Climate Valuation

WalesBigBank

Residential Mortgage Portfolio
PHYSICAL CLIMATE RISK REPORT

WalesBigBank SAMPLE

Overall Risk Profile

Assets Risk Distribution

Climate Change Hazards

Climate Valuation
www.climatevaluation.com

Prepared for: John Smith	Date: 2021

REPORT CONTENTS

IMPORTANT INFORMATION

What this report does and does not do.

Climate Valuation's Products and Services use the Climate Risk Engines operated by Climate Risk P/L that process information and return results. Generally, users select or create Representative Assets which are synthetic representations of a real or hypothetical asset which may include real estate properties, residential infrastructure or other physical objects. Information about this Representative Asset is processed together with other relevant information such as location, age or value.

The Climate Risk Engines integrate the information sent to it with information from a large number of national and international datasets from government institutions, universities and private companies to provide a generalised model of how climate change may affect a number of physical risks to the Representative Asset, all else being equal. The physical risks covered by the analysis will be displayed where the results are presented (on a Site or in a Report).

However, the Climate Risk Engines do not provide a forecast, prediction or projection based on any actual or planned asset. The analysis does not purport to 'cover the field' of all potential risks associated with climate change nor to address coincidence or correlation between such risks. For example, extremes of precipitation and flooding may be coincident with extreme wind-storms which can damage a building making it more vulnerable to damage. The Climate Risk Engines do not necessarily take into account the impact of any actual built infrastructure, modifications, adaptations or resilience-building measures (public or private) that have been, or may be, applied that reduce (or exacerbate) the relevant hazard. No representation is made in relation to the availability or coverage of insurance to an actual or planned asset.

Not forecast or prediction

Climate Valuation does not purport to generate statements of fact, forecasts or predictions, nor imply any representation regarding the likelihood, risk, probability, possibility or expectation of any future matter. To the extent that any statements made or information contained or generated might be considered forward-looking in nature, they are subject to physical, political, regulatory, technological and stakeholder-related variables and uncertainties that could cause actual results to differ materially. You are cautioned not to place undue reliance on any such forward-looking statements, which reflect assumptions and information available only as of the date of modelling.

No explicit or implicit assumption is made in relation to the current or future alignment of any climate change-related scenarios with climate- related policies of any government at international, national or sub-national level. The impacts of climate change analysed are only for a range of greenhouse gas emission and global warming scenarios presented in the Intergovernmental Panel on Climate Change Assessment Report (IPCC 2014, IPCC 2007).

Not financial advice

The information presented does not comprise, constitute or provide, nor should it be relied upon as, investment or financial advice, credit ratings, an advertisement, an invitation, a confirmation, an offer or a solicitation, or recommendation, to buy or sell any security or other financial, insurance, credit or lending product or to engage in any investment activity, or an offer of any financial service.

As this analysis is based on a 'representative property', the information in this report does not purport to quantify risk to the actual subject land, infrastructure, buildings or other physical assets or any part thereof, nor make any representation in regards to the saleability, mortgage ability, insurability, or defects, of any real subject property, nor its suitability for purchase, holding or sale. The Modelling Outputs presented are provided with the understanding and expectation that each user will, with due care, conduct their own investigation and evaluation of any real or planned asset at a specific location.

Exclusion of liability

To the extent permitted by law Climate Valuation and Climate Risk p/l and our data and analytic suppliers will not be liable for any loss or damage, whether in contract, tort (including negligence), breach of statutory duty or otherwise, even if foreseeable, arising under or in connection with use of or reliance on any information, data or content obtained via our services, including (without limitation) the modelling outputs presented.

Scientific Limitations

The information presented has been generated using an expert selection of the scientific methods and computational modelling techniques available at the time of creation. However, at any time there are known limitations of which you should make yourself aware. These are constantly refined and updated and are specified on the Climate Valuation site www.climatevaluation.com.

Scope of Modelling and Scenarios

Science is not able to definitively predict the exact range or rate of future global warming; or the scale and rate of change of atmospheric and oceanic processes that may be hazardous, including temperatures, precipitation, wind and the rise in sea levels that result from this warming. Many variables will determine society's continuing rate of emission of 'greenhouse gases' (including political, regulatory, technological and behavioural factors), and how the Earth's natural systems respond. However, we can estimate a range of potential impacts across what mainstream science considers to be a plausible set of scenarios for future ocean and atmospheric behaviour. The scenarios used are specified in the relevant Scenarios sections of websites and reports where the Climate Risk Engines are used.

DISCLAIMER

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While every effort has been made to ensure that this document and the sources of information used herein are free of error, the authors: Are not liable for the accuracy, currency and reliability of any information provided in this publication; Make no express or implied representation of warranty that any estimate of forecast will be achieved or that any statement as to the future matters contained in this publication will prove correct; Expressly disclaim any and all liability arising from the information contained in this report including, without, errors in, or omissions contained in the information; Except so far as liability under any statute cannot be excluded; Accept no responsibility arising in any way from errors in, or omissions contained in the information; Do not represent that they apply any expertise on behalf of the reader or any other interested party; Accept no liability for any loss or damage suffered by any person as a result of that person, of any other person, placing any reliance on the contents of this publication; Assume no duty of disclosure or fiduciary duty to any interested party.

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Included and Excluded Hazards: This analysis covers riverine flooding, surface water flooding, coastal inundation, forest fires, wind gusts, extreme heat and subsidence of clay soils. It does not include hurricane/cyclone, landslip, grass fires, hail, coastal erosion, lightening or any other hazards apart from those specifically identified.

Representative Assets: The analysis is based on synthetic representations of residential property with identifiable physical address such as free standing dwellings, apartments and duplexes. The results may include assumptions about the composition of a "Representative Property' and cannot be taken as confirmation of the actual future risks to, or value of, an actual or planned property or infrastructure asset. The analysis does not include movable dwellings without postal addresses such as caravans, annexes or tents.

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Contact: info@climatevaluation.com.au

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

Scope of this 2021 study.

Extreme weather and climate change drive a range of hazards which cause property damage. In this study, individual properties within the current WalesBigBank residential mortgage portfolio have been stress-tested against six extreme weather and climate change hazards; riverine flooding, surface flooding, coastal inundation, forest fires, soil subsidence and wind-storms. These hazards have then been tested using a range of climate change models under RCP8.5 scenario (representing a warming of 3.2-5.4 degrees by 2100). Physical risks have been calculated using a combination of engineering, climate science, weather and financial data.

Key Insight number one

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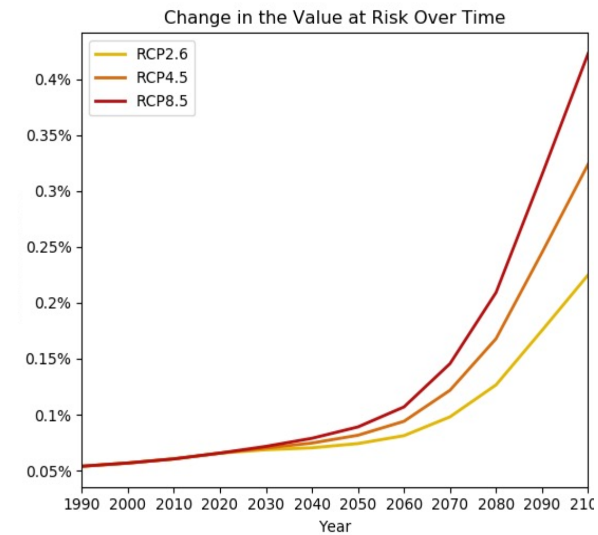

EXECUTIVE SUMMARY

Key Insight number five

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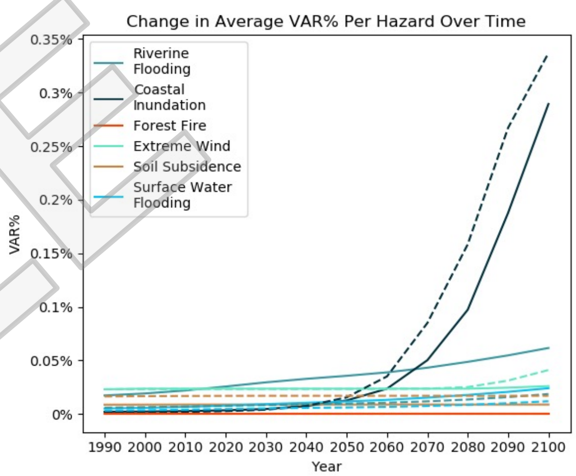

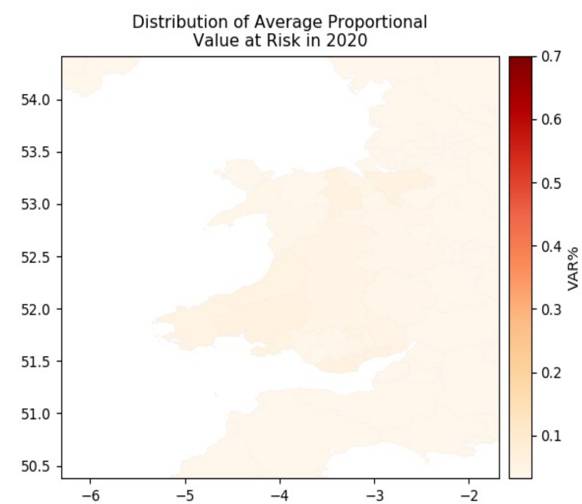

EXECUTIVE SUMMARY – KEY RECOMMENDATIONS

Based on the insights contained within this report on WalesBigBank residential portfolio's exposure and vulnerability to physical climate change, the key recommendations include:

1. Understand and address industry position.
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2. Undergo quantified scenario testing of different adaptation strategies.
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INTRODUCTION

PHYSICAL CLIMATE RISK AND THE FINANCIAL INDUSTRY

Climate-related risk is financial risk.

Continued emission of greenhouse gases will cause long-lasting changes in all components of the climate system and could have severe and irreversible impacts for global financial systems.

Following the release of the recommendations of the Taskforce for Climate Related Financial Disclosure (TCFD) in 2018, there has been growing momentum for organisational governance around climate-related risks and opportunities *(https://www.fsb.org/2020/10/fsb-welcomes-tcfd-status-report/).*

"Climate change will affect the value of virtually every financial asset…"

- Bank of England Governor Mark Carney (2019)

Organisations such as the Bank of England have indicated that they will soon require prescribed climate scenarios to be used for risk analysis in the financial sector – a process that is likely to be repeated in other international jurisdictions. This will include the testing of mortgage portfolios *(https://www.bankofengland.co.uk/climate-change).*

As the pressure for banks to reveal the extent of climate change risks in their mortgage books increases, there will be growing incentive to avoid writing new 'climate subprime' mortgages. As certain lenders screen out climate subprime assets, it will gradually increase the fraction of climate subprime for those lenders who are unaware of the liabilities associated with the incoming at-risk properties.

Meanwhile, widespread underinsurance against extreme weather risk threatens the stability of the residential lending market *(https://www.abc.net.au/news/2019-10-23/the-suburbs-facing-rising-insurance-costs-from-climate-risk/11624108?nw=0).* As extreme weather events increase in frequency and severity, insurance will become less accessible, leading to serviceability pressure and localised property de-valuations.

Of particular interest to the residential lending industry are the impacts of extreme weather and climate change on:

- **Serviceability** – ongoing damage costs and upward pressure on insurance premiums can put borrowers under financial strain and undermine their ability to service their mortgage repayments - exposing the lender to increased levels of mortgage delinquency and default.
- **Property Value** - Increased exposure or vulnerability to climate change hazards can be expected to lead to a gradual depreciation in property value compared to the general market. In some severe cases, such depreciations may impact LVR calculations and expose the bank and borrower to negative equity.
- **Relative Market Position** – The aggregated climate change risk to an entity based on the residential portfolio as a whole compared to a national benchmark or industry competitors are likely to impact the favourability of its RMBS and other investment-based products as industry awareness matures.

The aim of this report is to provide quantified insights into the scale, severity and concentration of current and future climate change risk to the company's residential mortgage book. Some initial recommendations have also been developed toward managing, mitigating or transferring this risk.

ABOUT THIS REPORT

Climate Valuation is committed to helping businesses and communities respond to the threat of climate change by:

- Facilitating access to climate change modelling for decision makers in government, non-government & the private sector.
- Assisting companies in the disclosure of physical climate change risk with the aim of advancing the finance sector's response to climate change.
- Supporting the development of lending products that support customers' climate change adaptation and improve property resilience.

Climate Valuation's Residential Mortgage Portfolio Report is designed to provide insights into the risks to a company's residential mortgage portfolio from extreme weather and climate change.

It provides a quantitative overview of physical climate risk to inform financial and risk management decisions, based on recommendations from the emerging literature on physical climate risk reporting.

Using the multi-award winning Climate Risk Engines technology, the results are derived by computationally testing the physical vulnerability of synthetic representatives of a residential asset and functional component parts against a range of extreme weather impacts such as flooding, heat, forest fire and wind. The results show the changing probability with which assets may (a) be damaged (b) fail to operate, and the possible implications on insurability and market value.

The forward looking results presented are based on the settings, scenarios and assumptions that have been selected and applied within the Climate Risk Engines. These are displayed throughout the relevant sections of this report. As such these results do not represent predictions.

This report is based on the asset, hazard and climate modelling data available at the time of the analysis. It can be updated as required if new science becomes available, data is added, or new analysis is undertaken.

"The Residential Portfolio Report provides quantitative insights into physical climate risk to inform financial and risk management decisions"

– Dr Karl Mallon

CEO of Climate Valuation

GLOSSARY – RISK REPORTING PARAMETERS

Technical Insurance Premium (TIP & TTIP)

The Technical Insurance Premium (TIP) is defined here as the Annual Average Loss (AAL) per Representative Property for all hazard impacts combined. The TIP is based on the cost of damage to a property, expressed in current day dollars with no discounting or adjustments for other transaction costs.

The Total TIP (TTIP) is the sum of all TIPs for all properties in a given area, for example all locations in a country. As such, the TTIP is useful in drawing attention to the likely financial risk associated with climate change hazards.

Value-At-Risk (VAR%) and Maximum-to-Date VAR (MVAR)

The Percentage of Value at Risk (VAR%) is the Technical Insurance Premium expressed as a percentage of a single property's replacement cost, specified for a one year period with no discounting of the TIP or the property replacement cost.

VAR% = TIP / asset replacement cost

The VAR% can also be applied to a portfolio of assets, in which case Average VAR% is the TTIP divided by the total replacement value of all assets, making it a non-dimensional average for TIP.

The VAR% is an excellent way of overcoming the bias of the TTIP toward larger assets and / or areas with higher concentrations of value.

Unless otherwise stated, for each analysed year, the highest VAR up to that date is used. This is because climate models can have considerable variability over time and some hazards may go down for periods, which can lead to misleading data if only a single year is presented. Therefore the Maximum-to-Date VAR is used as default because it provides a single insight into the peak physically damaging stress placed on each asset from extreme weather and climate change observed in the modelling results up to that year.

Climate Adjusted Value (CAV)

Climate Adjusted Value assumes that funding is finite and fixed and that money spent on insurance or self-insurance against climate related hazards must redirect financial resources away from servicing the mortgage. Using a default interest rate, this diversion of funds is calculated as an equivalent reduction in the principal value of the loan that may be borrowed.

As the value of a property may fluctuate with the market, the reduction in the lending capacity is expressed as a percentage reduction in equivalent value. The Climate Adjusted Value is therefore the percentage reduction in value for the Representative Property, relative an equivalent property unaffected by extreme weather & climate change.

Number Of High Risk Properties (HRP#)

In this analysis, a representative property is classed as becoming "High Risk" if its Value-At-Risk% for a given year exceeds 1.0%. This is based on the USA Federal Emergency Management Agency (FEMA) thresholds for government insurance schemes, which highlight properties in an (historic) 1-in-100 flood zone, also known as "Rating A Zones".

The number of High Risk properties is the sum of all properties for which the VAR% is above 1.0% in a given year.

The number of Moderate Risk Properties is the sum of all properties for which the VAR% is between 0.2% and 1.0%.

High Risk Properties As Percentage (HRP%)

The number of High Risk Properties can also be expressed as a percentage of all properties in a given area.

High Risk Properties are usually caused by substantial exposure to severely damaging hazards such as flooding or coastal inundation, as opposed to soil contraction or forest fire - which may only cause minor damage or where probabilities of loss remain small. This indicator is therefore useful to show where there are areas which have a concentration of acute risk.

Climate Valuation Ratings Legend:

C	High Risk = %VAR > 1.0%	Insurance may be high cost or unavailable unless adaptation actions are undertaken.
B	Moderate Risk = 0.2% < %VAR < 1.0%	Risk may lead to higher insurance costs.
A	Low Risk = %VAR< 0.2%	Risk may be insurable at reasonable cost.

GLOSSARY – OTHER ACRONYMS

Acronym	Description
BES	The Bank of England's discussion paper for the 2021 biennial exploratory scenario on the financial risks from climate change
CMSI	Climate Measurement Standards Initiative
FSB	Financial Stability Board of the G20
IPCC	Intergovernmental Panel on Climate Change
RCP	Representative Concentration Pathway
RCP8.5	The default climate change scenario used in this study. Refers to a concentration of greenhouse gases that cause global warming temperature increase of between 3.2°C to 5.4°C by the end of 2100.
TCFD	Taskforce on climate-related financial disclosure
RMBS	Residential Mortgage Backed Securities
CORDEX	Coordinated Regional Downscaling Experiment
GCM	General Circulation Models
RCM	Regional Climate Models
CMIP	Coupled Model Intercomparison Project

ANALYSIS SETTINGS

COMPANY PROFILE

Company Name:	WalesBigBank Banking Corporation
Brands and Trading Names:	WalesBigBank, WBB,
ISIN:	UK000000WB01
Industry:	Financial Services
Head Quarters:	123 Sample Street, Cardiff, Wales
Asset Data provided by:	WalesBigBank
Assessed Countries:	Wales, England, Scotland
Asset Data Internally Validated:	Yes

NUMBER OF UNIQUE ENTRIES SUPPLIED:
95,000

NUMBER OF ASSETS MATCHED TO EXACT ADDRESS:
92,000

NUMBER OF ASSETS MATCHED TO STREET PROXY:
816

NUMBER OF ASSETS ASSOCIATED WITH EACH ARCHETYPE

+ RESIDENTIAL DWELLINGS
92,816

+ COMMERCIAL BUILDINGS
0

+ INDUSTRIAL BUILDINGS
0

HAZARDS ANALYZED FOR THE ANALYSIS

RIVERINE FLOODING
SURFACE WATER FLOODING
COASTAL INUNDATION
SOIL SUBSIDENCE
FOREST FIRE
EXTREME WIND

MODELLED SCENARIOS & SETTINGS

Data, Settings and Scenarios	This Report's Settings
Primary RCP:	RCP 8.5
Secondary RCPs:	RCP 2.6 & 4.5
Archetype used:	A 'Modern' Free Standing Residential House
Number of Assets analysed in portfolio:	92,816
Countries Analysed:	Wales, England, Scotland
Sensitivity Testing:	Yes sensitivity testing conducted for low & high resilience archetype

Hazard	Regional Climate Models:
Coastal Inundation	1.5m by 2100 (midway IPCC high and NOAA high)
Soil Subsidence	ICHEC-EC-EARTH
Riverine Flood	CSIRO-QCCCE-CSIRO-Mk3-6-0
Surface Water Flood	CSIRO-QCCCE-CSIRO-Mk3-6-0
Extreme Wind	MPI-M-MPI-ESM-LR
Forest Fire	MPI-M-MPI-ESM-LR

MODERN BUILDING ARCHETYPE

This analysis is based on the following 'modern building archetype' which includes design and construction materials with a wind rating for 1 in 500 year return frequency, floor elevation of 0.5m, standard non-rigid foundations and no specialized forest fire protection. These design and construction settings materially impact the vulnerability of the "Representative Property" to the hazards to which it is likely to be exposed.

Build Year

Build Year is used to indicate building and design standards which is used as a proxy for calculating Wind Speed Threshold (WST)

Archetype Setting: Year 2000
WST: 1 in 500 years

Replacement Value

An estimation for the Replacement cost of the building which will impact financial metrics such as TIP and CAV

Archetype Setting: £190,000

Ignition Probability

This value represents the likelihood of a fire starting on a day with the conditions required for a fire

Archetype Setting: average protection

Floor Height

The Height of the Floor above the Ground Level impacts the asset's exposure to flooding risk

Archetype Setting: 0.5m

Foundation Design

The type of piers and foundation used impacts an asset's vulnerability to movement in clay soils

Archetype Setting: Non-Rigid Reinforced Concrete

HAZARDS ANALYSED

This report considers five different climate change exacerbated hazards with combinations of acute and chronic risk. The Residential Mortgage Portfolio Report analyses impacts from: coastal inundation, soil subsidence, riverine flooding, surface water flooding, extreme wind and forest fire.

Hazard	Effect of climate change on hazard	Impacts of hazard
Coastal Inundation	Rising sea levels and higher incidence of extreme sea events.	Sea water flooding due to high tides, wind, low air pressure and waves can damage coastal land and infrastructure.
Soil Subsidence	Changes in rainfall patterns and drought.	Soil contraction due to less rainfall causing subsidence damage to structures.
Riverine Flood (Fluvial)	Increased frequency and intensity of rainfall changing the frequency and intensity of river flooding.	Riverine flood can damage low-lying building or infrastructure assets.
Surface Water Flood (Pluvial)	Extreme rainfall event that creates a flood independent of an overflowing water body.	When an urban drainage system is overwhelmed and water flows out into streets it can inundate nearby structures.
Extreme Wind	Changes in wind regimes, sea surface temperature and wind speeds. Does not include cyclones and convective storms.	Extreme windstorms can damage buildings and infrastructure.
Forest Fire	Increased incidence of fire weather due to confluence of days with higher temperatures, high wind speeds and drier conditions.	Flames and heat from burning vegetation can damage buildings and infrastructure.

DATA & METHODS

CLIMATE VALUATION'S METHODOLOGY

Overview of Method

These results have been generated using purpose-built software running on an array of high-speed servers provided by Climate Risk Pty Ltd. The Climate Risk Engines assess climate impacts by placing a standardised dwelling at each address analysed. Using the design specifications and materials typical of a standard dwelling, the Climate Risk Engines compute the threshold at which its various key components would fail if exposed to hazards such as flooding, subsidence and forest fires.

Using this information, the annual probability of damage caused by such events is calculated by gathering a range of data on forests, soils, floods, elevations, tides, and then coupling this with long term data from local meteorological stations. Finally, the future probabilities of damage are calculated by extracting the changes in the statistical distribution of key parameters such as heat, precipitation, wind and humidity from global climate change models.

A Representative Property

The system creates a synthetic representation of property that is based on nominal industry archetypes and customisation by the user. This 'Representative Property' could be tailored to mimic a real asset at the same location – such as a house or apartment block – or be created as an entirely hypothetical asset in that location. The results therefore may include assumptions about the composition of a 'Representative Property' and cannot be taken as representations of the actual future risks to, or value of, a real or planned property or infrastructure asset.

Hazard Exposure

To understand if the Representative Property is exposed to a hazard or not, contextual information about each location is gathered. This may include information about the soils, tree cover, topology, elevation, flood plains, local tides or waves. Contextual information may even extend to current or historical national design standards for buildings or infrastructure.

Data is gathered on these contextual features from national and international sources selected on the basis of the scientific methods used, accuracy, spatial resolution, completeness and the standing of the institution that has generated the information.

Weather Data

To establish the probability that a hazard will exceed the damage or failure threshold of an asset or element, information about the driving weather indicators may be needed - for example the likelihood of flooding is linked to the likelihood of extreme precipitation. The Climate Risk Engines have access to 100,000 national weather stations around the world. Internal algorithms are used to select which stations to use when testing an asset based on proximity, data quality, duration and completeness. In some cases, the Climate Risk Engines may use a combination of data from more than one station or gridded data sets made by national meteorological centres.

Vulnerability Analysis

Each Representative Property in the portfolio is tested for its ability to withstand the hazards to which it is likely to be exposed each year. The system tests both failure thresholds and damage thresholds.

A damage threshold is breached when an asset is affected by a hazard such that it is broken or excessively weakened. Examples might be flood waters damaging an electrical control system, or a windstorm blowing sections of a roof off a house. A failure threshold is breached when an element of the asset prevents the asset from performing is function. For example, when coastal inundation causes a property to be washed away it is irrevocably damaged and no longer habitable.

Key Time Intervals

The base year upon which the analysis is conducted is set as 1990, as many weather statistics are taken from data sets dominated by data post satellite era (1960s onwards). Using a 1990 baseline allows the additional risk attributable to climate change in the current year to be represented. Looking forward, 2050 is included as an important time step as it is the end of an average 30-year mortgage. At a maximum, the climate models go out to the year 2100. Such long-term impacts may affect buyer sentiment and property value as information about longer-term risks such as coastal inundation become more widely available. It has been known for some changes to manifest faster than expected and so a farsighted appreciation of risks may be prudent.

Such time intervals account for the profile of climate-related physical risks, available data and shorter-term management decisions.

SCIENTIFIC UNCERTAINTY & CONFIDENCE

Risk analysis of any type has inherent uncertainties. This is compounded in climate related risk analysis, as risk calculations combine information from many different sources, many of which change over time. Each of these sources of information contain uncertainties of some kind, and only a few of these types of uncertainties are reasonably quantifiable. Key sources of uncertainty in the Climate Valuation analysis methodology include:

- **Climate projections**: This includes quantifiable uncertainty in historical weather observations and in model behaviour in response to driving variables (including emissions scenarios), as well as unquantifiable uncertainty around model structure, and likelihood of socio-political trajectories associated with proposed emissions scenarios.

- **Geospatial context data**: This includes uncertainties in observed and modelled data representing various physical quantities that affect an asset's exposure to various climate-related hazards.

- **Asset vulnerability data**: Every asset is different, and asset-specific data (e.g. material and design information) usually only captures some aspects of that variance. Much information about an asset that might heavily impact its vulnerability (e.g. how often the gutters of a house in a fire zone are cleaned), is not practically available or estimable.

- **Impact model structure**: Models that can estimate the damage, system failure, and financial and human impacts to an asset in the event of a climate event need substantial data (e.g. historical impact data) to adequately constrain their design. This data is often only sparsely available.

Throughout this study, uncertainty is addressed in two ways:

Firstly, each asset is analysed using the IPCC's RCP8.5 scenario, which presents the most high-risk possible future for which projections are available. Developed by International Institute for Applied Systems Analysis (IIASA) Austria, RCP 8.5 refers to a concentration of greenhouse gases that cause global warming temperature increase of between 3.2°C to 5.4°C by the end of 2100. RCP 8.5 represents the closest approximation to current business-as-usual socio-political outcomes, based on measured climate changes over the last few decades.

There are many modelling institutions around the world that have separately modelled the outcomes of an RCP8.5 concentration pathway. The Climate Risk Engines are programmed to select the climate model that represents the strongest driver for each hazard, for a given region of the globe. These projections are then adjusted to indicate the effects of lower emission pathways, according to calculated difference between using global projections for temperature for RCP8.5, RCP4.5, and RCP2.6. This enables provides a comparison with socio-political scenarios.

Secondly, a representative sample of assets has been analysed using two different sets of assumptions about vulnerability, which help explore the uncertainty due to lack of asset-specific information. The VAR for both the high and low resilience properties is calculated, and the higher and lower boundaries of possible risk distribution are determined.

The position of the 'Modern Building' archetype used in this study is then located within the distribution to determine the appropriate range of uncertainty to apply to the results. While this sensitivity analysis includes the likely range of forward-looking resilience, it is not a dynamic projection that accounts for changes to building standards and possible vulnerability over time.

SCIENTIFIC UNCERTAINTY & CONFIDENCE (CONT'D)

KEY TAKEOUT: In order to account for uncertainty, sensitivity testing has been executed across a sample of random addresses in WalesBigBank's portfolio, using both high and low resilience property archetypes. The results from this sensitivity testing place the 'Modern Building' archetype (on which the body of the analysis was conducted) within the lower quartile of the risk distribution. By applying the results from this sensitivity test, its likely that the actual portfolio risk could be between the quoted results or up to 30% higher.

OBSERVATION:

A sensitivity analysis suggests that the range of Value-At-Risk for the WalesBigBank Portfolio sits between 22% and 30% either side of the median. The 'Modern Building' archetype used in this study is at the higher resilience end for flood, coastal inundation and wind–storms, but with no special provisions for subsidence or forest fire. Thus a high resilience property would have approximately 20% lower Value-At-Risk than the 'Modern Building' archetype upon which this study was conducted. Similarly a low resilience property would result in a VAR% approximately 50% higher than the 'Modern Building' archetype.

A high confidence can be given to the VAR% range between the reference data contained within this report and a VAR% of 30% higher. This range should be assumed to apply to all other risk matrix provided throughout the report.

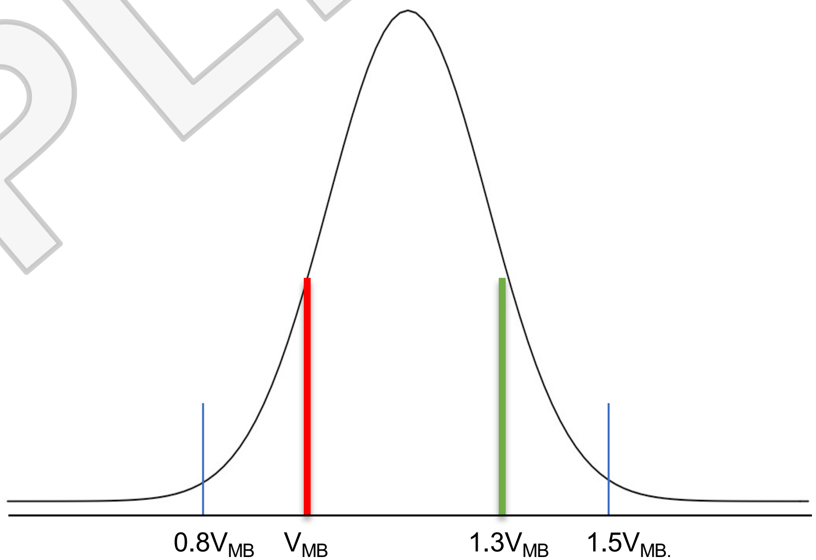
How is this result calculated?

A sample set of high and low resilience properties are analysed individually. The average VAR for both is calculated, including median and difference. The position of the 'Modern Building' archetype is estimated within the distribution and a proposed uncertainty range around the reference archetype data is identified.

Caveats & Assumptions

The mix of building designs and standards will change over time, and while this sensitivity analysis includes the likely range of forward looking resilience, it is not a dynamic projection changing in vulnerability over time.

Distribution of VAR% Based on Sensitivity Analysis



Schematic distribution of Value-at-Risk (VAR%) for the sensitivity analysis using the 'Modern Building' archetype (V_{MB}) as the reference.

Assuming a normal distribution of VAR, the sensitivity analysis provides the results for the higher and lower resilience archetypes (blue lines) . The actual position of the whole portfolio is likely to lie between the "Modern Building' archetype (red line) and up to 30% higher (green line).

OTHER DATA SOURCES & ASSUMPTIONS

Climate Data and RCP Selection

Climate projections are based on the Coordinated Regional Downscaling Experiment (CORDEX) for a range of Global Circulation Models (GCMs), generally using the NARCLIM1.0 downscaled modelling from the University of NSW.

By default, Climate Valuation uses RCP8.5 as the reference scenario most appropriate for 'stress testing' the portfolio. RCP 8.5 provides concentration of greenhouse gases that cause global warming temperature increase of between 3.2°C to 5.4°C by the end of 2100, relative to pre-industrial temperatures. Current emissions most closely follow RCP8.5 and it is sometimes referred to as Business-as-Usual as it assumes high growth without significant decarbonization of the economy.

Other emission pathways will generally result in impacts that are slower to occur or less sever. Therefore, derived impacts for RCP2.6 and RCP4.5 have been mapped from RCP8.5 based on global heat projection differences in the IPCC Fifth Assessment Report.

Weather & Sea Level Rise Data

Empirical statistical extreme weather distributions are based on weather station data from the nearest stations with a multi-decadal data. Coastal Inundation projections are based on a set of real and synthetic tide gauges for the region, off-shore wave buoy and land movement gauges. The analysis uses a sea level rise projection of 1.5m by 2100 which is between the IPCC AR5 projections and the 'high risk' NOAA projections used by the US gov.

Asset Location & Unmatched addresses

In order to match contextual data (such as elevation, topography and historical weather patters) to individual addresses, Climate Valuation extract unique property identifiers from the client's database (such as latitude and longitude, physical address or national building IDs) to match against an existing database of national addresses.

Depending on the accuracy and completion of the input data, a small percentage of properties may not be able to be matched to an exact postal address. Mortgage addresses for which no specific street address can be found may alternatively be assigned with a risk rating from the same street. In this instance, the street name, state and postcode are identified and the highest risk property in that street is included in the aggregate analysis. It is important to note that by using the 'worst in street' as a proxy to exact postal address, the resulting risks may be slightly amplified. Alternatively, unmatched addresses may be assigned with a portfolio average however this may serve to under-represent risk.

Building Specifications

Climate Valuation is able to account for asset-specific customisation depending on the property attributes available in the client's database. In the absence of client data, standardised archetypes are used to represent the possible risk at each address. A sample 'Modern Building' archetype used in this study is provided in the settings section of this report.

Portfolio Composition

This analysis assumes that the existing portfolio of mortgages potentially exposed to climate risk remains static over time, with no changes in volume or spatial distribution.

Building Standards and Adaptation

The assumption is that building standards remain unchanged as does the build year of properties. It is assumed that there is no municipal or property level adaptation.

Property Value & Replacement Cost

Financial metrics such as current market value & replacement cost may be supplied by the client to inform metrics such as Technical Insurance Premium and Climate Adjusted Value. In the absence of first party data, a 'representative replacement cost' is calculated.

For this analysis, the replacement value at each address is assumed to be £190,000 in keeping with national average rebuild costs.

Discounting and Growth

No growth of population or of property value are accounted for in the analysis. There is no adjustment for inflation and all risks costs are reflected in current year dollars.

Insurance Coverage

All hazards are assumed to be fully insured for all properties to allow annualization of the costs. Though in reality hazards like Coastal Inundation are difficult to insure and Subsidence insurance is not available in Australia.

DETAILED RESULTS

PORTFOLIO OVERVIEW

PORTFOLIO AVERAGE VALUE-AT-RISK % DISTRIBUTION

KEY TAKEOUT: In the current year, under the RCP8.5 scenario & using a modern building archetype, **1.0%** of WalesBigBank's mortgage portfolio is deemed to be at high-risk from physical climate change impacts. This is expected to increase to **4.1%** by the year 2100. Overall, this result is slightly lower risk than a national distribution curve, where high-risk assets will constitute **4.85%** of all national addresses by 2100.

Why is this result useful?

This distribution curve provides a overarching insight into the extent to which the company's portfolio is exposed to extreme weather damage and how that will evolve over time. The proportion of the portfolio which is high risk (Value-At-Risk > 1.0%) is especially important as this can lead to underinsurance, insurance cost stress, devaluation and mortgage defaults.

OBSERVATION:

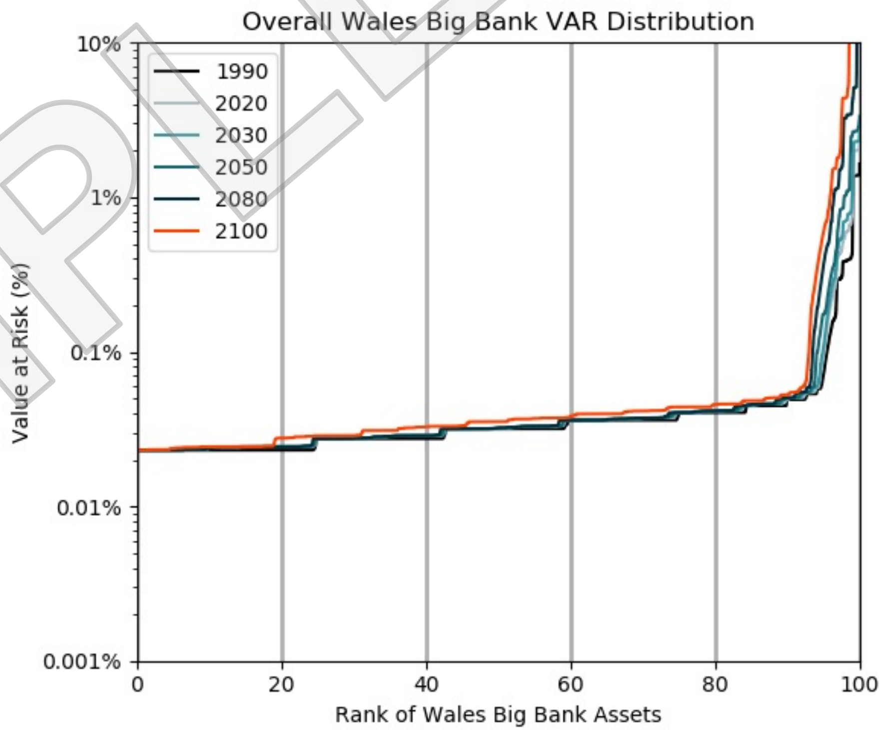
In the current year 2020, 1.0% of WalesBigBank's mortgage portfolio is deemed to be at high-risk from physical climate change impacts. Assuming volumes of mortgages analysed, this represents over 928 homes that will suffer damages greater than or equal to 1.0% of the replacement cost of the building. This is expected to increase to 2.1% of the company's mortgage portfolio in the year 2050 and 4.1% in in the year 2100. Overall this result is slightly better that a typical distribution curve, where high-risk assets constitute 4.85% of the national average in 2100.

How is this result calculated?

The median VAR% for each property in the company's portfolio is calculated and then all properties are ranked from lowest VAR to highest VAR for the given year and climate change scenario.

Caveats & Assumptions

VAR% is an indication of damage related impacts and will not provide a complete picture for non-damaging disruptions (Failure Probability) or the duration of impacts (Productivity Loss/ Loss of Use). Furthermore, any adaptation plans for exposed properties by the company have not yet been accounted for.



This graph shows the distribution of value-at-risk across the portfolio under the RCP8.5 scenario for the Modern Building archetype.The vertical axis is Value-At-Risk % and the horizontal axis is the percentile of the company's assets in that VAR band. The different coloured lines represent different time points between 1990 and 2100.

CHANGE IN VALUE-AT-RISK % OVER TIME

KEY TAKEOUT: WalesBigBank's Average Value-At-Risk % increases by XXX% **from 1990 to 2100** under RCP8.5 scenario & using a modern building archetype. This is driven by increased risks from a range of hazards. Even under the lower emission climate scenarios (RCP 2.6), the increase in VAR% is around XX%.

Why is this result useful?

This graph helps identify the extent to which climate change is contributing to asset risk across the portfolio under three different RCP scenarios and how that risk is expected to change over time without adaptation or intervention. The shape of the curve reflects different levels of climate forcing of the hazard.

OBSERVATION:
Under the RCP8.5 scenario & using a modern building archetype the average Value-At-Risk % for WalesBigBank's residential mortgage portfolio rises linearly over time and approximately doubles from XX% in 1990 to XX% 2100. Under lower emission pathways the increase is curbed but still rises as some hazards have long term inertia, so the observed change in VAR% for lowest emissions scenario (RCP2.6) still represents a XX% increase.

How is this result calculated?

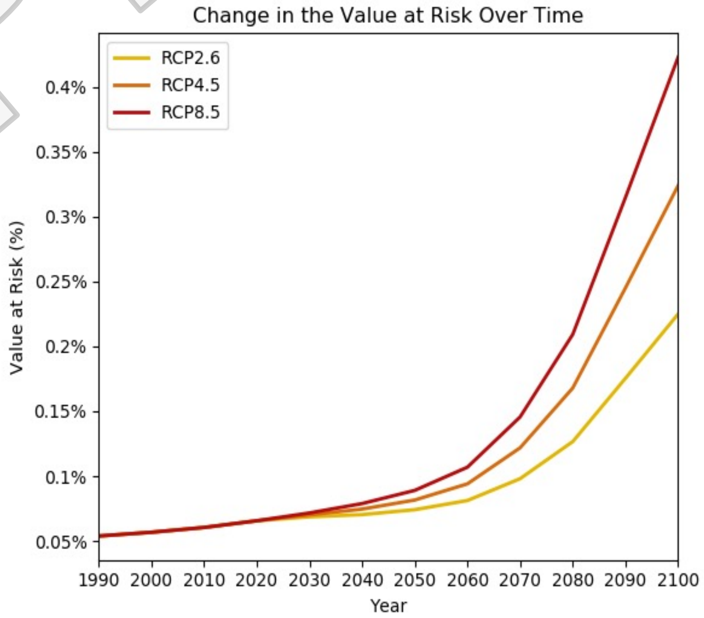
The costs of damage as a fraction of replacement costs is calculated to give the Value-At-Risk which is averaged across the portfolio, under each Representative Concentration Pathway for each year.

Caveats & Assumptions

The average Value-At-Risk is heavily affected by a small percentage of high risk properties. Any adaptation plans for exposed properties by the company have not yet been accounted for.

Year	1990	2020	2030	2050	2080	2100
Avg VAR%	0.057%	0.062%	0.075%	0.082%	0.22%	0.43%

This table shows the average VAR% for the entire portfolio under the RCP 8.5 scenario



This graph shows the average Value-At-Risk% for the entire portfolio as a function of time under RCP 8.5, 4.5 and 2.6.

THE PERCENTAGE OF LOW, MODERATE & HIGH RISK PROPERTIES

KEY TAKEOUT: The majority of the WalesBigBank portfolio can be considered low risk today, but by the end of the standard 30 year mortgage term, **2.4%** will be at moderate risk (Value-At-Risk >0.2% resulting in higher than normal insurance costs) and **2.1%** of the WalesBigBank's mortgage portfolio will be deemed to be at high-risk from physical climate change impacts (Value-At-Risk > 1.0% resulting in possible unaffordable/unavailable insurance).

Why is this result useful?

It is useful for companies to identify the portion of their portfolio that is classified as low, moderate and high risk and how this is likely to change over time. These figures may indicate the level of credit risk to the company now and in the future, as well as the timelines for the portfolio's deterioration.

OBSERVATION:
Based on an interpretation of the US Government's FEMA index used for insurance, WalesBigBank's portfolio risk under RCP8.5 scenario & using a modern building archetype is:

- **High Risk**: 1.0% in 2020, increasing to 4.1% by 2100
- **Moderate Risk**: 3.0% in 2020, decreasing to 2.6% by 2100
- **Low Risk**: 96% in 2020, decreasing to 93.3% by 2100

How is this result calculated?

Low Risk Properties (LRP) is calculated as properties with Value-At-Risk % less than 0.2% of the total asset value. Moderate Risk Properties (MRP) are those between 0.2% and 1% VAR%. High Risk Properties (HRP) are those with greater than or equal to 1.0% VAR%

Caveats & Assumptions

The severity of impact above the High Risk Property threshold is not shown and can give rise to very high insurance premiums and severe loss of value.

Year	LRP%	MRP%	HRP%
1990	96.8%	2.3%	0.9%
2020	96.0%	3.0%	1.0%
2030	95.8%	3.2%	1.0%
2050	95.4%	2.4%	2.1%
2080	94.3%	2.2%	3.6%
2100	93.3%	2.6%	4.1%

This table shows the % of the portfolio that is classified as low, moderate and high risk at each given time interval under the RCP8.5 scenario (using a modern building archetype). .

Climate Valuation Ratings Legend:

C	High Risk = %VAR > 1.0%	Insurance may be high cost or unavailable unless adaptation actions are undertaken.
B	Moderate Risk = 0.2% < %VAR < 1.0%	Risk may lead to higher insurance costs.
A	Low Risk = %VAR< 0.2%	Risk may be insurable at reasonable cost.

CHANGE IN PERCENTAGE OF HIGH RISK PROPERTIES OVER TIME

KEY TAKEOUT: Under the RCP8.5 scenario & using a modern building archetype, the number of High Risk Properties (HRP) in WalesBigBank's portfolio rises steeply from 2030 onwards. Approximately **1.0%** of the WalesBigBank's residential mortgage portfolio will be categorised as high risk from physical climate change impacts within the next 10 years. This will increase to **4.1%** by the year 2100. These represent the properties most at risk of unaffordable or unavailable insurance.

Why is this result useful?

This graph provides insight into scale and timing of acute risk across the portfolio. The proportion of the portfolio which is High Risk is especially important and this can impact mortgage default and present credit risk to the company.

OBSERVATION:

For WalesBigBank's portfolio under RCP8.5 scenario & using a modern building archetype, **1.0%** of the company's properties are deemed high risk in 2020, rising to **4.1%** in 2100.

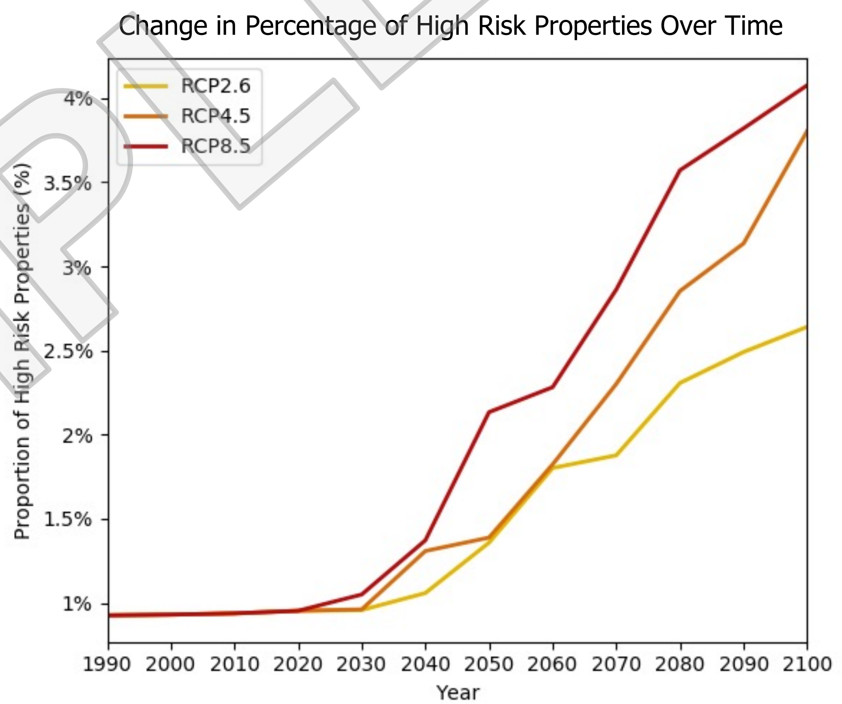
It is quite common that there is not a uniform change, as different hazards impact different assets at different time periods. For WalesBigBank, the point of divergence begins around 2030 as Flooding risks become more prevalent.

How is this result calculated?

The percentage of high risk properties is calculated by tallying all properties above 1.0% Value-At-Risk then dividing this by the total number of properties in the portfolio.

Caveats & Assumptions

By classifying assets into broad 'high' and 'moderate' risk bands, this analysis does not take into account the upper severity of that risk. There may be properties significantly above 1.0% VAR threshold. It also masks widespread low impact or low probability risks like subsidence and forest fire.



This graph illustrates the changes in the percentage of high risk properties over the period analysed for all three scenarios RCP 2.6, 4.5 and 8.5.

THE NUMBER OF LOW, MODERATE & HIGH RISK PROPERTIES

KEY TAKEOUT: Under the RCP8.5 scenario & using a modern building archetype, the number of High Risk Properties (HRP#) in WalesBigBank's portfolio rises exponentially. Approximately **974** of the WalesBigBank's residential mortgage portfolio will be categorised as high risk from physical climate change impacts within the next 10 years. This will increase to over **3,784** by the year 2100. These represent the number of borrowers that are most likely to be exposed to unaffordable or unavailable insurance.

Why is this result useful?

It is useful for companies to identify the number of properties in their portfolio that are classified as low, moderate and high risk and how this is likely to change over time. When applied to financial exposure, these figures may indicate the level of credit risk to the company now and in the future, as well as the timelines for the financial impacts expected.

OBSERVATION:
Based on 92,816 properties analysed in this study, WalesBigBank's portfolio risk under RCP8.5 scenario & using a modern building archetype is:

- **High Risk**: 884 properties in 2020, rising to 3,784 by 2100.
- **Moderate Risk**: 2,829 properties in 2020, decreasing to 2,404 by 2100.
- **Low Risk**: 89,103 properties in 2020, falling to 86,628 by 2100.

How is this result calculated?

By applying the % of properties at low, moderate and high risk to the number of properties identified in the company's portfolio of addresses, a volume of properties is calculated

Caveats & Assumptions

This analysis assumes that the existing portfolio of assets remains static over time, with no changes in the vulnerability of the assets due to adaptation or resilience measures.

Year	LRP#	MRP#	HRP#
1990	89,818	2,139	859
2020	89,103	2,829	884
2030	88,880	2,962	974
2050	88,575	2,261	1,980
2080	87,483	2,018	3,315
2100	86,628	2,404	3,784

This table shows the number of properties in the portfolio that are classified as low, moderate and high risk at each time interval under the RCP8.5 scenario (using a modern building archetype

PORTFOLIO TECHNICAL INSURANCE PREMIUM (TIP) OVERVIEW

KEY TAKEOUT: Based on an average replacement cost for a property in Wales (£190,000), the average Technical Insurance Premium across the WalesBigBank portfolio is currently around £XX per property. Note that this has increased significantly from 1990 levels, which is the data upon which the market still prices many insurance premiums today. By the end of the century, Technical Insurance Premiums due to climate change and extreme weather risk are expected to double to £XX.

Why is this result useful?

This result may help WalesBigBank infer the sorts of insurance costs to be expected for many homes, and in turn, how these costs may impact the serviceability of mortgages on their books.

OBSERVATION:

Over the course of the century the average TIP approximately doubles from £XX in 1990 to £XX by 2100.

This increase is driven my a small percentage of the properties which will experience significant impacts from climate change and extreme weather, while majority of properties will be have only small cost impacts

How is this result calculated?

The TIP is calculated based on the probability of a hazard exceeding the threshold for damage of an asset component and the consequential costs of damage to each component. Total TIP (TTIP) is the average TIP multiplied by the total number of properties within the portfolio

Caveats & Assumptions

TIP assumes all properties have been assigned the same replacement value ($313,800). It also assumes all hazards are o be fully insured for all properties.

Year	Average TIP	Total TIP
1990	£XXX	£XXX
2020	£XXX	£XXX
2030	£XXX	£XXX
2050	£XXX	£XXX
2080	£XXX	£XXX
2100	£XXX	£XXX

This table shows the change in average Technical Insurance Premium per property, as well as the total Technical Insurance Premium expected across the entire portfolio

CHANGE IN TOTAL TECHNICAL INSURANCE PREMIUM (TIP)

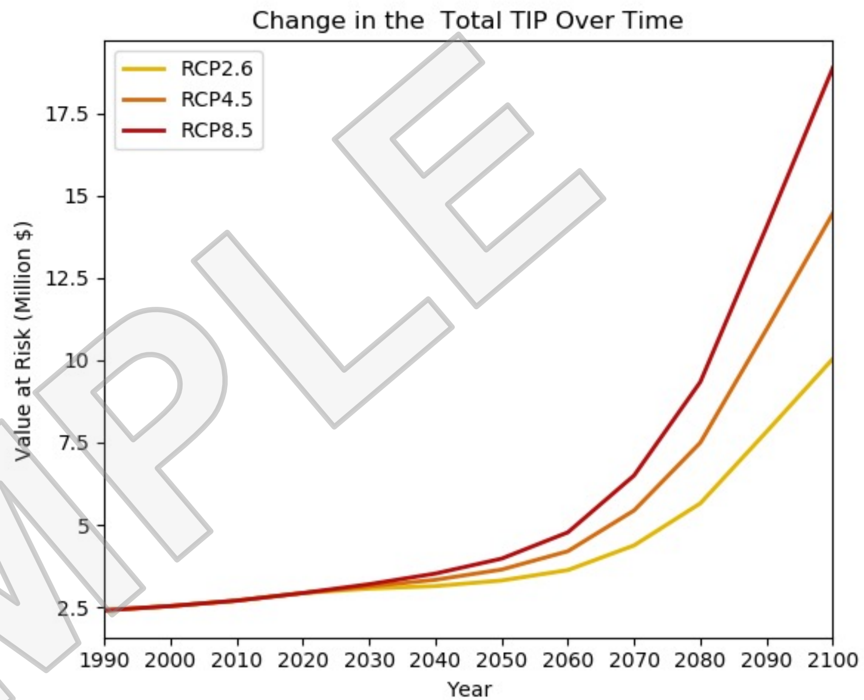
Why is this result useful?

This graph shows the change in Total Technical Insurance Premium (TTIP) over time. Note that the Total TIP graph axis is in millions. It shows the scale and speed of change which will have a bearing on identifying financial exposure and serviceability pressures on customers

OBSERVATION

Because all properties are assigned the same value, the TTIP trend is the same as that of VAR and shows a doubling of TTIP over the century due to climate change impacts. Over the course of the century the Total Technical Insurance Premium (TTIP) approximately doubles from £XX Billion in 1990 to £XX billion by 2100.

This increase is driven my a small percentage of the properties which will experience significant impacts from climate change and extreme weather, while majority of properties will be have only small cost impacts



This graph shows the change Total Technical Insurance Premium expected across the entire portfolio under PCR 8.5, 4.5 & 2.6

How is this result calculated?

The Technical Insurance Premium (TIP) is defined as the Annual Average Loss (AAL) per Representative Asset for all hazard impacts. The TIP is based on the cost of damage to an asset, expressed in current day dollars with no discounting or adjustments for other transaction costs. The Total TIP (TTIP) is the sum of all TIPs for all assets within the portfolio

Caveats & Assumptions

The TIP is based on the cost of damage to an asset, expressed in current day dollars with no discounting or adjustments for other transaction costs. In practice some hazards may not be insurable. *Actual replacement values may not be available in which case an average replacement cost has been applied to all properties. The result can adjusted to actual or changing portfolio value.*

PORTFOLIO CLIMATE ADJUSTED VALUE (CAV)

KEY TAKEOUT: Increased insurance costs will reduce the income available for mortgage repayments, resulting in value adjustments for higher risk properties. This is projected to be a correction to the WalesBigBank portfolio worth £XX million by 2050 and £XX million by 2100 by 2100 based on a long term interest rate of XXX% and XXX%

Why is this result useful?

As the value of a property may fluctuate with the market, the reduction in the lending capacity may also be expressed as a percentage reduction in equivalent value. The Climate Adjusted Value can therefore represented as the percentage reduction in value for the portfolio of properties relative an equivalent property unaffected by extreme weather & climate change.

OBSERVATION:

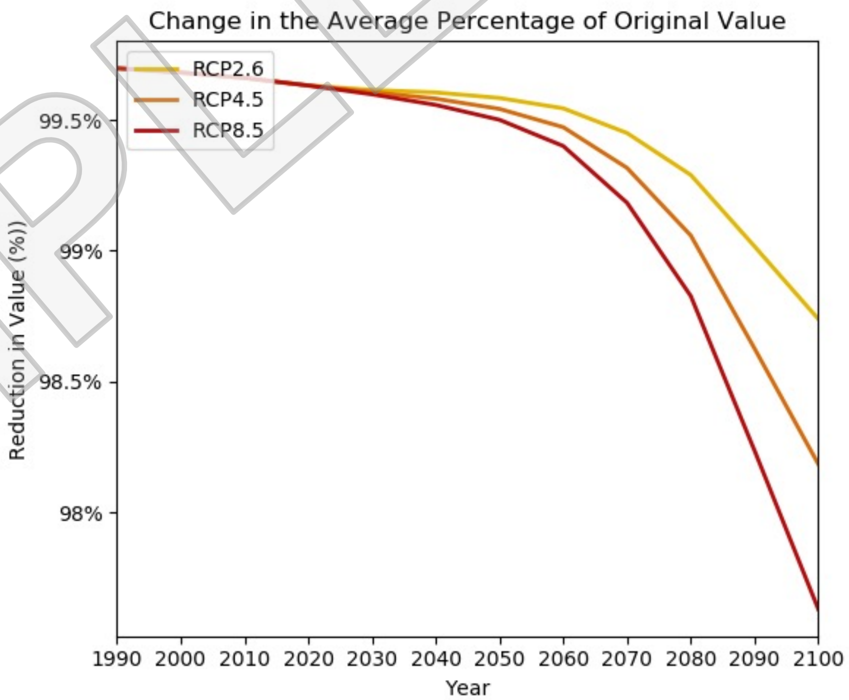
As extreme weather events continue to be exacerbated by climate change, there will be an overall decrease in WalesBigBank's portfolio value. This result shows that without any adaptation measures the impact to the WalesBigBank portfolio is up to an XX% reduction in value by 2100. This correction is projected be worth £XX million by 2050 and £XX million by 2100. Lower concentration pathways will reduce this impact.

How is this result calculated?

Climate Adjusted Value assumes that available income for housing costs is finite and that money spent on insurance or self-insurance against climate related hazards must redirect financial resources away from servicing the mortgage. Using a default interest rate (3.5%), this diversion of funds is calculated as an equivalent reduction in the principal value of the loan that may be borrowed.

Caveats & Assumptions

Interest rate is assumed to 3.5% as per recent WalesBigBank statements. Market Value assumed to be $£300,000 and property replacement cost is assumed to be £190,000



This graph shows the change in relative Market Value expected across the entire portfolio under RCP 8.5, 4.5 & 2.6

PORTFOLIO BENCHMARKING

BENCHMARKING VALUE-AT-RISK AGAINST NATIONAL AVERAGE

KEY TAKEOUT: Across all tested time points WalesBigBank's average Value-at-Risk (VAR%) for majority of the mortgage portfolio is below that of the UK national address database, with the exception of the last 5%, which is above the national benchmark. The cause is a persistently higher volume of properties in the lowest risk quintile which is offset by a small portion of properties with extreme risk. This means that if WalesBigBank were to address its small portion of high risk properties, it would position its investment based products (such as RMBS) much more favourably with shareholders.

Why is this result useful?

The company's mortgage portfolio has been benchmarked against the national average Value-at-Risk percentage (VAR%) for a given year. National Average VAR% provides a non-dimensional insight into the physical vulnerability of all residential properties aggregated across a given geographical area. Benchmarking the company's risk distribution against the national average allows the company to assess the extent to which it is over or under exposed compared with the rest of the domestic industry.

OBSERVATION IN 2020:

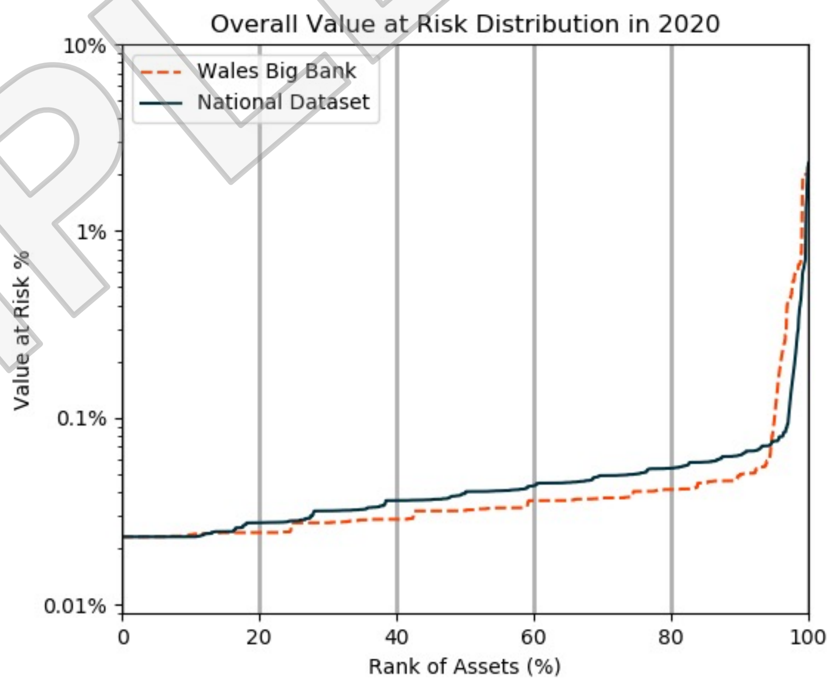
In 2020 WalesBigBank's average Value-at-Risk percentage (VAR%) across the majority of its portfolio of mortgages is below that of the national address database, with the exception of the last 5%. The company's risk distribution curve shows a higher portion of assets in the lower risk quintile, while the high risk subset represents a larger portion of its overall portfolio compared with the national benchmark.

How is this result calculated?

The system identifies every known residential address from a range of public data sources. The Value-At-Risk % is then calculated based on the mean Technical Insurance Premium (TIP) based on damage only, expressed as a percentage of the asset replacement cost.

Caveats & Assumptions

The benchmark of all addresses will include commercial and industrial properties, where as the company portfolio is only residential properties.



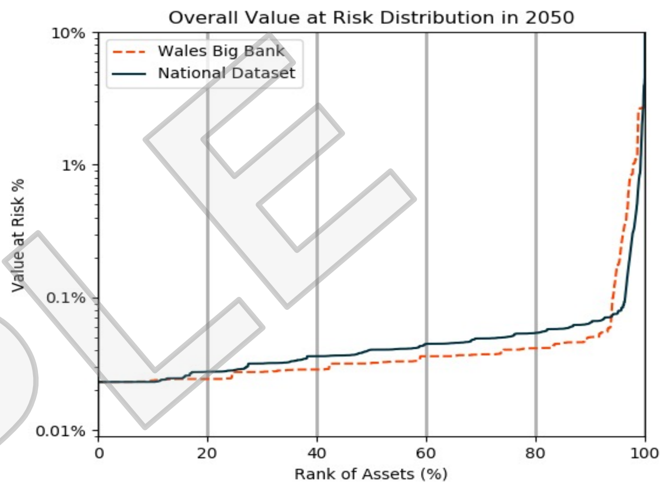
This graph benchmarks the company's portfolio of mortgages against the national average Value-at-Risk percentage (VAR%) for the year 2020 under the RCP8.5 scenario (using a modern building archetype)

BENCHMARKING VALUE-AT-RISK AGAINST NATIONAL AVERAGE

OBSERVATION IN 2050:

Under RCP8.5 scenario & using a modern building archetype, the average Value-At-Risk % in 2050 for the national sample is XX%, whereas for WalesBigBank this number is XX%. Nationally XX% of assets are classified High Risk in 2050 whereas for the WalesBigBank data this number is XX%.

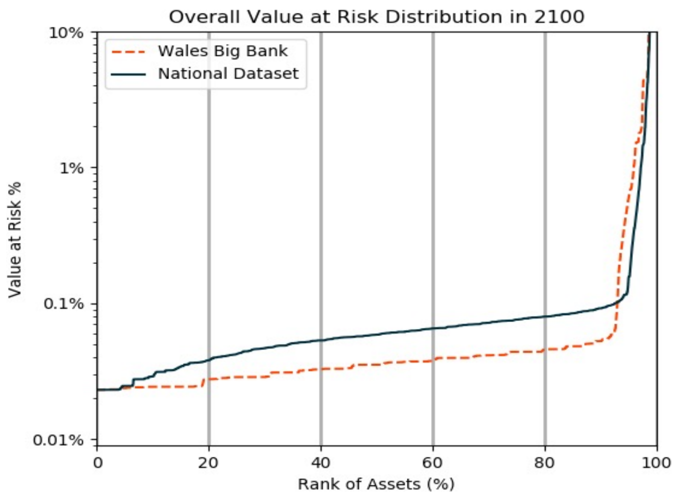
This indicates that the the company is considerably less exposed to the impacts of physical climate risk than the national average.



OBSERVATION IN 2100:

Under RCP8.5 scenario & using a modern building archetype, the average Value-At-Risk % in 2100 for the national sample is XX%, while for WalesBigBank this number is XX%. Nationally XX% of assets are classified High Risk in 2100 while for the WalesBigBank data this number is XX%.

This indicates that the the company is considerably less exposed to the impacts of physical climate risk than the national average.



SPATIAL RISK MAPPING

GEOGRAPHICAL DISTRIBUTION OF PORTFOLIO ASSETS

KEY TAKEOUT: The WalesBigBank portfolio of residential mortgages consists of **92,816 identifiable properties**. The bank has mortgages in all counties and towns. The majority of mortgaged properties are located in the capital of Cardiff.

Why is this result useful?

This physical distribution of total mortgaged properties can be compared to maps of the distribution of various risk indicators (later in this report) to help visualise the difference between locations where risk is dominated by asset density and those dominated by hazard exposure.

OBSERVATION:

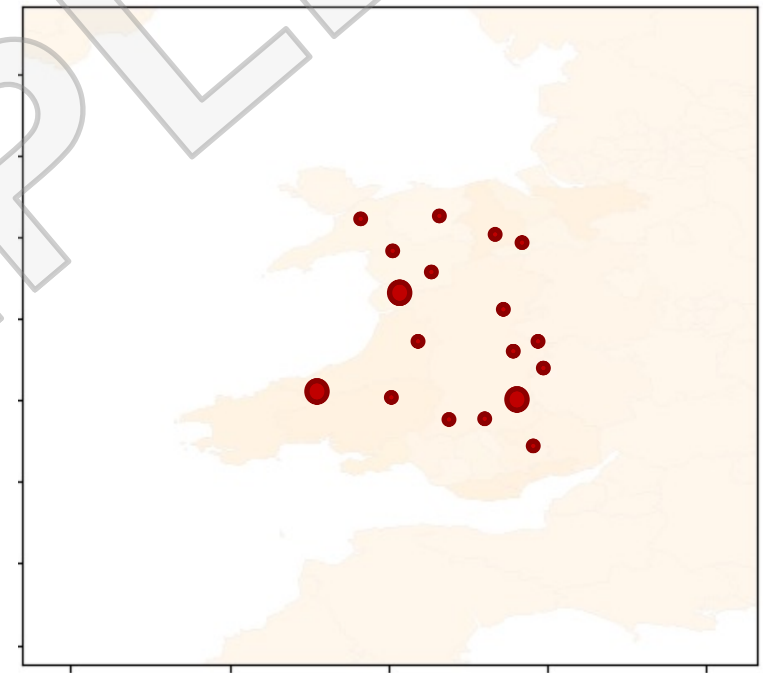
This map plots a total of 92,816 assets identified within WalesBigBank's all counties and towns in Wales. Cardiff is where the majority of assets are located.

This distribution is what would typically be expected for a portfolio of this size.

How is this result calculated? *The exact geospatial coordinates and/or physical addresses of the properties within the portfolio have been provided by the company. These addresses are then verified against geolocation data sets from national government sources to both verify locations and provide a consistent geolocating protocol across all assets.*

Caveats & Assumptions

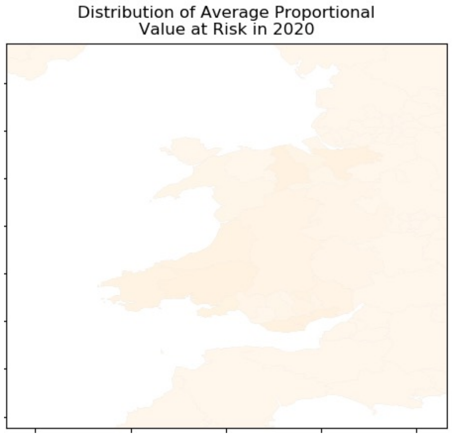
In the case where a physical address was not able to be identified, the relevant street name, postcode and state have been used as proxy to the asset's location and the highest risk asset on that street is included in the analysis.

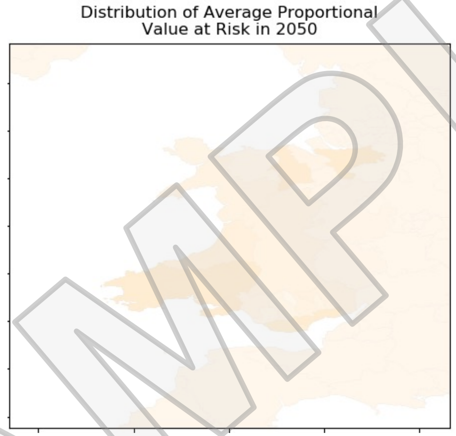


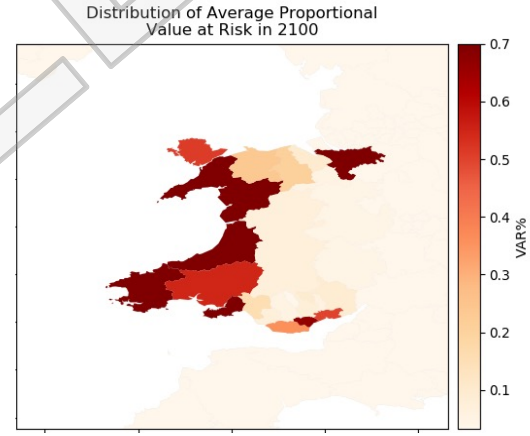
This map shows the locations and density of the properties which are identified as associated with the company's current portfolio of mortgages. The intensity of the colour represents the density of assets in that location.

GEOGRAPHICAL DISTRIBUTION OF VALUE AT RISK (VAR%)

KEY TAKEOUT: These maps of average Value-at-Risk (VAR%) intensity for the years 2020, 2050 and 2100 show a trend in the increase of average physical risk over time in all areas. These maps demonstrate that climate risk distribution is not necessarily proportionate to the number of mortgaged properties in that area.







Why is this result useful?

These maps show the locations and density of the company's median Value-At-Risk (VAR%) across several time periods. It focusses attention on where risks of damage are highest and avoids property value bias, and may therefore be a useful indication of the regions where the company needs to focus risk management attention.

How is this result calculated?

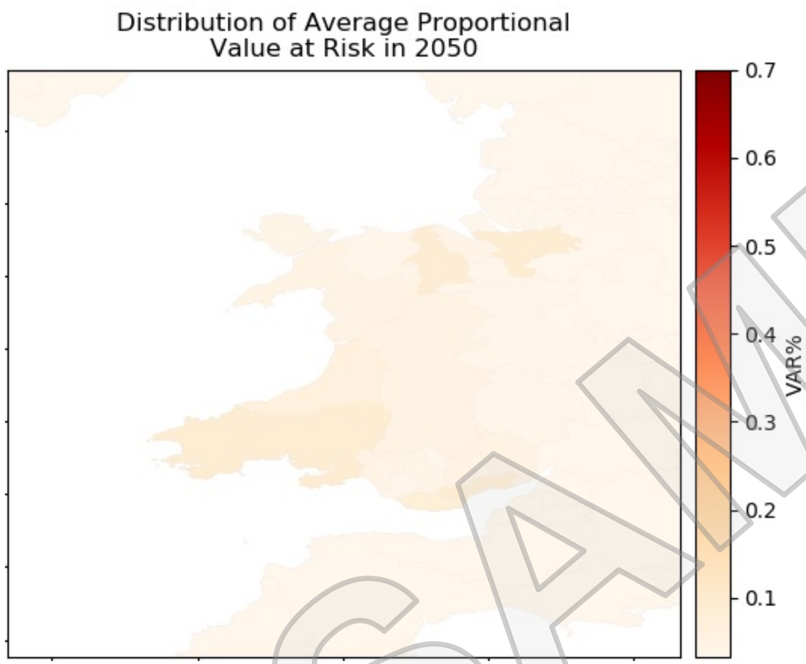
Using an average replacement cost, the Value-At-Risk% of each asset within the portfolio is summed and averaged for each geographical area shown. All maps use the climate scenario RCP8.5 based on a 'stress-test' selection of CORDEX models.

Caveats & Assumptions

Replacement cost of property is used to calculate Value-At-Risk% but it does not account for variations in material or labour costs for regional versus metro areas. Therefore actual dollar costs may be higher in metro and coastal areas.

TOP 10 AREAS BASED ON VAR% IN 2050

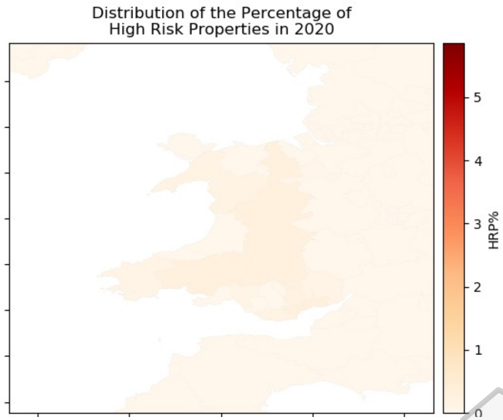
The following suburbs have the highest average Value-At-Risk by the year 2050.

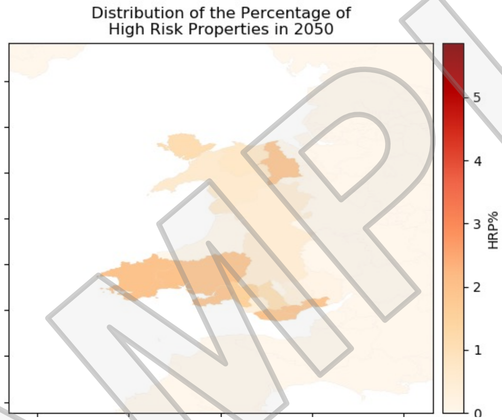


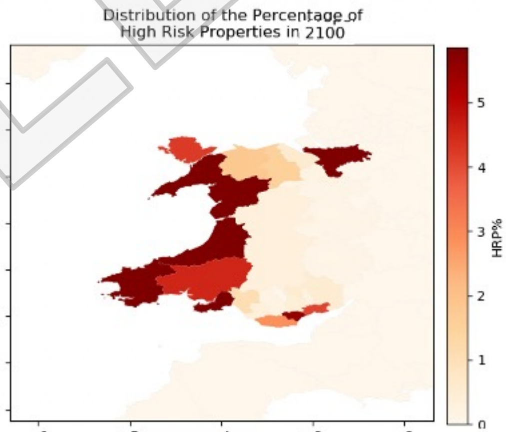
	County	VAR%
#1	Cardiff	0.24%
#2	Cheshire West and Chester	0.15%
#3	Carmarthenshire	0.12%
#4	Pembrokeshire	0.11%
#5	Swansea	0.10%
#6	Newport	0.09%
#7	Denbighshire	0.09%
#8	Vale of Glamorgan	0.08%
#9	Ceredigion	0.07%
#10	Blaenau Gwent	0.06%

GEOGRAPHICAL DISTRIBUTION OF PERCENTAGE OF HIGH-RISK PROPERTIES (HRP%)

KEY TAKEOUT: The modelling suggests that a large number of counties will have a significant increase in the proportion of high-risk properties with majority of change concentrated around low lying coastal and inland regions with exposure to flooding. This could have potential negative effects on the local economy leading to these areas becoming undesirable for buyers and insurers.







Why is this result useful?

These maps show the areas which have the highest proportion of high risk properties as a percentage of all of the properties in that area. The high risk properties are those at most risk of under insurance, devaluation and serviceability stress. These maps could be used as a proxy for regions where high levels of mortgage default and credit risk may be expected.

How is this result calculated?

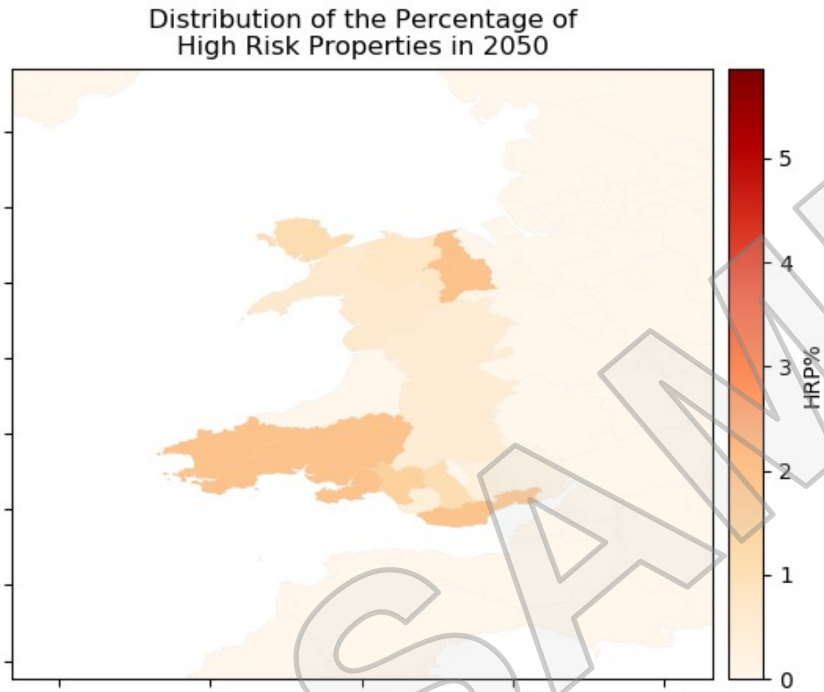
For each region, the number of properties with a Value-At-Risk% above 1.0% are summed and divided by the total number of properties in the region.

Caveats & Assumptions

This map can be heavily biased by areas which have a small number of properties all located in a very high risk location. For example if a small town has a large geographical area (eg. Farm land) but the majority of its population in a flood plain, it will appear very high risk on the map even though only a small number of people are affected.

TOP 10 SUBURBS BASED ON HRP% IN 2050

The following suburbs have the highest percentage of high risk properties as a portion of the total number of properties within the suburb by the year 2050.



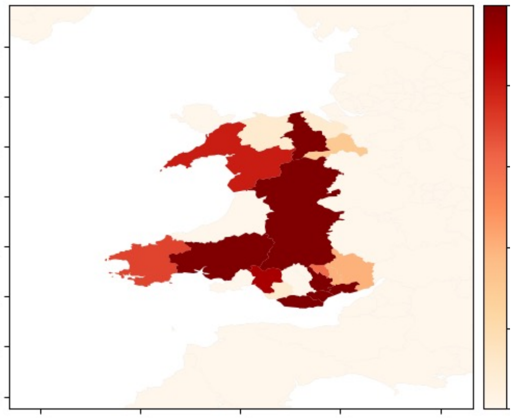
	Region	HRP%
#1	Cardiff	7.39%
#2	Swansea	5.33%
#3	Carmarthenshire	3.58%
#4	Pembrokeshire	3.09%
#5	Denbighshire	2.16%
#6	Vale of Glamorgan	1.91%
#7	Newport	1.88%
#8	Neath Port Talbot	1.52%
#9	Isle of Anglesey	1.13%
#10	Rhondda Cynon Taf	1.11%

Note: suburbs with at less than 20 properties have been excluded from this list

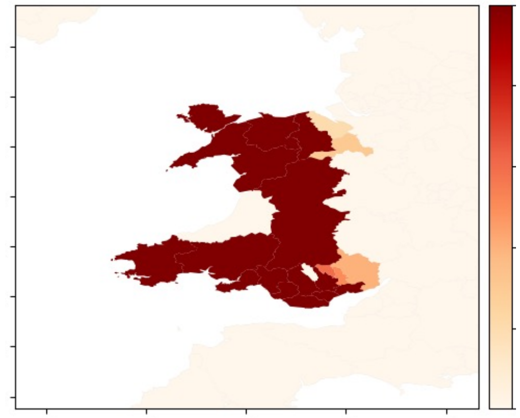
GEOGRAPHICAL DISTRIBUTION OF NUMBER OF HIGH-RISK PROPERTIES (HRP#)

KEY TAKEOUT: These maps show the locations and density of WalesBigBank's High Risk Properties (HRP#) in years 2020, 2050 and 2100 for all properties within its residential mortgage portfolio. These maps are heavily influenced by population density, with Cardiff and Swansea showing some of the higher number of high risk properties. These regions may be used as a proxy for regions where high numbers of mortgage default may be expected.

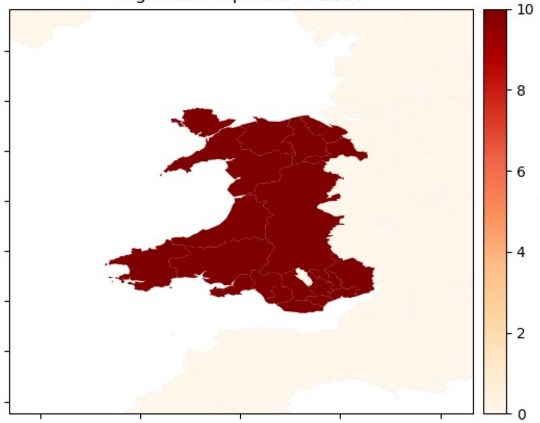
Distribution of the Number of High Risk Properties in 2020



Distribution of the Number of High Risk Properties in 2050



Distribution of the Number of High Risk Properties in 2100



Why is this result useful?

The high risk properties (HRP#) map focusses attention on where risks of damage have the highest concentration. These maps could be used as a proxy for regions where high levels of mortgage default and credit risk may be expected.

How is this result calculated?

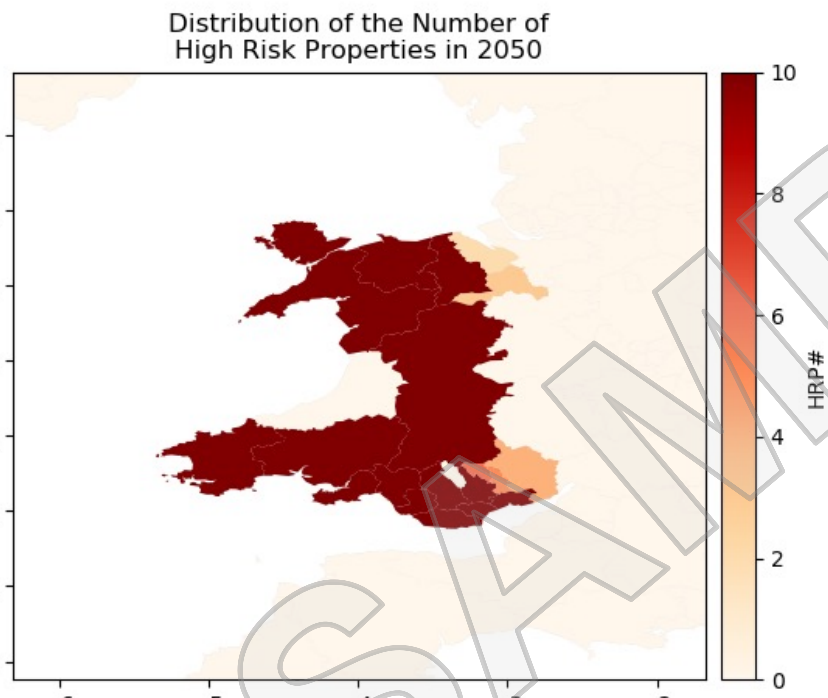
For each region, the number of properties with a Value-At-Risk above 1% are summed and provided as a real value for the SA1 area. All maps use the climate scenario RCP8.5 based on a 'stress-test' selection of CORDEX models.

Caveats & Assumptions

This map shows HRP# as a real value and can be biased by areas with large population density. The resolution is down to an SA1 area and therefore rural regions that cover large areas can appear overrepresented in size.

TOP 10 SUBURBS BASED ON HRP# IN 2050

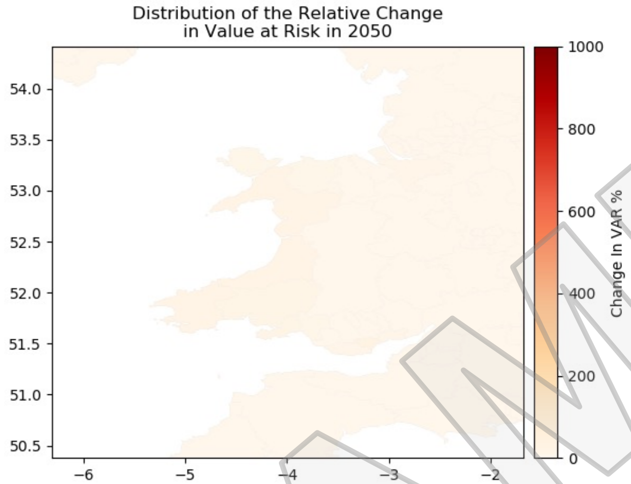
The following suburbs have the highest number of high risk properties within the suburb by the year 2050.

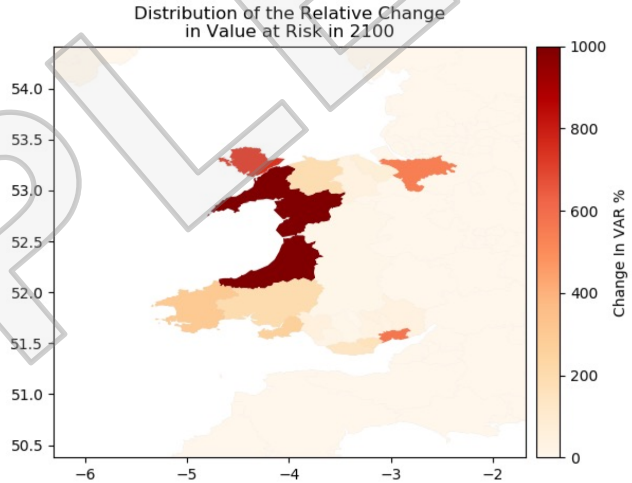


	Suburb	HRP#
#1	Cardiff	944
#2	Swansea	194
#3	Pembrokeshire	148
#4	Carmarthenshire	128
#5	Neath Port Talbot	126
#6	Vale of Glamorgan	104
#7	Newport	89
#8	Conwy	29
#9	Denbighshire	29
#10	Rhondda Cynon Taf	29

CHANGE IN AVERAGE VALUE AT RISK (VAR%) SINCE 1990

KEY TAKEOUT: The greatest increase in physical risk to the WalesBigBank portfolio is seen to be geographically located closer to the coast. The majority of regions will see about a 200% to 300% increase in Value-At-Risk over the century. There are a number of areas where 10-fold increases of risk are projected, with Aberystwyth and Porthmadog notable examples.





Why is this result useful?

These maps show change in median Value-At-Risk % from a baseline of 1990. It focusses attention on where risks are increasing most over different time periods and may be a useful indication of abnormally high climate change impacts.

How is this calculated?

The map shows the absolute increase in VAR% as as a fraction of the 1990 base-line VAR% for the two time periods.

Caveats & Assumptions

The maps show a percentage increase, so small increases in VAR on a small base VAR will be highly represented. This may drive attention toward hazards like subsidence, rather than increases in flood risk which start from with a higher VAR base.

HAZARD BREAKDOWN

NUMBER OF ASSETS EXPOSED TO EACH HAZARD

EXPLANATION: Before calculating vulnerabilities and level of risk, the Climate Risk Engines address (a) exposure to predisposed features; such as forests or moveable soils, and (b) the degree of that exposure; such as the amount of canopy cover or concentration of clay in the soil. In this table the percentage of mortgages that are exposed to each hazard are shown – even if the risks of damages from that hazard are small.

KEY TAKEOUT: Hazards such as coastal inundation and Riverine Flooding are only relevant to a very small percentage of WalesBigBank properties, where as most properties have some amount of clay in the soils and all properties are exposed to extreme wind conditions at some point. This is commonly seen across all national addresses and does not indicate the severity of the risk to the bank.

Hazard	Percentage of Properties Exposed in 2100.	Number of Properties Exposed in 2100.
Coastal Inundation	11.34%	10,522
Extreme Wind	100.00%	92,816
Forest Fire	16.49%	15,303
Riverine Flooding	3.11%	2,889
Surface Water Flooding	2.76%	2,565
Soil Subsidence	72.73%	67,509

Why is this result useful?

This table provides an insight into the underlying exposure which can be compared to risk results. It helps explain why hazards like soil subsidence can often contribute significantly to average VAR%. as such hazards affect a large number of properties but don't cause high risk to any individual property.

How is this calculated?

The sum and proportion of total properties with a none-zero exposure to each hazard are calculated with no adjustment for severity of exposure or resilience of individual properties.

Caveats & Assumptions

Exposure is simply a measure of the presence of a hazard at the property's address. Just because exposure numbers are high, does not mean that the risk metrics (such as VAR%) will be high because vulnerability and probability of damage or loss may be very low.

HAZARD CONTRIBUTION TO TOTAL VAR% IN EACH YEAR

KEY TAKEOUT: Flood and Coastal Inundation are the highest contributors to Value-at-Risk in each year. Therefore, while coastal inundation affects a small volume of properties, those that are affected have very high associated damage. On the other hand, soil subsidence and extreme wind impact a larger volume of properties but, when examining the associated damage risks, the expected cost and corresponding portion of Value-At-Risk for every given year is lower.

Hazard	1990	2020	2050	2100
Coastal Inundation	XXX%	XXX%	XXX%	XXX%
Extreme Wind	XXX%	XXX%	XXX%	XXX%
Forest Fire	XXX%	XXX%	XXX%	XXX%
Riverine Flooding	XXX%	XXX%	XXX%	XXX%
Surface Flooding	XXX%	XXX%	XXX%	XXX%
Soil Subsidence	XXX%	XXX%	XXX%	XXX%
	100%	*100%*	*100%*	*100%*

Why is this result useful?

These pie charts show the portion of total Value-At-Risk that each hazard represents of the total (100%) in each given year. It is relevant because it identifies which hazards are contributing to the greatest portion of risk each year, regardless of the volume of properties impacted.

How is this calculated?

Value-At-Risk% for each given hazard is aggregated across the company portfolio of assets in each time period. The VAR% for each hazard is then divided by the total VAR% across all hazards for that year to determine what portion of the total risk each hazard represents.

Caveats & Assumptions

As these figures are a portion of the total value at risk in each year, they can never exceed 100%. Therefore the results can mask the level of growth in individual hazards if it is proportionately smaller than another.

THE CHANGE IN AVERAGE HAZARD VAR% OVER TIME

KEY TAKEOUT: Across all hazards, WalesBigBank's average Value-At-Risk % is increasing through the century under the RCP 8.5 scenario & using a modern building archetype. When comparing WalesBigBank's risk to the national average of all addresses; WalesBigBank has a much lower exposure to coastal inundation than the national average but it above the national average in risk from riverine flooding.

Why is this result useful?

This graph shows the change in the company's Value-At-Risk % (solid line) calculated, compared to the national benchmark (dotted line) for each hazard over time. It can be useful to see which hazards are likely to increase over time and how the company will be impacted compared to the national database of properties.

OBSERVATION:

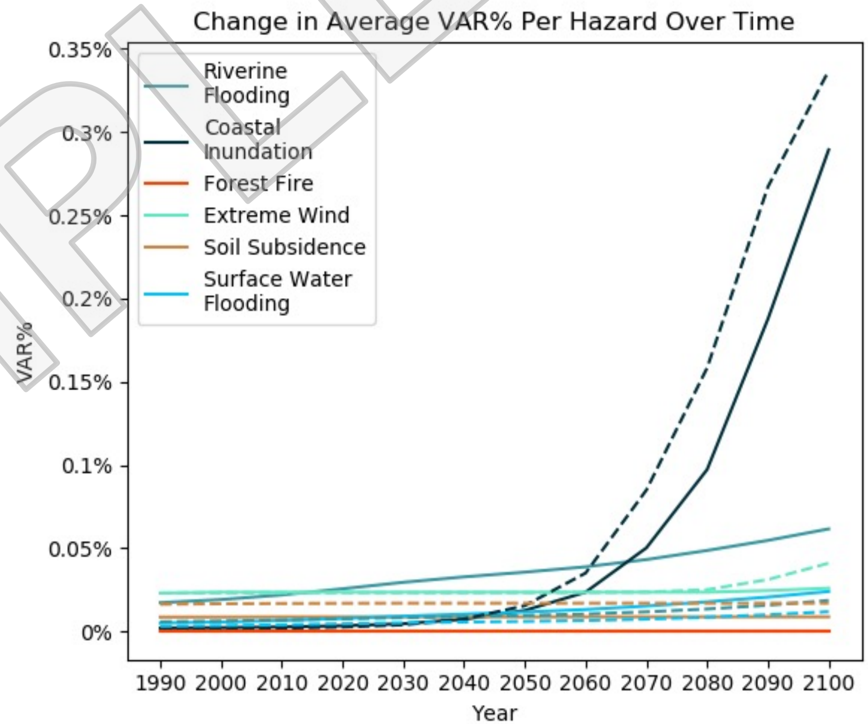
Across all hazards WalesBigBank's average Value-At-Risk % is increasing through the century. Typically Flooding and Coastal Inundation are the hazards responsible for most damage. This is represented within WalesBigBank's dataset as expected. There are also large increases in the later part of the century for Coastal Inundation as is typically expected for exponentially increasing exposure. Other hazards are increasing linearly. When comparing WalesBigBank's risk to the national average; coastal inundation risk is considerably below the national average while riverine flooding risk is above the national average.

How is this result calculated?

The average Value-At-Risk % for each property in the company's portfolio is calculated for each hazard in each given year under RCP 8.5 scenario (modern building archetype). This VAR% is then aggregated and averaged based on the number of properties in the portfolio.

Caveats & Assumptions

The results are for a Modern Building archetype which has relatively resilient design and construction. Allowance should be made for properties without elevated floors and with lower wind speed design specifications.



This graph shows VAR% for each hazard under RCP 8.5 scenario over time. The company's VAR% by hazard is the solid line and the dotted line represents the national average change in VAR% for that hazard.

COASTAL INUNDATION – CHANGE IN VAR%

KEY TAKEOUT: Under RCP8.5 scenario & using a modern building archetype, WalesBigBank's average Value-At-Risk from coastal inundation is expected to triple by 2100. The impacts of this hazard can be seen to exponentially increase over the century.

Why is this result useful?

For each emissions scenario, this graph shows the projected Value-at-Risk (VAR%) or average annual Technical Insurance Premium as a fraction of the portfolio's value. This is useful in determining the severity of the financial risk present to the portfolio from each hazard.

OBSERVATION:

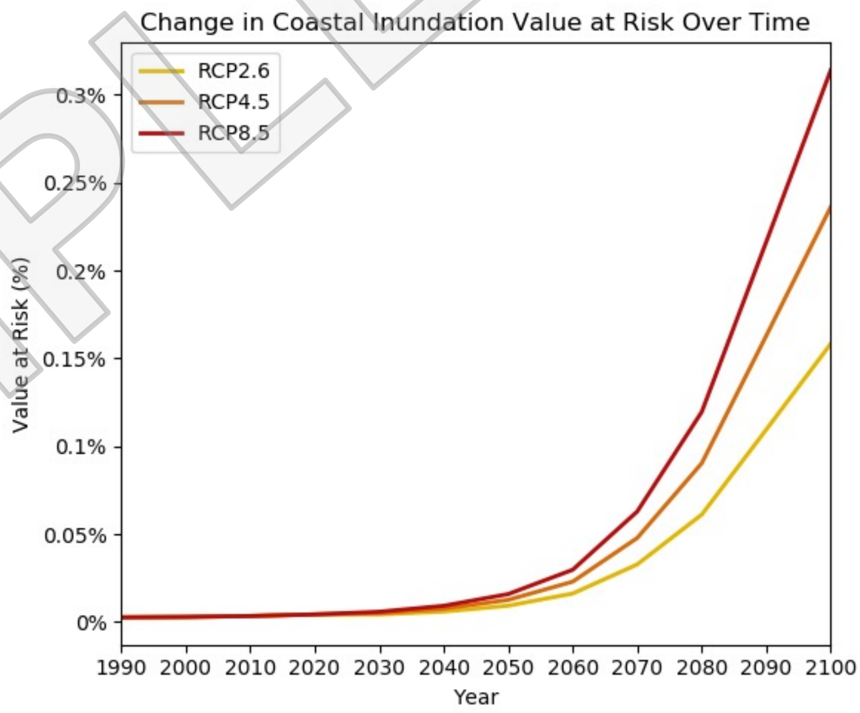
Unlike many other climate exacerbated hazards, Coastal Inundation increases exponentially over time. There has already been a small increase from XX% VAR% in 1990 to XX% in 2020. This is projected to double to XX% in 2100. Note that sea levels will continue to rise for some time, even after global greenhouse gas concentrations have been stabilised, thus damage from coastal inundation is evident in the portfolio regardless of which RCP is selected.

How is this result calculated?

Refer to the Appendix for an explanation of how Climate Risk Engines calculates VAR% for this specific hazard.

Caveats & Assumptions

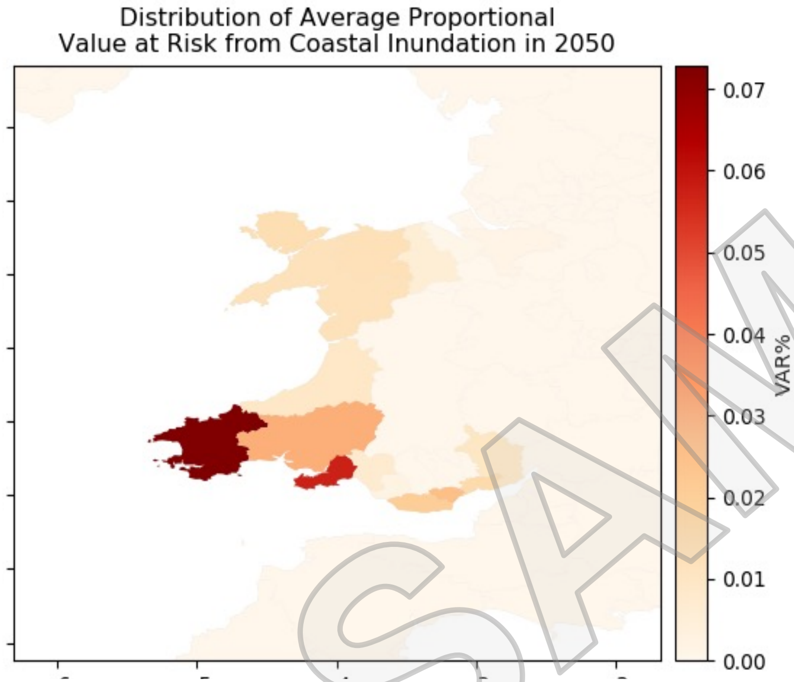
The Coastal Inundation projections are based on a Sea Level Rise scenario of 1.5m by 2100, which is at the highest end of IPCC AR5 estimates but below the NOAA high (2m) and extreme (2.5m) projections.



This graph shows the change in the VAR% from coastal inundation over time under RCP 8.5, 4.5 and 2.6.

COASTAL INUNDATION – GEOGRAPHIC DISTRIBUTION

GEOGRAPHIC DISTRIBUTION OF VAR%



TOP 10 SUBURBS BY VAR% in 2050

	Region	VAR%
#1	Pembrokeshire	0.07%
#2	Swansea	0.06%
#3	Carmarthenshire	0.03%
#4	Cardiff	0.03%
#5	Vale of Glamorgan	0.02%
#6	Newport	0.01%
#7	Isle of Anglesey	0.01%
#8	Conwy	0.01%
#9	Gwynedd	0.01%
#10	Monmouthshire	0.01%

Note: suburbs with at less than 50 properties have been excluded from this list

FOREST FIRE – CHANGE IN VAR%

KEY TAKEOUT: Forest fire risk is driven by the confluence of low humidity, temperatures and high winds. These are conditions are projected to increase exponentially under RCP 8.5 scenario, and be significantly contained under a the RCP 2.6 emission scenario.

Why is this result useful?

For each emissions scenario, this graph shows the projected change in Value-at-Risk (VAR%) or average annual Technical Insurance Premium as a fraction of the portfolio's value. It is useful in determining the severity of the financial risk present to the portfolio from each hazard.

OBSERVATION:

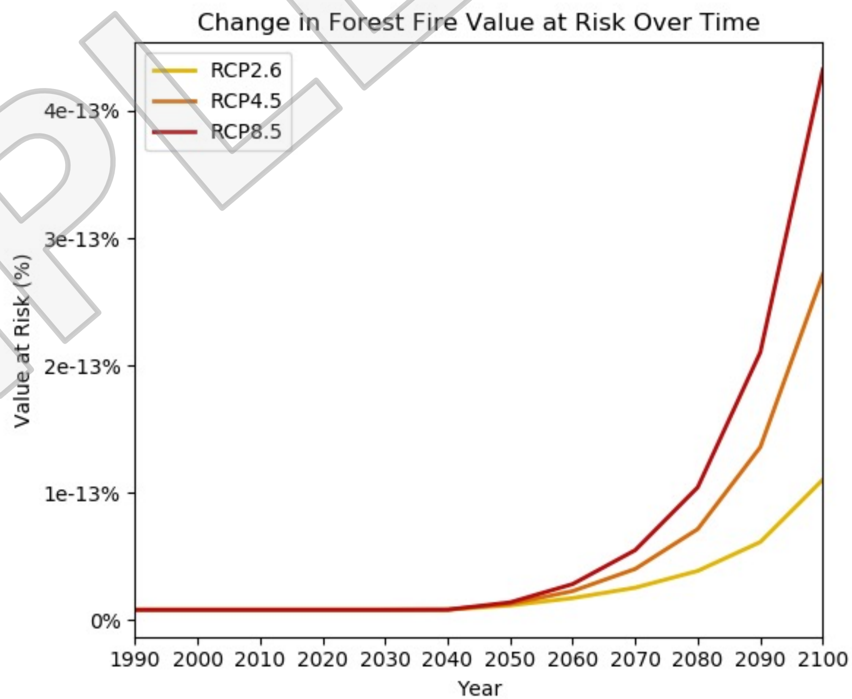
Forest fire risk is driven by the confluence of low humidity, temperatures and high winds. These are conditions are projected to increase exponentially under RCP 8.5 scenario, and be significantly contained under a the RCP 2.6 emission scenario.

How is this result calculated?

Refer to the Appendix for an explanation of how Climate Risk Engines calculates VAR% for this specific hazard.

Caveats & Assumptions

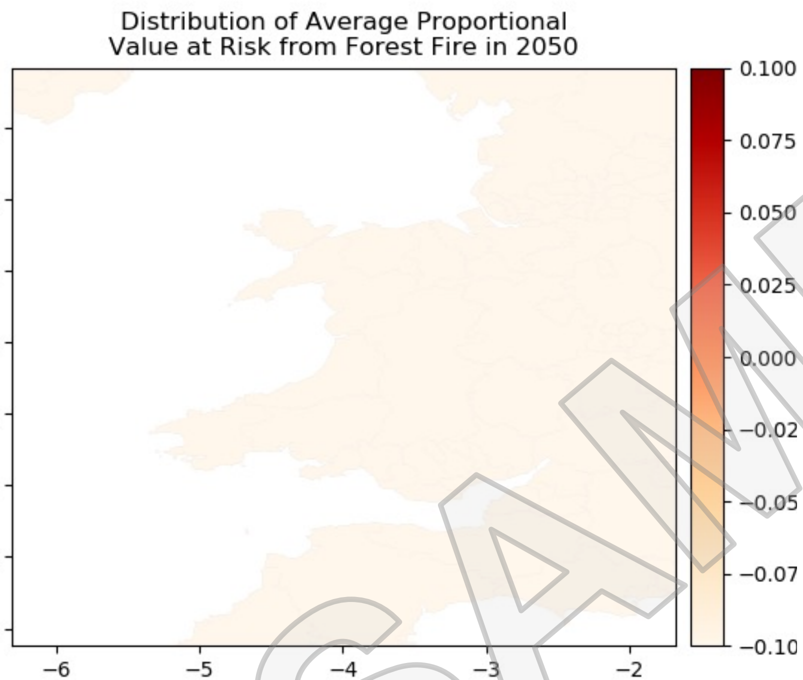
The analysis does not account for the coincidence of fire risk conditions and the effects on vegetation of prolonged drought, which increase the severity of fires considerably.



This graph shows the change in the VAR% from forest fire over time under RCP 8.5, 4.5 and 2.6.

FOREST FIRE – GEOGRAPHIC DISTRIBUTION

GEOGRAPHIC DISTRIBUTION OF VAR%



TOP 10 SUBURBS BY VAR% in 2050

	Region	VAR%
#1	Pembrokeshire	>0.00%
#2	Carmarthenshire	>0.00%
#3	Merthyr Tydfil	>0.00%
#4	Ceredigion	>0.00%
#5	Rhondda Cynon Taf	>0.00%
#6	Neath Port Talbot	>0.00%
#7	Bridgend	>0.00%
#8	Vale of Glamorgan	>0.00%
#9	Cardiff	>0.00%
#10	Caerphilly	>0.00%

RIVERINE FLOODING – CHANGE IN VAR%

KEY TAKEOUT: WalesBigBank's aggregate Value-At-Risk from Riverine Flooding under RCP8.5 scenario & using a modern building archetype shows linear growth, leading to 200% increase by 2100. Lower emission pathways lower or curb the long term growth in flood risks.

Why is this result useful?

For each emissions scenario, this graph shows the projected change in Value-at-Risk (VAR%) or average annual Technical Insurance Premium as a fraction of the portfolio's value. It is useful in determining the severity of the financial risk present to the portfolio from each hazard.

OBSERVATION:

WalesBigBank's aggregate Value-At-Risk from Riverine Flooding under the RCP8.5 scenario & using a modern building archetype shows linear growth, leading to 200% increase by 2100. Lower emission pathways lower or curb the long term growth in flood risks (100% increase for RCP4.5).

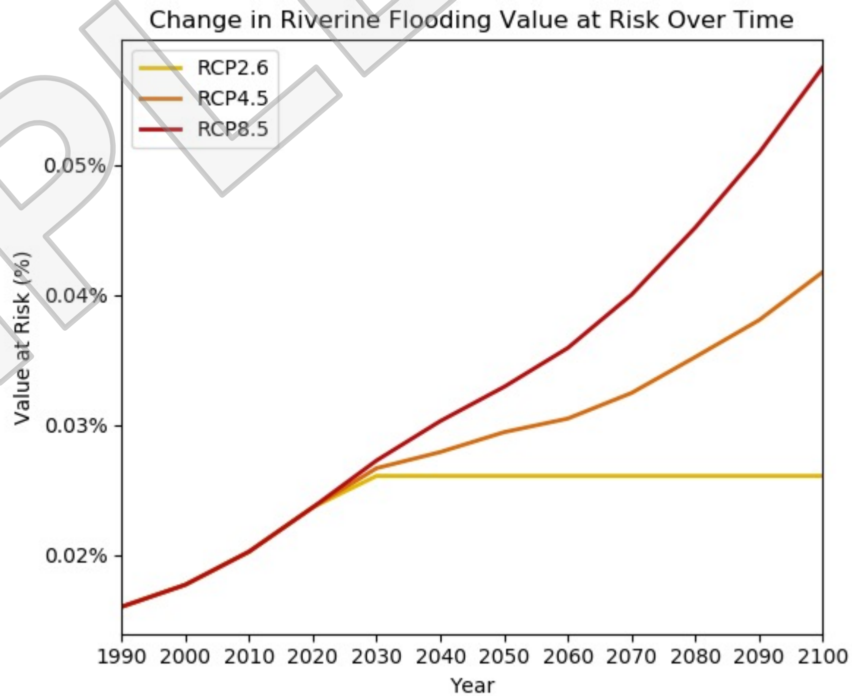
Note that 40 years of change in risk probability between 1990 and 2030 appear to be unavoidable.

How is this result calculated?

Refer to the Appendix for an explanation of how Climate Risk Engines calculates VAR% for this specific hazard.

Caveats & Assumptions

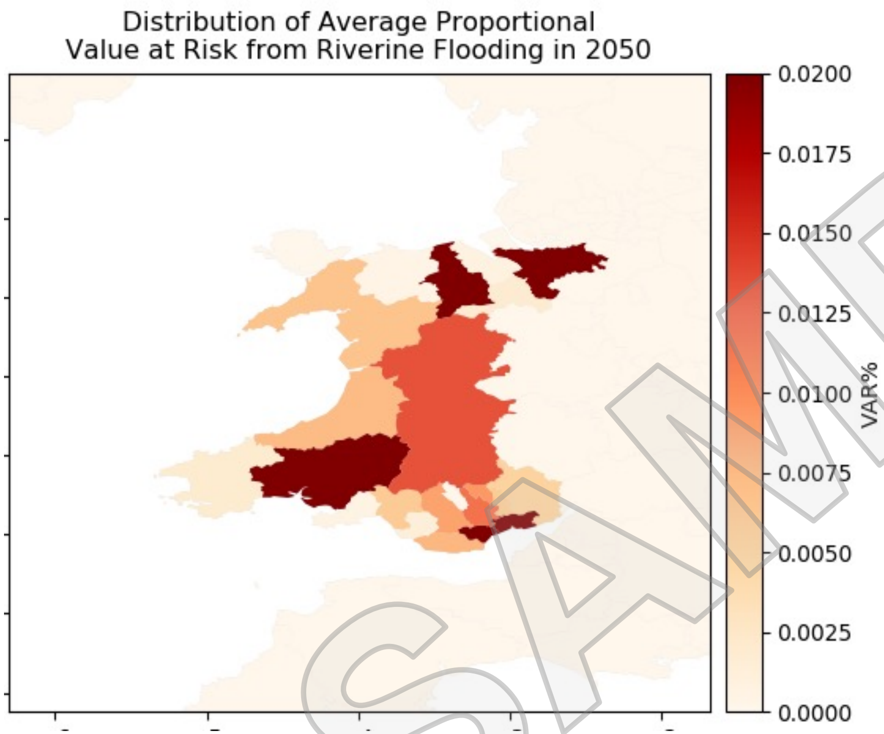
The VAR% is based on a modern property archetype with elevated floors 0.5m above ground and as such allowance should be made for the wide spread use of slab-on-ground construction methods.



This graph shows the change in the VAR% from riverine flooding over time under RCP 8.5, 4.5 and 2.6.

RIVERINE FLOODING – GEOGRAPHIC DISTRIBUTION

GEOGRAPHIC DISTRIBUTION OF VAR%



TOP 10 SUBURBS BY VAR% in 2050

	Region	VAR%
#1	Cardiff	0.17%
#2	Cheshire West and Chester	0.12%
#3	Carmarthenshire	0.05%
#4	Denbighshire	0.04%
#5	Newport	0.04%
#6	Powys	0.01%
#7	Caerphilly	0.01%
#8	Blaenau Gwent	0.01%
#9	Rhondda Cynon Taf	0.01%
#10	Vale of Glamorgan	0.01%

SURFACE WATER FLOODING – CHANGE IN VAR%

KEY TAKEOUT: WalesBigBank's aggregate Value-At-Risk from Surface Water Flooding under RCP8.5 scenario & using a modern building archetype shows linear growth, leading to 233% increase by 2100. Lower emission pathways lower or curb the long term growth in flood risks.

Why is this result useful?

For each emissions scenario, this graph shows the projected change in Value-at-Risk (VAR%) or average annual Technical Insurance Premium as a fraction of the portfolio's value. It is useful in determining the severity of the financial risk present to the portfolio from each hazard.

OBSERVATION:

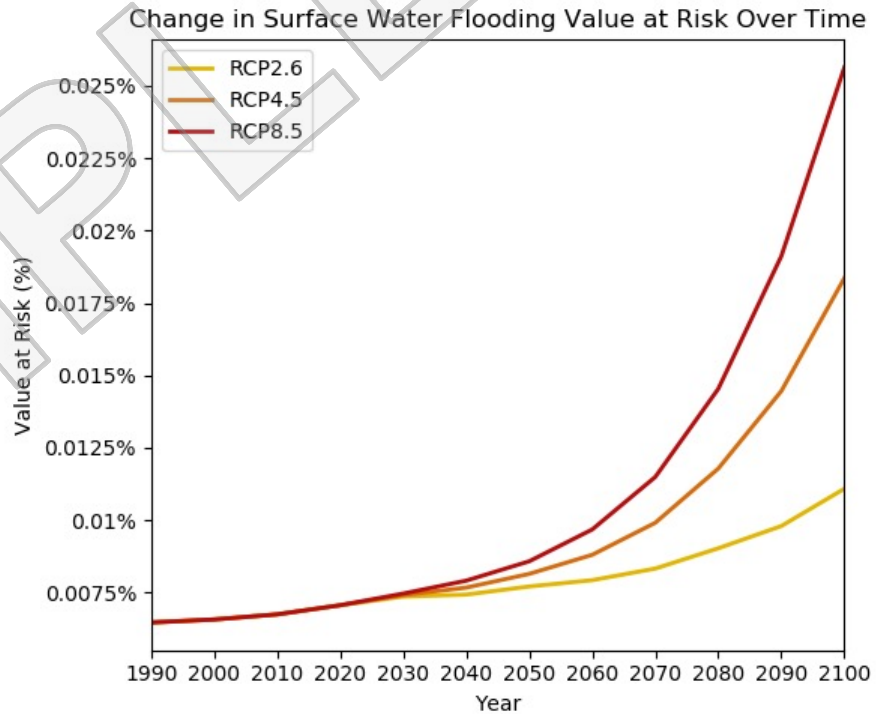
WalesBigBank's aggregate Value-At-Risk from Surface Water Flooding under the RCP8.5 scenario & using a modern building shows exponential growth, leading to 295% increase between 1990 and 2100. Lower emission pathways lower or curb the long term growth in flood risks (XX% increase for RCP2.6). Note that 40 years of change in risk probability between 1990 and 2030 appear to be unavoidable however it is important to note that the damage associated with this type of flooding is significantly lower than riverine flooding.

How is this result calculated?

Refer to the Appendix for an explanation of how Climate Risk Engines calculates VAR% for this specific hazard.

Caveats & Assumptions

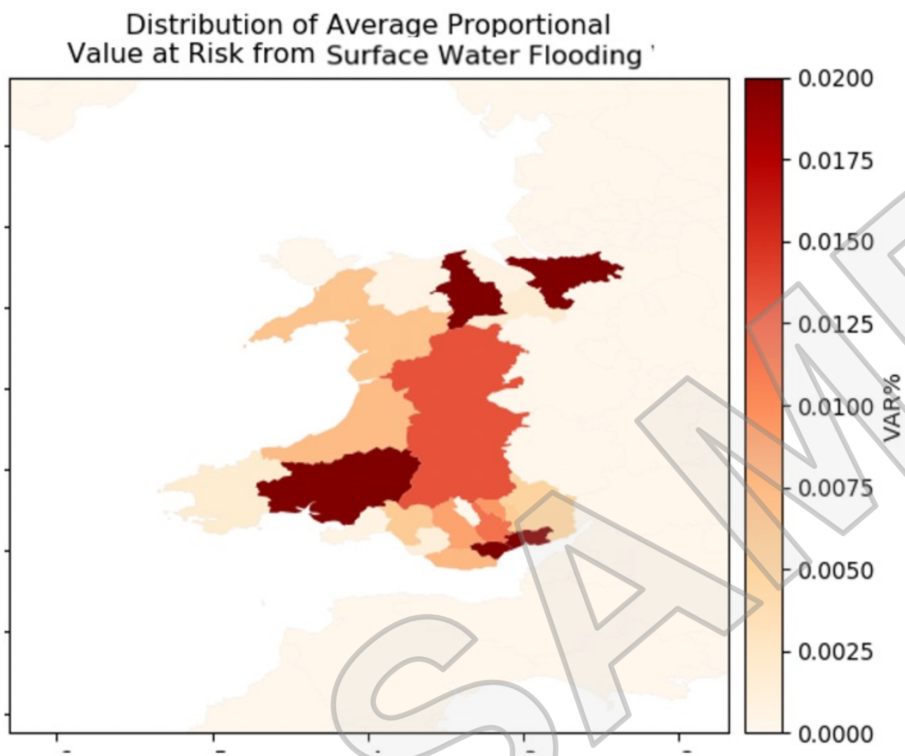
The VAR% is based on a modern property archetype with elevated floors 0.5m above ground and as such allowance should be made for the wide spread use of slab-on-ground construction methods.



This graph shows the change in the VAR% from surface flooding over time under RCP 8.5, 4.5 and 2.6.

SURFACE WATER FLOODING – GEOGRAPHIC DISTRIBUTION

GEOGRAPHIC DISTRIBUTION OF VAR%



TOP 10 POST CODES BY VAR% in 2050

	Region	VAR%
#1	Cardiff	0.32%
#2	Cheshire West and Chester	0.07%
#3	Carmarthenshire	0.07%
#4	Denbighshire	0.04%
#5	Newport	0.04%
#6	Powys	0.04%
#7	Caerphilly	0.04%
#8	Blaenau Gwent	0.03%
#9	Rhondda Cynon Taf	0.03%
#10	Vale of Glamorgan	0.02%

Note: suburbs with at less than 5 properties have been excluded from this list

SOIL SUBSIDENCE – CHANGE IN VAR%

KEY TAKEOUT: The modelling suggests Soil Subsidence Value-At-Risk in WalesBigBank's portfolio has already increased due to an increased probability of droughts and this is projected to stabilise over the century. These risks are generally non-catastrophic for an individual property, but can be widespread. Majority of insurers do not currently offer coverage for damage due to soil subsidence.

Why is this result useful?

For each emissions scenario, this graph shows the projected change in Value-at-Risk (VAR%) or average annual Technical Insurance Premium as a fraction of the portfolio's value. It is useful in determining the severity of the financial risk present to the portfolio from each hazard.

OBSERVATION:

Under RCP8.5 scenario & using a modern building archetype, the modelling suggests WalesBigBank's aggregate Value-At-Risk from Soil Subsidence has already increased from 1990 to 2020 due to increased probability of droughts. This is projected to stabilise over the century however most change will occur before 2030.

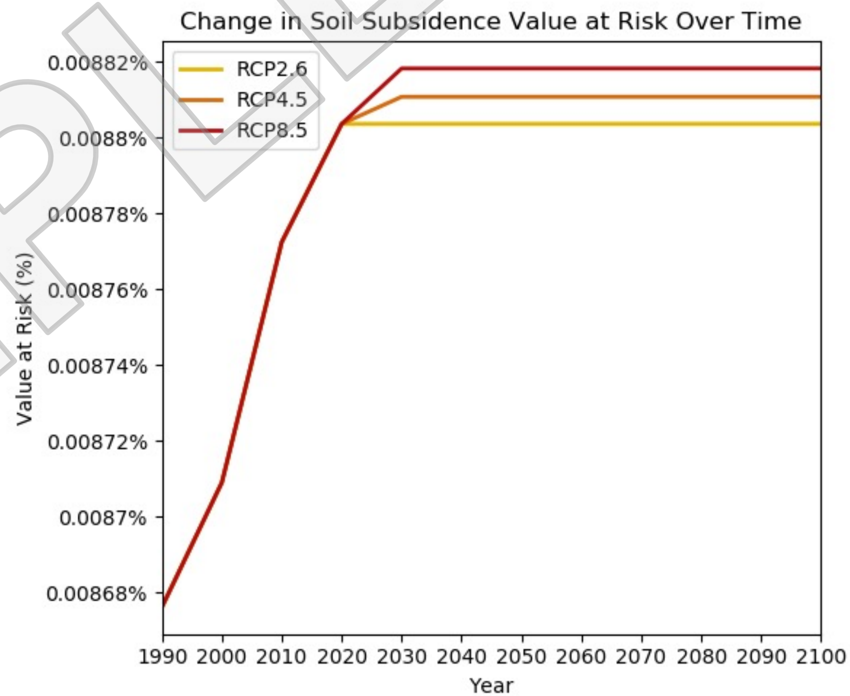
These risks are generally non-catastrophic for an individual property, but can be widespread.

How is this result calculated?

Refer to the Appendix for an explanation of how Climate Risk Engines calculates VAR% for this specific hazard.

Caveats & Assumptions

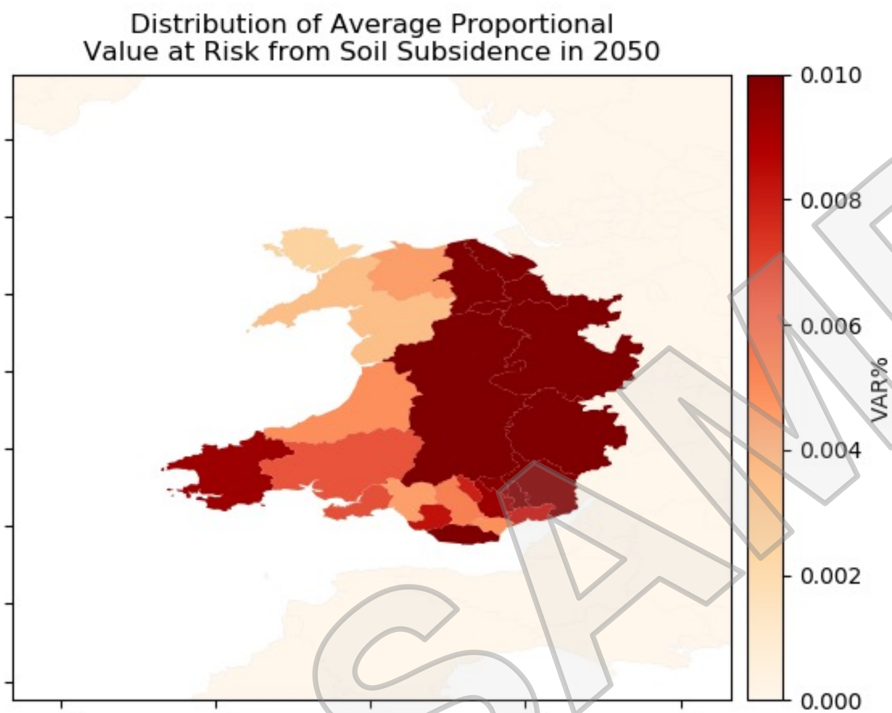
In some cases drought risks can go up and down over time in the climate models as weather systems change (such as the southerly movement of monsoons and tropics), so the maximum VAR% is assigned to each given year to remove the effects of this variability.



This graph shows the change in the VAR% from soil subsidence over time under RCP 8.5, 4.5 and 2.6.

SOIL SUBSIDENCE – GEOGRAPHIC DISTRIBUTION

GEOGRAPHIC DISTRIBUTION OF VAR%



TOP 10 SUBURBS BY VAR% IN 2050

	Region	VAR%
#1	Shropshire	0.02%
#2	Flintshire	0.02%
#3	Vale of Glamorgan	0.02%
#4	Herefordshire, County of	0.02%
#5	Monmouthshire	0.01%
#6	Powys	0.01%
#7	Wrexham	0.01%
#8	Denbighshire	0.01%
#9	Torfaen	0.01%
#10	Blaenau Gwent	0.01%

EXTREME WIND – CHANGE IN VAR%

KEY TAKEOUT: The overall risks from wind storms are low for modern buildings. Though risks have increased with climate change they are projected to remain well below levels that could impact insurance. Beyond the current modelling, there is a risk that rising Pacific and Indian ocean temperatures could cause cyclones to reach further south in future, exceeding the design standard of buildings in southern parts of the globe.

Why is this result useful?

For each emissions scenario, this graph shows the projected change in Value-at-Risk (VAR%) or average annual Technical Insurance Premium as a fraction of the portfolio's value. It is useful in determining the severity of the financial risk present to the portfolio from each hazard

OBSERVATION:

Wind risks to the portfolio from the climate models start low but increase sharply from 2080. However VAR% still remain well below thresholds that would lead to higher insurance premiums.

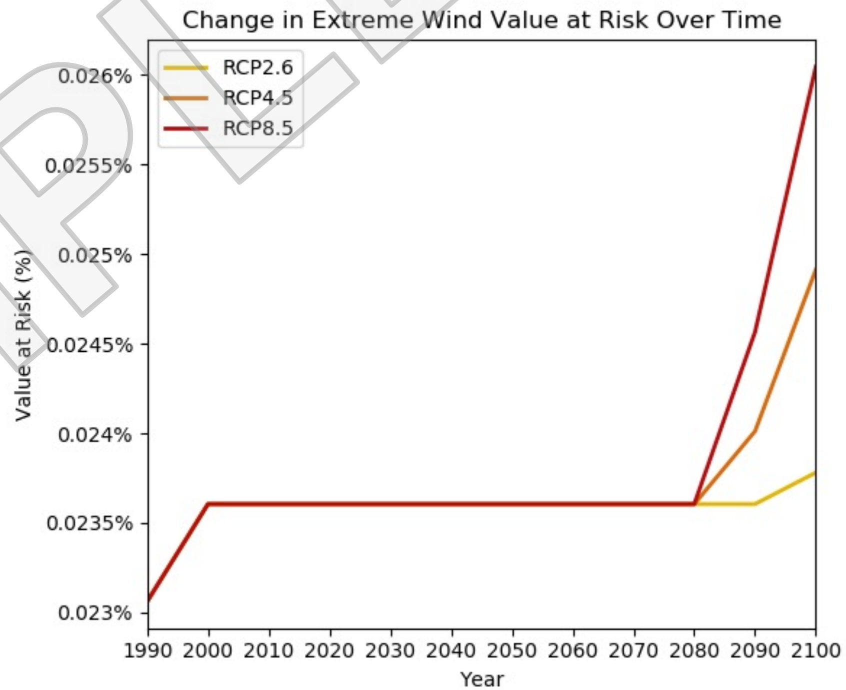
Most climate models have limitations with regard to wind, (a) they do not yet model small convective storms and (b) they do not yet model the creation of cyclones caused by warming. So the wind results should be treated with low confidence and as work in progress.

How is this result calculated?

Refer to the Appendix for an explanation of how Climate Risk Engines calculates VAR% for this specific hazard.

Caveats & Assumptions

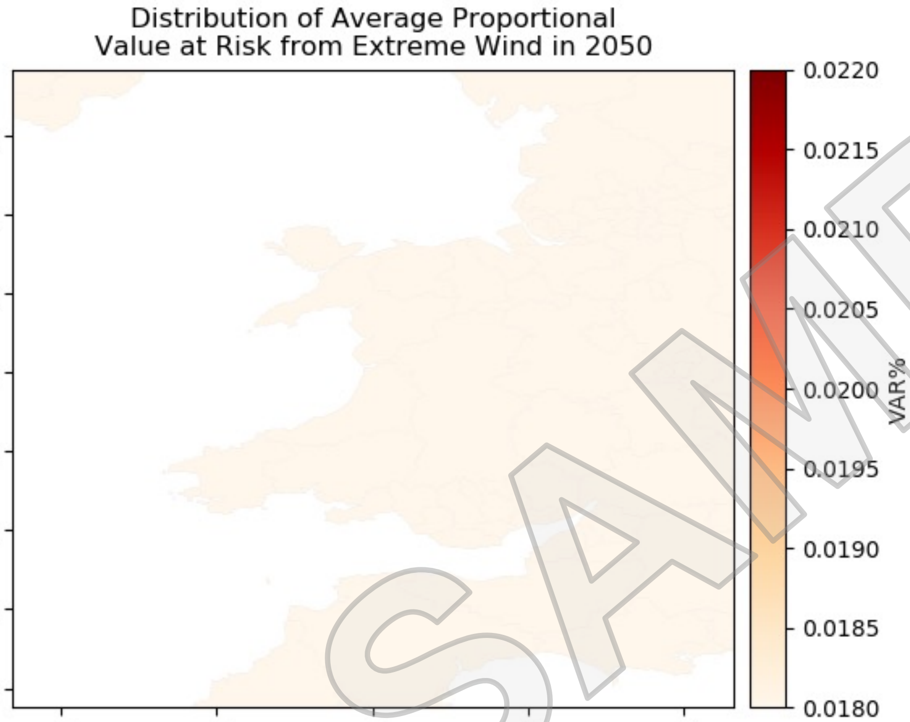
Most climate models have limitations with regard to wind, (a) they do not yet model small convective storms and (b) they do not yet model the creation of cyclones caused by warming. So the wind results should be treated as work in progress. The maximum VAR to a given year to remove the effects of temporal variability



This graph shows the change in the VAR% from extreme wind over time under RCP 8.5, 4.5 and 2.6.

EXTREME WIND – GEOGRAPHIC DISTRIBUTION

GEOGRAPHIC DISTRIBUTION OF VAR%



TOP 10 SUBURBS BY VAR% IN 2050

	Region	VAR%
#1	Neath Port Talbot	0.02%
#2	Bridgend	0.02%
#3	Rhondda Cynon Taf	0.02%
#4	Merthyr Tydfil	0.02%
#5	Vale of Glamorgan	0.02%
#6	Conwy	0.02%
#7	Ceredigion	0.02%
#8	Carmarthenshire	0.02%
#9	Swansea	0.02%
#10	Gwynedd	0.02%

ASSET RANKINGS

The following asset-specific insights have been produced for WalesBigBank's 'high risk subset' only. This high risk subset is defined as those properties that are equal to or above 1% Value-At-Risk in the year 2050. A more detailed export of the asset-specific insights for this high risk subset has been provided in CSV format to accompany this report.

LIST OF HIGHEST RISK PROPERTIES BASED ON VAR%

RANKING (Highest to Lowest VAR%	ASSET ID	VAR%
1	2152610942	0.763
2	2151475457	0.763
3	2151472588	0.763
4	2151963440	0.763
5	2120292755	0.760
6	1243757752	0.757
7	2015477861	0.756
8	1114928304	0.754
9	2015468057	0.753
10	1218425937	0.753
11	2015527098	0.742
12	2111425813	0.739
13	2015519863	0.738
14	1217019353	0.734
15	1128313126	0.733
16	1264217845	0.712
17	1128313123	0.699
18	2152157116	0.680
19	2015482066	0.677
20	2015485704	0.675
21	1117597507	0.669
22	9010400344	0.647
23	2151444602	0.646
24	1121720771	0.642
25	2151460227	0.638
26	2029432795	0.638
27	1131297648	0.638
28	2151692454	0.638
29	1229103050	0.638
30	1229031526	0.638
31	2162448161	0.638
32	2014056699	0.638
33	2129182756	0.638
34	2021419274	0.638
35	2112283248	0.638
36	2122001711	0.638
37	2015802184	0.638
38	2019145207	0.638
39	2152210862	0.638
40	2016917866	0.638
41	2172419396	0.638
42	2152290023	0.638
43	2020284239	0.638
44	2157603722	0.638
45	2151509632	0.638
46	2162051483	0.638
47	5000071108	0.638
48	2160821986	0.638
49	1124622993	0.638
50	2124547679	0.638

*Top 100 High Risk Properties are listed by VAR%. A full list of the high risk subset is provided in an accompanying CSV file.

RECOMMENDATIONS

KEY RECOMMENDATIONS

The insights contained within this report are designed to support stakeholders in making decisions relating to WalesBigBank's portfolio exposure and vulnerability. Key recommendations arising from this report include:

1. Understand and address an industry position.
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2. Undergo quantified scenario testing of different adaptation strategies.
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KEY RECOMMENDATIONS

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APPENDIX

LOCATING THIS ANALYSIS IN TCFD LEADING PRACTICE

SUMMARY TABLE: CLIMATE VALUATION DELIVERY OF TCFD REPORTING RECOMMENDED PRACTICE

Elements Of Physical Risk Assessment	Guidance And Recommendations	What Climate Valuation Delivers
Hazards	Storms, extreme rainfall, extreme heat, heatwave, flood, drought and wildfire, variability in precipitation and temperature, water stress, sea- level rise, land degradation (IIGCC 2020a). Heat stress, extreme rainfall, drought, cyclones, rising sea levels, wildfire and other industry-relevant and/or locally specific climate hazards across the corporate value chain (EBRD 2018).	Climate Valuation modelling incorporates six climate hazards: coastal inundation (sea level rise), riverine flooding, extreme wind (storms), soil contraction (effect of drought), forest fire & extreme heat.
Timeframes	Short and medium term: 2020-2040 (IIGCC 2020a, EBRD 2018). For this time frame, the EBRD recommends probabilistic risk analysis. Longer term: 2040-2100 (IIGCC 2020a, EBRD 2018). For this time frame, the EBRD recommends scenario-based analysis. The BOE's biennial exploratory scenario will model 2020-2050 but for the "no policy action" scenario, physical impacts in 2050 will represent expected physical impacts in 2080 (BOE 2019b).	The analysis is probabilistic from 2020 to 2100 for multiple climate scenarios ranging from "no policy action" (RCP8.5) through to "extreme policy action" (RCP2.6). Results can be presented in different decadal time steps (e.g. 2030, 2050 and 2100) depending on client requirements.
Scale	Location (country or city) of key supplier facilities and critical business facilities with evaluation of their importance (EBRD 2018). Asset-level data and assessment with attention to downscaling limitations of models (IIGCC 2020a, CISL 2019).	Climate Valuation works at address level, data is aggregated from suburbs to national as required. Regional Climate Models (RCMs) include local topology and land surface information to provide spatial resolutions to between 5 and 50km square resolution. Further hazard layer context includes local weather data, elevation data, vegetation maps and wind zones with resolutions between 5 and 250 metres.
Scenarios	Most guidance for physical risk assessment recommend use of 2°C and 4°C pathways (CISL 2019, IIGCC 2020a). Consistent with IIGCC recommendation, the TCFD 2019 Status report indicates that RCPs 2.6 and RCP8.5 are commonly being used as best and worst case 2°C scenario and 4°C scenarios respectively.	Climate Valuation can model comparative effects of RCP2.6 and RCP8.5 and can also include RCP4.5 as a moderate mitigation pathway (which still results in average warming over 2°C). Please refer to the 'modelled scenarios' section for the RCPs used for this analysis.
Direct and indirect physical climate impacts	Direct and first-order: damage and loss of real assets, disruption to value chains, supply chain costs, lost hours of staff (IIGCC 2020a, EBRD 2018). Indirect and second-order: Insurance costs, energy costs, regulatory change, legal liabilities, market changes, borrowing costs, social license (IIGCC 2020a, EBRD 2018).	Direct and first-order: damage and loss of real assets Indirect and second-order: increase in insurance premiums, impacts to market value of properties at risk from damage.

LOCATING THIS ANALYSIS IN TCFD LEADING PRACTICE

SUMMARY TABLE: CLIMATE VALUATION DELIVERY OF TCFD REPORTING RECOMMENDED PRACTICE

Elements Of Physical Risk Assessment	Guidance And Recommendations	What Climate Valuation Delivers
Metrics and outputs	Data: Most guidance recommended climate data overlaid with business data, within a socio-economic and regulatory context. Recent and historic impacts: EBRD recommends firms estimate current costs of extreme weather events, including days of business interruptions and associated costs, costs of repairs or upgrades, fixed-asset impairment, supply chain disruptions and lost revenues. Average Annual Loss (CISL 2019, BOE 2019b, EBRD 2018). Number of sites and business lines exposed to relevant climate impacts (EBRD 2019). Value-At-Risk (EDRB 2018). Identification of critical thresholds (IIGCC 2020a).	Climate data overlaid with client asset data. Outputs include: • Total Technical Insurance Premium (TTIP), (total annual cost of damage assuming all hazards are insured) • Percentage of Value-at-Risk (VAR%), (TTIP as a percentage of the replacement cost of the property). • Number of High-Risk Properties (HRP#), (property assets where the VAR is greater than 1%). • Percentage of High-Risk Properties (HRP%), (HRP# expressed as a percentage of all properties in the LGA). • Climate Adjusted Value (CAV)
Adaptation measures	Inclusion of asset-level and broader adaptation options in model (CISL 2019, BOE 2019b, IIGCC 2020a) including planned improvements, retrofits, relocations, or other changes to assets.	Analysis of available adaptation measures at the address and locality scale and how they change risk profile. Evaluation of net risk exposure after adaptation applied.
Strategy, policy and advocacy	Supply-chain risk management strategy incl. engagement with suppliers on strategy (EBRD 2018). Engagement with local or national governments and local stakeholders on local climate resilience (EBRD 2018).	Cross dependency analysis identifies shared risk with upstream infrastructure including road access, water and power supply.

References

Taskforce on Climate-related Financial Disclosure: The 2017 Final Report from the Task Force for Climate-related Financial Disclosure (TCFD 2017)

European Bank for Reconstruction and Development (EBRD): Advancing TCFD guidance on physical climate risks and opportunities (EBRD 2018)

Cambridge Institute for Sustainability Leadership (CISL): Physical risk framework Understanding the impacts of climate change on real estate lending and investment portfolios. (CISL 2019).

TCFS 2019 Status Report 2019: (TCFD 2019).

Institutional Investor Group on Climate Change (IIGCC): Understanding physical climate risks and opportunities – a guide for investors (IIGCC 2020)

Bank of England (BOE): Discussion paper for the 2021 Biennial Exploratory Scenario (BES) on the financial risks from climate change. (BOE 2019b).

LOCATING THIS ANALYSIS IN CMSI LEADING PRACTICE

SUMMARY TABLE: CLIMATE VALUATION DELIVERY OF CMSI RECOMMENDED PRACTICE

Elements Of Physical Risk Assessment	Guidance And Recommendations	What Climate Valuation Delivers
Hazards	Acute physical risks: • Tropical cyclones • East coast lows • Extreme rainfall and riverine floods • Extreme sea level events • Large hail • Extreme bushfire events Chronic physical risks: • Average temperature and extreme heat events • Average rainfall • Sea level rise • Drought	Climate Valuation cover all Acute & Chronic Physical risks recommended by CMSI, with the exception of: 1. Poleward shift of tropical cyclones and changes to small scale wind and hail storm events. This is not included because current CORDEX models do not provide sufficient resolution to capture creation and behaviour of cyclones and convective storms. New approaches and results are being developed (e.g. AIG, 2020) and may be included in future studies when commonly accepted by the scientific community. 2. Average temperature and rainfall. These are are not considered to present a risk of physical damage to property. Additional hazards considered in this study above CMSI recommendations: 1. Subsidence due to soil contraction 2. Pluvial (surface) flooding
Timeframes	Disclosure of the financial impact of climate change under each scenario should be made for 2030 and 2050. In addition, disclosers should also consider disclosing the financial impact for timeframes within the next 5 years (to align with business planning), and 2090.	This study has exceeded CMSI requirements by computing physical risk for each year from 1990 to 2100. The 5 year horizon is managed both with respect to 'today' but also with respect to a 1990 baseline of weather data on which much conventional risk quantification in planning, property and insurance is based.
Scale	As well as in aggregate, disclosures should also consider the following sectoral splits where they are material to the business: • by portfolio (for example, home loans, commercial loans, commercial insurance, personal insurance) • by hazard (for example, tropical cyclones, floods, convective storms and hail, coastal inundation, bushfire, soil contraction) • by geographic region.	The analysis is for a single residential portfolio. It includes both aggregate and assert specific insights. The contribution of each hazard are disclosed separately and spatial files have been provide that allow interrogation of results by geographic region.
Scenarios	Disclosures should be made under the following RCP scenarios: • for a 2°C or lower scenario, RCP 2.6 • for a greater than 2°C scenario, RCP 8.5.	The analysis meets CMSI by analysing RCP8.5 and providing a IPCC based adjusted data set of RCP2.6. The study also provides an additional data set for RCP4.5

LOCATING THIS ANALYSIS IN CMSI LEADING PRACTICE

SUMMARY TABLE: CLIMATE VALUATION DELIVERY OF CMSI RECOMMENDED PRACTICE

Elements Of Physical Risk Assessment	Guidance And Recommendations	What Climate Valuation Delivers
Direct and indirect physical climate impacts	Direct Risks: • Damage to property (buildings and infrastructure) Indirect Risks: • Loss of use of asset • Loss due to cross-dependency on other assets • Health and human impacts	For each year and each hazard, the analysis provides modelled impacts to the Representative Property in terms or mean probability of failure and mean probability of damage to component elements and its associated non-dimensional costs. For indirect physical impacts, the analysis provides metrics relevant to mortgage serviceability (Technical Insurance Premium / Value at Risk) and relative property value changes. Supply chain and critical infrastructure failure risks have not been included in this report.
Metrics and outputs	Where relevant, accounting items should be disclosed in line with existing financial reporting accounting standards adopted by the discloser. These may include: • Values of investments in physical infrastructure and/or other real estate • Overall % of value of investments subject to material physical risk • Impact on probability of default • Impact on loss given default	A wide range of financial orientated metrics have been applied consistent with CMSI guidance including: • Percentages of properties at high, moderate and low risk • Comparison of exposed properties to a national baseline • Annual per property Value-at-Risk for the property owner expressed using the mean Technical Insurance Premium as a fraction of property replacement cost. If combined with data on LVR and the extent of the borrowers mortgage obligations compared to income, these metrics can provide an indication of the mortgages at risk of default or negative equity.
Adaptation measures	Disclosures should include a static scenario which assumes that the existing portfolio of assets or liabilities potentially exposed to climate risk remains static over time, with no changes in the vulnerability of the assets or liabilities due to adaptation or resilience measures.	This study assumes that the existing portfolio of assets or liabilities potentially exposed to climate risk remains static over time. Adaptation strategies have not been analysed in this report and are recommended for analysis in future work.
Strategy, policy and advocacy	Disclosures should include company specific strategies to address climate-related risks and opportunities and test their resilience under the scenarios—for example adaptation strategies to improve the resilience of buildings and infrastructure within the company's portfolio	The report recommends a wide range of measures toward reducing physical climate change risks in the portfolio which include strategies for the bank, new and existing customers, the property sector and the ways in which all levels of government could improve property resilience.

References

Scenario analysis of climate-related physical risk for buildings and infrastructure: financial disclosure guidance. Technical report developed by the Climate Measurement Standards Initiative. Climate-KIC Australia (CMSI 2020)

COASTAL INUNDATION - DATA & ASSUMPTIONS

OVERVIEW

Flooding caused by sea-water is referred to as Coastal Inundation. It can be caused by high tides in combination with elevated water levels driven by winds, low air pressure, waves and the dynamics at the sea-land interface. Over the course of the century, climate change is projected to result in elevated sea levels, which will increase the frequency and severity of coastal inundation events.

ASSET DATA

The vulnerability of an asset to coastal inundation is based on the elements present at the property, the relative elevations of each exposed element and the behaviour of the materials used in that element when exposed to water. Most critical is the elevation of the Civil element (e.g. floor heights), as empirical data shows a sharp increase in loss once water breaches the normal floor level. Climate Valuation can adjust elevations for individual assets (to override that of the archetype), or for sensitivity testing and adaptation planning.

CONTEXTUAL DATA

Coastal inundation levels are referenced relative to the national height datum taken from a range of international digital elevation models. In more populated areas, where airborne light detection and ranging (LIDAR) surveys have been conducted, these models typically have a 5X5 m horizontal resolution, and a height resolution of a few centimetres. In less populated areas, where the source of geospatial data is commonly satellite imagery, the resolution may be 30x30m, with uncertainty of at least 0.5 m.

BASELINE HAZARD DATA

Seal level data is based on an array of national tidal gauges located around the world. These tide gauges provide a spectral probability distribution of tide levels, including during extreme sea events, based on empirical measurements.

CLIMATE CHANGE PROJECTIONS

Currently the average global sea level is rising by 3.2 mm per year (NASA, 2017). The IPCC has established a series of sea level rise projections for different emissions pathways (Church et al 2013) for the scenarios known as RCP 8.5, RCP 6.0, RCP 4.5 and RCP 2.6. These provide the Climate Risk Engines with a nominal 'likely' range of 0.28 m to 0.98 m of sea level rise by 2100 (including 95% confidence bounds). The system includes two projections from a United States National Oceanic and Atmospheric Administration (NOAA) report (Sweet et al 2017) outlining (less likely but still possible) 'High' (2 m) and 'Extreme' (2.5 m) 2100 average global sea level rise scenarios. Climate Valuation's analysis also includes an intermediate projection (Haigh et al 2014) and a 1.1 m by 2100 projection to match the Australian Government's research into coastal impacts (Department of Environment 2009).

FOREST FIRE - DATA & ASSUMPTIONS

OVERVIEW

Forest fires can destroy buildings and infrastructure through direct flame or intense radiant heat. Assets considered to be at risk are those under or surrounded by trees, or close enough to trees to be affected by intense thermal radiation should the forest catch on fire. Grass fires are also a potential risk but are not covered by Climate Valuation's analysis

ASSET DATA

The exposure of the elements of an asset (e.g. roof, walls, floor) to a forest-fire are defined within each asset archetype.

CONTEXTUAL DATA

Context layers used for the forest fire hazard are as follows:

- Global Land Analysis and Discovery's per pixel estimates of circa 2010 maximum tree canopy cover percentages (at growing season peak period), derived from cloud-free annual growing season composite Landsat 7 ETM+ data
- An economic activity intensity layer, used to moderate fire weather projections based on the assumption that more urbanised areas face lower overall fire risks as they have better fire prevention and suppression capabilities.
- An empirical ignition probability model, which is based on analysis of insurance loss data.

BASELINE HAZARD DATA

The driving parameters of forest fire are temperature, humidity, wind speeds and forest-fire prone land. The Hot-Dry-Windy index (HDW) is a new index of fire-weather based on maximum wind speed and vapour pressure deficit (VPD, the difference between the absolute humidity and the water vapour saturation point for a given temperature).

The forest fire hazard layers in the Climate Risk Engines use forest canopy cover from satellite data in conjunction with algorithms to account for proximity and surroundedness for a specific location. The baseline annual probability of ignition draws upon empirical data on annual average forest fire extents, as well as on typical natural and human caused ignition rates.

CLIMATE CHANGE PROJECTIONS

Gridded projections for future epochs, based on GCM/RCMs from CORDEX are used to project the changes to the key inputs for the HDW index.

RIVERINE FLOODING - DATA & ASSUMPTIONS

OVERVIEW

Climate Valuation computes fluvial flooding - also known as riverine flooding as opposed to sea water or surface level flooding.

ASSET DATA

The vulnerability of an asset to flooding is based on the elements present in each archetype, the relative elevations of each exposed element, and the assumed behaviour of the materials used in that element when exposed to water. Most critical is the elevation of the Civil element (e.g. floor heights), as empirical data shows a sharp increase in loss once water breaches the normal flood level (Bundaberg Regional Council 2014). Climate Valuation can adjust elevations for individual assets (to override that of the archetype), or for sensitivity testing and adaptation planning.

CONTEXTUAL DATA

Flood maps used in the Climate Risk Engine analysis contain water depths and flood extents for each of a number of flood events characterised by Return Periods (RPs - such as 1 in 100, 1 in 20 and 1 in 50). The Climate Risk Engines use flood data from multiple sources, including various commercial providers, as well as regionally specific flood data. In general these datasets contain information on water depths for 4-8 different RPs. The Climate Risk engines interpolate between these layers to estimate the return probability for a flood that would breach the asset floor height (and in some cases specific element heights). This return period is then used as a threshold for the climate projection risk estimates.

BASELINE HAZARD DATA

To consider changes to the probability of flooding due to climate change, projected changes to precipitation must be examined. For historical data, annual maximum 24-hour precipitation weather station data for the 30 years pre-2000 is used. Only data sets with at least 20 years of data are considered to have sufficient statistical depth. Regionalisation, which is the process of combining distant data sets to create longer time series for a given location, is not applied.

CLIMATE CHANGE PROJECTIONS

Climate change impacts on precipitation and flooding are computed through the locally downscaled modelling of future precipitation changes (using CORDEX GCMs/RCMs). A commonly used approximation for calculating increased flood risk is the application of a 5% increase in precipitation intensity for each degree rise in global mean temperature (Ball et al 2016). This factor can be applied to modelled or measured Intensity-Frequency (IF) curves for any given location.

SOIL SUBSIDENCE - DATA & ASSUMPTIONS

OVERVIEW

Low soil moisture within reactive clay soils is a trigger for major soil movement and cracking, as the process of lower level suction leads to clay soils drawing moisture away from the surface soils during drought. Shrinking and subsequent swelling can lead to extensive asset damage if the asset's foundations move. Buildings on light strip footings or unstiffened slabs are particularly vulnerable to soil movement.

ASSET DATA

The vulnerability of assets to severe soil movement is associated with the design of foundations, and less so with the type of materials used. Foundations can be designed to cope with soil movements and such designs are captured at the archetype level. For foundations vulnerable to soil movement, an empirical probability of damage is assigned to the civil elements.

CONTEXTUAL DATA

Assets are initially checked to test for the types of soils upon which they are located, and thereby the level of exposure to soil movement. Climate Valuation's analysis uses soil clay percentage (at 30 cm depth) data, derived from the International Soil Reference and Information Centre's Soil Grids global digital soil mapping system.

BASELINE HAZARD DATA

For the soil movement due to drought hazard, Climate Valuation assumes 'drought' to equate to 'serious rainfall deficiency', defined as the circumstance in which annual total rainfall is in the lowest decile (that is lowest 10%) of records for the local region (Bureau of Meteorology 2012). The probability of droughts occurring at an asset's location is based on interrogation of data from the nearest historical weather stations and rain gauges. The annual precipitation data is extracted, and the rainfall consistent with the lowest 10% of annual precipitation is analysed. This provides a base probability for drought conditions that may lead to soil movement.

CLIMATE CHANGE PROJECTIONS

Soil movement in reactive soil types is correlated with the amount of moisture within the soil. Most changes in soil moisture content are caused by seasonal climate variations and precipitation volumes. Downscaled data for 'drought' is drawn from the GCMs and RCMs. Generally, Climate Valuation selects the drier GCMs/RCMs which also have the highest spatial resolution.

EXTREME WIND - DATA & ASSUMPTIONS

OVERVIEW

Air travelling at high speeds, even in short gusts, can cause direct damage to buildings and infrastructure assets. High winds can also cause indirect disruption when trees drop limbs onto power lines or debris puts life and property at risk. General increases in the amount of moisture in the air caused by warming can change convective forces in storms and the severity of down draughts.

Climate Valuation does not currently analyse risks associated with cyclones and convective storms, due to:

- unavailability of the very high-resolution modelling outputs required
- difficulty in making clear statements about changes in cyclone frequency, duration or intensity, as for a individual given location a cyclone is actually quite a rare event.

ASSET DATA

The wind speed design threshold for each asset is assumed to follow national building code for the year of build or re-build. Increased design resilience may be applied for dwellings that have been built beyond code requirements to specific wind speed thresholds or return frequencies. Reduced resilience may be applied based on empirical wind performance data.

CONTEXTUAL DATA

No context data layers are used for the extreme wind hazard

BASELINE HAZARD DATA

Bias correction for wind damage is disabled by default, as wind data is only very sparsely available at the required record length and quality. This does not however pose a problem, as the Climate Risk Engines use asset-level probabilistic wind tolerance thresholds (such as 1:500 year), and calculates the physical wind speed threshold from this probabilistic threshold over the baseline period. This means that a bias in the wind data will not affect the results, as we are only looking at the trend in risk relative to the baseline, and the wind tolerance design threshold as specified by the relevant building code.

CLIMATE CHANGE PROJECTIONS

Climate projections are used to establish baseline wind gust speed for threshold return frequencies and then used to project how this speed changes over time. The main climate variable used is the 2-10 second wind gust speed or the 1-5 minute maximum wind speed, depending on how the relevant projection was produced.

THANK YOU

For any further enquiries, please contact your dedicated Climate Valuation Account Manager.

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