weighted by euro exposure value on the individual asset level. However, even with natural hazard risks there can be a lot of variance within countries and cities. Figure 2 shows an example of storm surge risk for locations within the greater Tokyo area and highlights the extreme spatial variability in estimated storm surge risk within this area. Knowing which parts of the portfolio are most heavily exposed to particular types of risk allow much more efficient review of potential mitigants in place to lower the actual risk at the building level.

City/MSA, Country	Extratropical Storm	Flash Flood	Riverflood	Storm Surge	Tornado	Tropical Cyclone	Wildfire
Marrero, United States	1.67	3.33	5.00	5.00	5.00	4.00	1.25
Savannah, United States	1.67	3.33	5.00	5.00	3.33	3.00	2.50
Palm Harbor, United States	1.67	3.33	1.00	5.00	5.00	4.00	3.75
Metairie, United States	1.49	3.33	5.00	5.00	5.00	3.11	0.00
Newark, United States	1.67	3.33	5.00	5.00	5.00	1.00	1.25
Amagasaki, Japan	1.67	3.33	5.00	5.00	1.67	4.00	1.25
Quanzhou, China	0,00	4.17	5.00	5.00	3.33	3.00	0.00
Miami, United States	1.49	3.58	0.60	3.14	5.00	4.00	0.98
Dalian Shi, China	1.67	4.91	4.43	4.43	3.33	0.00	0.00
Philadephia, United States	1,67	3.33	0.00	5.00	5.00	1.00	2.50

Table 4: Climate risk overview for the portfolio at the city-level.

Note: numbers are based on PGGM portfolio weights of assets in each country and PGGM's rebasing of underlying hazard and risk scores.

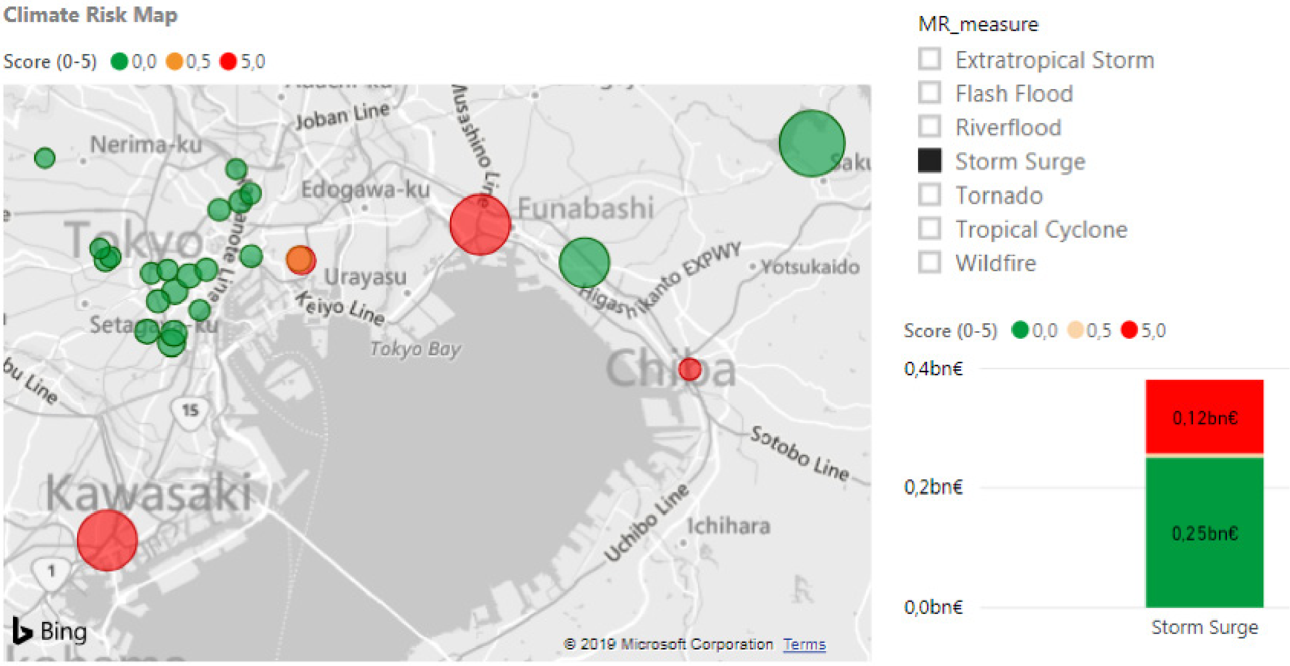


Figure 2: Example of storm surge risk at the individual building level.

Note: numbers are based on PGGM portfolio weights of assets in each city and PGGM's rebasing of underlying hazard and risk scores.

Portfolio analytics beyond hazard risk factors

Munich Re NATHAN® also provides additional information on location characteristics valuable for real estate investors. An example is the elevation profile and distance to coast for all assets in a portfolio based on the specific location of the property. This granular information enables investors to make an elevation analysis of the portfolio. Such an analysis provides insights on the euro exposure value of the portfolio that might be at risk when sea levels rise as a result of global warming. Countries across the globe will be facing the challenges of potential sea-level rise and the associated costs of damages or investments for protection. Figure 3 shows the cumulative percentage of euro exposure value within a certain range of elevation above, or below, sea level. The analysis reveals that about 3% of the total portfolio value has an elevation of 0 or below. This can almost be fully attributed to the portfolio exposure in the Netherlands; a country known for its lowlands but also its world renowned sea defences like The Eastern Scheldt Barrier and The Maeslant Barrier (see Figure 4). Reassuring for PGGM's portfolio is the fact that properties below sea-level are located in a well-protected country and that over 80% of the exposure is at least 13 meters above current sea-level.

Next steps

The analysis presented in this paper is largely based on historic events that impact current natural hazards. While the current risk metrics are based on historic events, the future is expected to be an amplified version of current risks to a certain extent. Areas currently facing high risk will experience even higher risk when more frequent extreme weather events occur and areas currently less exposed might also see an increase in risk level but remain at a lower level.

The outcome of the analysis summarized in this paper provides meaningful insights on the physical risk of climate related natural hazards for PGGM's Private Real Estate portfolio. In this way, it enables PGGM to examine not only where physical risk of various climate related natural hazards is concentrated but also to which extent specific properties, cities, countries or regions are exposed to various types of risk. Based on this insight PGGM is able to enhance the discussions with external investment managers on the risks and necessary control mechanisms to protect its investments. Where needed this analysis leads to disposal of assets where the risks are regarded as outsized. Besides the review of current investments, consistent global analysis of natural hazard risks allows PGGM to further complement the underwriting of new investment proposals. Climate risk becomes an integral part of the underwriting model of real estate investments. Traditionally these models focused on economic variables such as economic growth, construction activity and interest rates and where physical

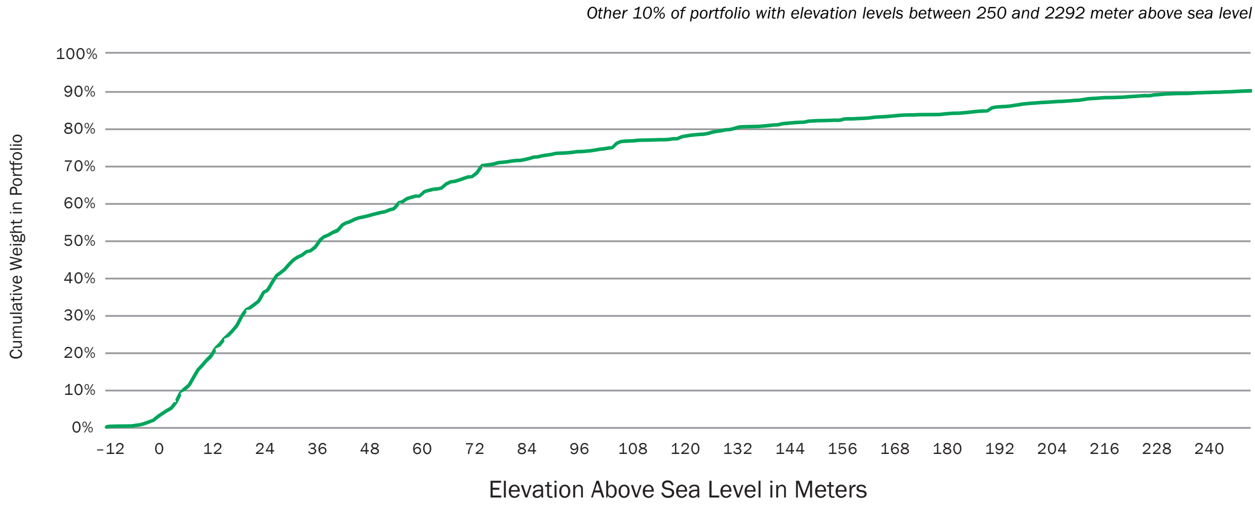


Figure 3: Elevation profile of PGGM private real estate portfolio.

longevity of assets is taken as a given. The potential of rising insurance costs or depreciation of assets and locations, both with adverse impact on investment returns, due to a potentially changing climate can now be included into the investment equation.

We can expect climate scenarios to change over time which will almost certainly have an impact on the risk assessment of real estate portfolios. Uncertainty about future changes should impact the way outcomes are interpreted but can never be a reason to neglect potential risks in a portfolio. Therefore, the next step of the partnership between Munich Re and PGGM is to get a better understanding of long term risks by incorporating standard climate scenarios into the risk models in order to further enhance the forward looking quality of the risk assessment.

Figure 4: The Maeslant Barrier protecting Rotterdam from storm surges.

Legend

Earthquake

- Zone 0: MM V and below
- Zone 1: MM VI
- Zone 2: MM VII
- Zone 3: MM VIII
- Zone 4: MM IX and above

Probable maximum intensity (MM: modified Mercalli scale) with an exceedance probability of 10% in 50 years (equivalent to a „return period“ of 475 years) for medium subsoil conditions.

Volcanoes

- No hazard*
- Unclassified
- Zone 1: Minor hazard
- Zone 2: Moderate hazard
- Zone 3: High hazard

*Secondary effects that can occur as a result of the large-scale distribution of volcanic particles (e.g. climate impacts, supraregional ash deposits) are not considered

Tsunami

- No hazard
- Zone 0 minimal flood risk
- Zone 1000 year return period
- Zone 500 year return period
- Zone 100 year return period

Zones based on 100m SRTM (Version 4.1) elevation model, taking into account height above sea level and distance from coasts.

Tropical cyclone

Peak wind speeds

- No hazard: < 76 km/h
- Zone 0: 76 – 141 km/h
- Zone 1: 142 – 184 km/h
- Zone 2: 185 – 212 km/h
- Zone 3: 213 – 251 km/h
- Zone 4: 252 – 299 km/h
- Zone 5: ≥ 300 km/h
- Typical track directions

Probable maximum intensity with an exeedance probability of 10% in ten years (equivalent to „return period“ of 100 years).

Extratropical storm

Peak wind speeds

- No hazard
- Zone 0: ≤ 80 km/h
- Zone 1: 81 – 120 km/h
- Zone 2: 121 – 160 km/h
- Zone 3: 161 – 200 km/h
- Zone 4: > 200 km/h

Probable maximum intensity with an average exeedance probability of 10% in ten years (equivalent to a „return period“ of 100 years). Areas were examined in which there is a high frequency of extratropical storms (approx. 30°–70° north and south of the equator).

Lightning

Global frequency of lightning strokes per km² and year

- Zone 1: 0,2 – 1
- Zone 2: 1 – 4
- Zone 3: 4 – 10
- Zone 4: 10 – 20
- Zone 5: 20 – 40
- Zone 6: 40 – 80

Lightning frequency is determined by counting the total number of lightning flashes independently of whether they strike the ground or not.

Tornado

- Zone 1: low
- Zone 2
- Zone 3
- Zone 4: high

Frequency and intensity of tornados.

Wildfire

- No hazard
- Zone 1: low
- Zone 2
- Zone 3
- Zone 4: high

The effects of wind, arson and fire-prevention measures are not considered.

River flood

- Zone 0 minimal flood risk
- Zone 500 year return period
- Zone 100 year return period

Areas threatened by extreme floods. JBA flood maps with return periods of 100 and 500 years.

Flash flood

- Zone 1: low
- Zone 2
- Zone 3
- Zone 4
- Zone 5
- Zone 6: high

Frequency and intensity of flash floods.

Storm surge

- No hazard
- Zone 1000 year return period
- Zone 500 year return period
- Zone 100 year return period

Detailed calculation for coasts and the shores of large lakes. Zones based on 30m ALOS Digital Elevation Model (DEM), taking into account wind speed and bathymetry (underwater depth of lake or ocean floors). Does not consider dykes.

Soil and Shaking Hazard

- Class 1 - Low: Hard Bedrock
- Class 2 - Rock
- Class 3 - Soft Rock/dense soil
- Class 4 - Stiff Soil
- Class 5 - Soft Soil
- Class 6 - High: Reclaimed Land

Underground conditions influencing earthquake intensity (based on geological, soil and hydrological information).

Hail

- Zone 1: low
- Zone 2
- Zone 3
- Zone 4
- Zone 5
- Zone 6: high

Frequency and intensity of hailstorms.

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