Overview paper - Do No Significant Harm (Appendix A) of the EU Taxonomy

December 2023

ENERGY EFFICIENT MORTGAGES
Netherlands

EEM NL Hub
Working group 1 – DNSH

On the (theoretical) interpretation & application of DNSH (Appendix A)
in respect of Dutch residential real estate.

Version	V1.00
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The EEM NL Hub is an association set up with the aim of supporting and promoting the acceleration and adaptation of energy efficient housing in the Netherlands and the financing thereof. The EEM NL Hub therefore has no formal capacity when it comes to interpreting (EU or other) legislation. The interpretation of the EU Taxonomy as presented in this document is only that: an interpretation, specific to the Dutch residential real estate market.

EEM NL Hub as collected feedback during working group sessions. This document is therefore a summary as composed by the EEM NL Hub but is not necessarily the official position of any of the individual institutions participating in the Energy Efficient Mortgages NL Hub.

Great care has gone into compiling this document. However, it could contain mistakes. We welcome any observations and recommendations for improvement. Please feel free to submit them to the Energy Efficient Mortgages NL Hub at: info@eemnl.com.

Contents

Executive Summary

In this document we describe the analysis of the Do No Significant Harm (DNSH) criteria of Appendix A of the Climate Delegated Act for the EU Taxonomy environmental objective: Climate Change Mitigation.

As part of the EU Taxonomy alignment calculation practitioners must adhere to the DNSH criteria by investigating the (potential) impact of physical climate hazards and risks. The EU Taxonomy prescribes performing a Climate Risk and Vulnerability Assessment (CRVA) for the identified risks. We look into the (theoretical) interpretation and application in the context of economic activity 7.7 "Acquisition and ownership of buildings".

This subject is closely related to the field of climate risk analysis. Therefore, in this document, we will provide a general introduction on the conduct of climate risk analysis from a real estate perspective.

The goal of this document is to make the reader familiar with:

- The Do No Significant Harm (DNSH) wording of the EU Taxonomy.
- The conduct of climate risk analysis towards real estate.
- Best practices and (regulatory and supervisory) guidance on this topic.
- The (linguistic) interpretation and analysis of the DNSH wording in the context of activity 7.7.
- The potential (data) (re)sources to apply to the Netherlands.
- Introduce methods and best practices to perform a CRVA for buildings.

Figure 1: Summary of Appendix A of the CDA - Annex I and its assessment (steps).

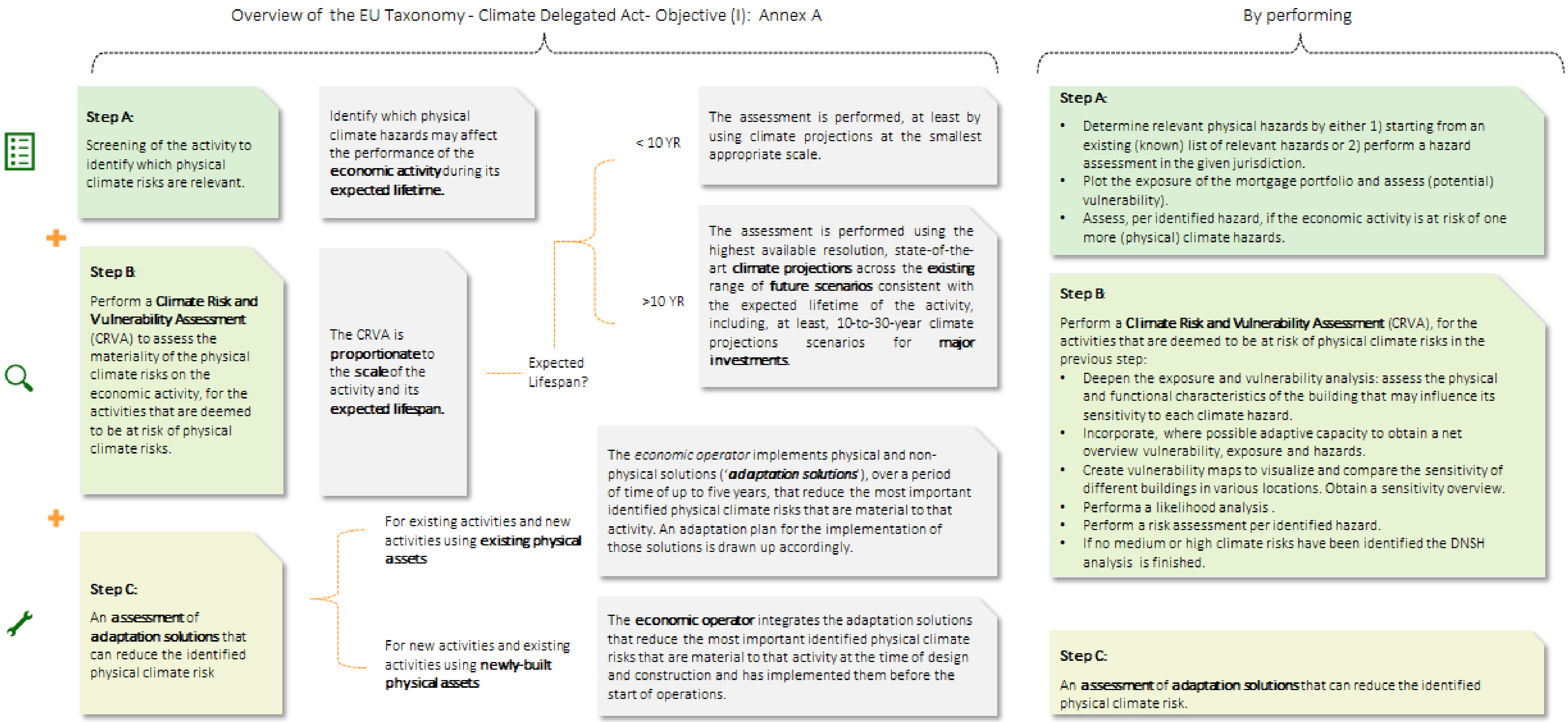
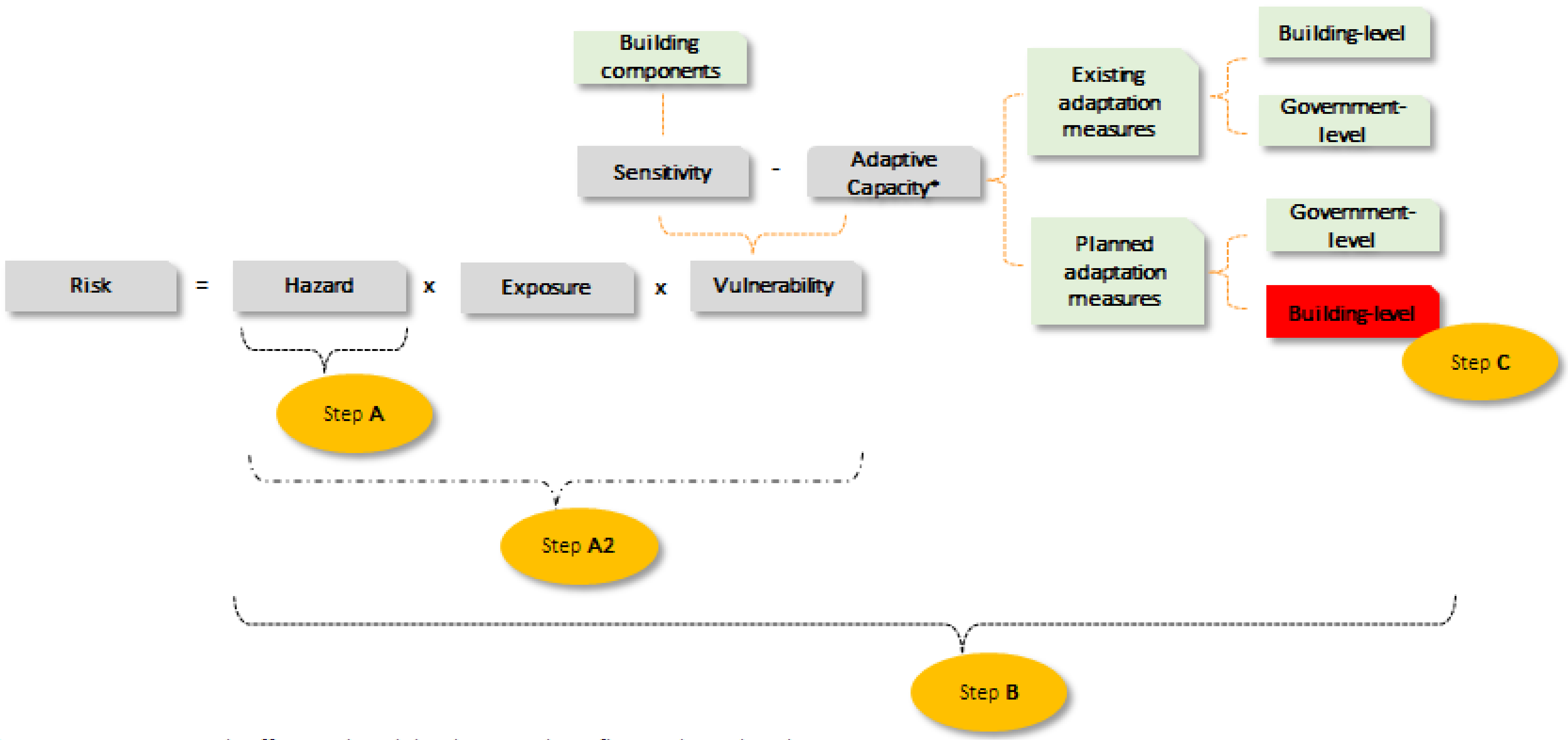
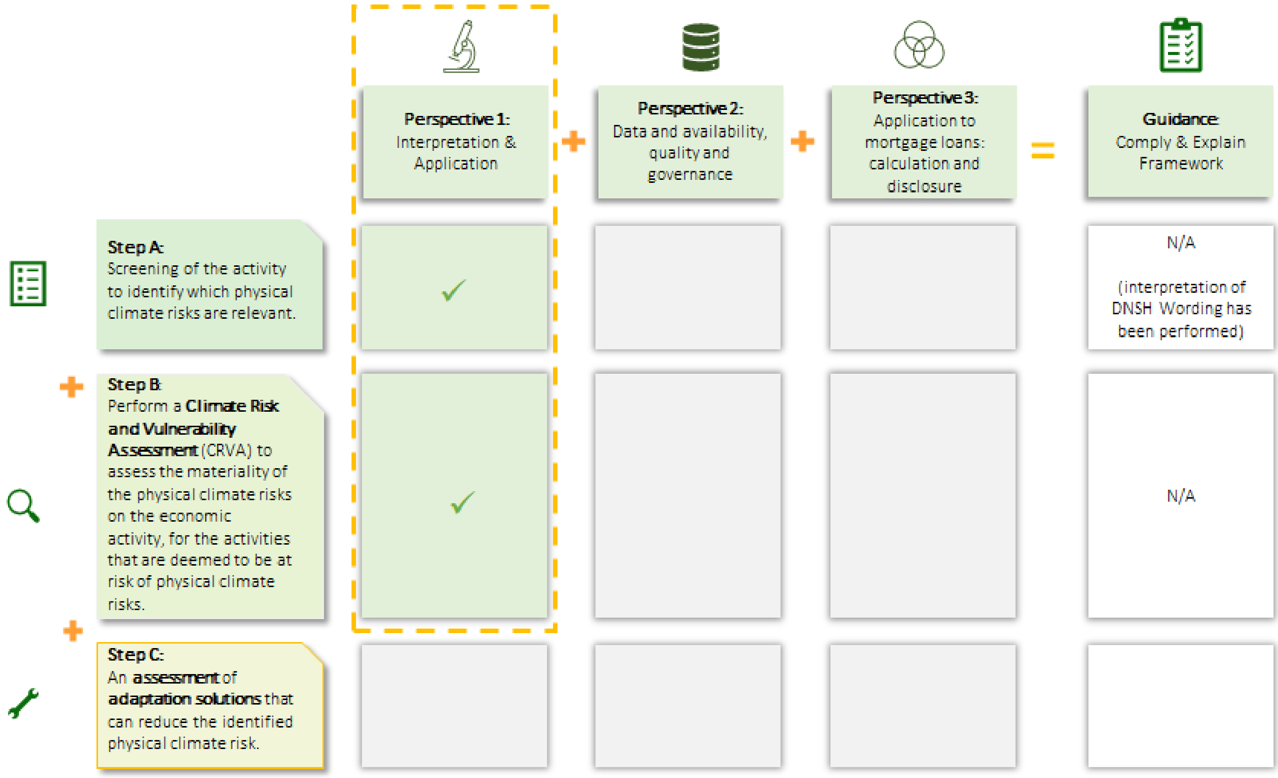


Figure 2: Appendix A of the CDA - Annex I - Converted into a conceptual risk representation.



* Adaptive capacity not only affects vulnerability but can also influence hazard and exposure

Figure 3: Scope of this document depicted with on the horizontal axis: the EEM NL Hub three-stage approach for analysis and on the Vertical Axis the core components of Appendix A: the DNSH Criteria. The orange line indicates the scope of this document.



1 Introduction

1.1 The concept of Do No Significant Harm

The EU Taxonomy regulation has introduced a set of Technical Screening Criteria (TSC) for determining whether an economic activity is environmentally sustainable. An economic activity must (1) contribute substantially (hence the definition Substantial Contribution Criteria or SCC for these TSC) to one or more of the below objectives; and crucially, (2) it must do no significant harm (DNSH) to any of the other objectives; and in addition, (3) it must fulfil minimum safeguards as described in Article 18 of the EU Taxonomy[1].

The CDA describes the TSC that an economic activity is required to meet both in terms of substantial contribution and in terms of not doing significant harm, in order to be classified as Taxonomy Aligned. The TSC are formulated around the substantial *contribution* and *harm* of the economic activity to one of six environmental objectives:

1. Climate change mitigation
2. Climate change adaptation
3. Sustainable use and protection of water and marine resources
4. Transition to a circular economy
5. Pollution prevention and control
6. Protection and restoration of biodiversity and ecosystems

The DNSH principle serves as a guardrail to ensure that while promoting one environmental objective, an economic activity does not adversely impact, from an environmental perspective, the other objectives. This approach ensures a holistic perspective on sustainability, discouraging siloed improvements at the expense of broader environmental degradation. The DNSH principle pushes to adopt a comprehensive view of environmental sustainability. It encourages the prevention of harmful trade-offs and promotes balanced progress across all environmental objectives.

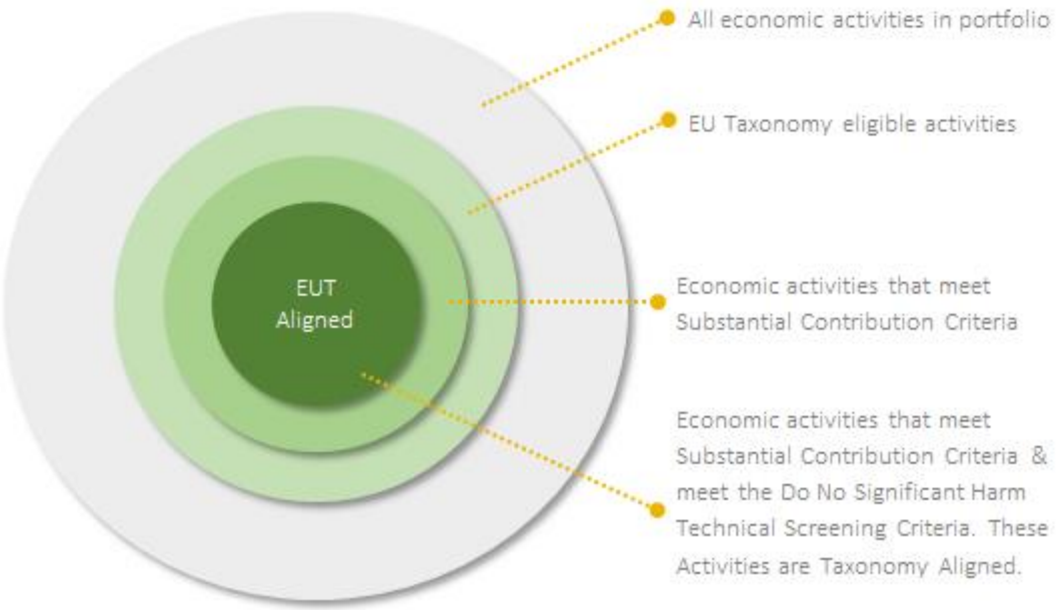
Most of the EU Taxonomy analyses, including our own, on the interpretation and application towards real estate financing has been centred around the Substantial Contribution Criteria (SCC) which are often 'checked' on a loan and collateral level. However, in the remainder of this document we will analyse the application of the TSC in respect of DNSH for (individual or a portfolio of) residential mortgage loans.

When applying the TSC of the environmental objective Climate Change Mitigation (CCM), it is a requirement to a) check which DNSH criteria are prescribed for the economic activity at hand and b) ensure that the criteria of the applicable DNSH provision are met.

Figure *4* contains a visual representation of a Taxonomy Alignment analysis in terms of the Technical Screening Criteria (this without the Minimum Safeguards). Note that it is possible that an economic activity is aligned with a substantial contribution criterium but not with a DNSH criterium (or vice versa, in theory). In this case the economic activity would **NOT** be EU Taxonomy aligned. It is therefore not sufficient to just determine if an economic activity meets the SCC, but it is crucial to also perform the DNSH analysis to determine if a financial exposure can be designated as Taxonomy Aligned.

[1] Note that there are no Technical Screening Criteria for minimum safeguards.

Figure 4: Synthesising concepts of EU Taxonomy alignment of TSC from a portfolio perspective.



Although the DNSH principle is a necessary step in determining EU Taxonomy alignment and disclosure thereof, it can also serve as a basis to gain more insight into residential mortgage loans and real estate from a different perspective: a climate vulnerability perspective.

These insights could stimulate innovation (in the medium to long run), as companies that for instance provide real estate services, can offer new technologies and solutions that can meet the EU Taxonomy's stringent criteria. It may also lead to greater investment transparency, as the EU Taxonomy provides a framework for identifying sustainable investments that are not only energy efficient on a building (unit) level but also resilient towards impacts of climate change. In addition, the tools and analytical concepts are similar to the assessments that need to be made for CRR Pilar 3 ESG disclosures.

1.2 Economic Activity Scope

This document describes the concept of Do No Significant Harm and its application to Dutch (residential) real estate and residential mortgage loans. Given the complexities involved in analysing the DNSH TSC and the fact that some of these are still evolving, for now, our analysis of the DNSH TSC has been limited to the following elements:

1. Section 7.7 Acquisition and Ownership of Buildings of the Climate Delegated Act – Annex I.
    i. Appendix A: Generic criteria for DNSH to Climate Change Adaptation.
2. The guidance published in the Q&A[2].

Note that the wording of Appendix A can also be found in the Environmental Delegated Act Technical Screening Criteria that have been published for the four other environmental objectives[3]. It is important to assess the DNSH TSC relative to the economic activity. When reading Section 7 of the CDA, the reader will find that the document it is divided into sub-sections that describe individual economic activities and specific Technical Screening Criteria. For the DNSH TSC often a reference is included to generic DNSH TSC that are described in the Annexes of the Climate Delegated Act.

However, in some cases additional criteria, clarifications or exemptions are described per economic activity. Therefore, it is important to assess the **generic criteria** (from the perspective of the applicable economic activity) and check if there

[2] Draft Commission notice on interpretation and implementation of certain legal provisions of the EU Taxonomy Climate Delegated Act
[3] https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/13237-Sustainable-investment-EU-environmental-taxonomy_en

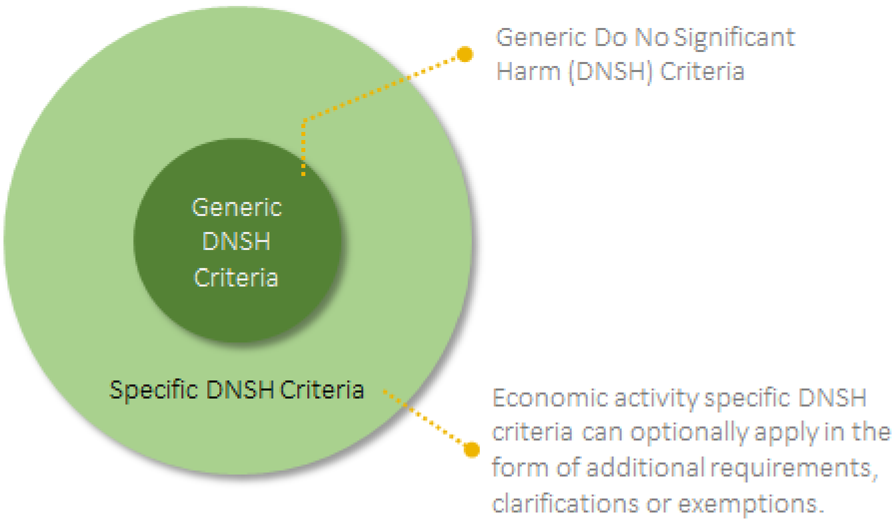
are additional (**activity specific**) DNSH considerations. Figure 5 depicts the relationship between generic and activity specific criteria. The latter can be regarded as an add-on detailing specific requirements.

Table 1 indicates on the vertical axis the economic activities described in Section 7 of the CDA, complemented with the applicable DNSH TSC (corresponding to the 5 'other' environmental objectives) on the horizontal axis. As can be seen from Table 1, the DNSH TSC for Climate Change Adaptation is applicable to all economic activities of Section 7.

Table 1 provides a summary overview of the applicable DNSH TSC applicable to the Climate Change Mitigation objective for the different economic activities described in Section 7 of the CDA. Note that for some environmental objectives only one DNSH TSC is applicable whereas for other economic activities multiple DNSH TSC are applicable.

As we will discuss in Section 6, the scope and exposure of the DNSH analysis can be severely impacted by the exposure or details of the economic activity. For instance, the DNSH analysis should be proportionate to the economic activity that is being financed: one can imagine that the financing of the activity 'acquisition and installation of solar panels' is different from that of 'acquisition of a building'.

Figure 5: Generic and Specific DNSH TSC



<u>Not in scope of this document</u>

In this document we only cover the DNSH TSC for the economic activity 7.7 'Acquisition and ownership of buildings' as described in the CDA – Annex I.

As confirmed in the Q&A, the financing of new constructions can be considered either from the perspective of Section 7.1 or Section 7.7 of the CDA. For residential mortgage lending, under DEEMF the proposed interpretation is that properties under construction are classified under Section 7.7 and therefore the DNSH TSC applicable to Section 7.7 are applied and not the DNSH TSC of Section 7.1.

Calculating or checking Taxonomy Alignment is not a one-time process but involves regular assessments and adjustments as criteria and activities evolve. It requires in-depth knowledge of the EU Taxonomy, access to relevant data and dedicated resources to ensure consistent and continuous analysis of alignment.

It is possible that a residential (mortgage) loan is aligned with multiple Substantial Contribution Criteria. For instance, in the case where part of the financing is used for solar panels (which can meet the SCC of Section 7.6) and part of the financing is used for insulation (which can meet the SCC of Section 7.3). In these cases, in theory there are DNSH TSC for both economic activities. In this document we do not analyse these cases, as it is uncertain if the DNSH TSC should be assessed individually or considering the conjoint economic activities[4].

[4] The published Q&A has not addressed these use cases. The EEM NL Hub intends to ask for guidance from the Commission on these use cases.

Table 1: An overview of the DNSH TSC applicable to Section 7 of Climate Delegated Act – Annex I.

Economic Activity vs DNSH Screening Criteria	(2) Climate change adaptation	(3) Sustainable use and protection of water and marine resources	(4) Transition to a circular economy	(5) Pollution prevention and control	(6) Protection and restoration of biodiversity and ecosystems
7.1 Construction of new buildings	The activity complies with the criteria set out in Appendix A to this Annex.	The activity complies with the criteria set out in Appendix E to this Annex. Additional criteria for water appliances. To avoid impact from the construction site, the activity complies with the criteria set out in Appendix B to this Annex.	At least 70 % (by weight) of the non-hazardous construction and demolition waste generated on the construction site is prepared for reuse, recycling and other material recovery. Compliance with EU Construction and Demolition Waste Management Protocol. Building designs and construction techniques support circularity --> ISO 20887:2020, Sustainability in buildings and civil engineering works.	Building components and materials used in the construction comply with Appendix C: Generic criteria for DNSH pollution prevention. A set of Building components and material emission standards in line with (EC) No 1907/2006.	The activity complies with the criteria set out in Appendix D to this Annex. The new construction is not built on one of the following: (a) arable land and crop land with a moderate to high level of soil fertility (b) The land is not on the IUCN European Red List of Threatened Species (c) land matching the definition of forest as set out in national law used in the national greenhouse gas inventory.
7.2 Renovation of existing buildings		Idem 7.1	Idem 7.1	Idem 7.1	N/A
7.3 Installation, maintenance and repair of energy efficiency equipment		N/A	N/A	Building components and materials used in the construction comply with Appendix C: Generic criteria for DNSH pollution prevention.	N/A
7.4 Installation, maintenance and repair of charging stations for electric vehicles in buildings (and parking spaces attached to buildings)		N/A	N/A	N/A	N/A
7.5 Installation, maintenance and repair of instruments and devices for measuring, regulation and controlling energy performance of buildings		N/A	N/A	N/A	N/A
7.6 Installation, maintenance and repair of renewable energy technologies		N/A	N/A	N/A	N/A
7.7 Acquisition and ownership of buildings		N/A	N/A	N/A	N/A

1.3 Assumptions

When we refer to 'DNSH' in this document we refer to the criteria of Appendix A of the Climate Delegated Act – Annex I, in the context of the economic activity: '7.7 Acquisition and Ownership of Buildings'. In the analysis presented in this document we often use terms that are explained in more detail in DEEMF Part I and Part II, V1.0. For instance, when referring to the interpretation applicable to the Substantial Contribution Criteria and certain definition of, for instance, the NTA 8800 energy performance methodology in the Netherlands.

1.4 Approach

Analysing the DNSH TSC, more specifically Appendix A, entails, for a large part, analysing residential mortgage loans and the underlying collateral in terms of its potential exposure to physical climate risks. Appendix A of the CDA prescribes the provisions of the DNSH criterium. An important component of this analysis, as we will see in Sections 6 and 8 is concerned with performing a Climate Risk and Vulnerability Assessment (CRVA).

This subject is very much related to the field of climate risk analysis. Therefore, in this document, we will provide a general introduction on the conduct of climate risk analysis from a real estate perspective, to get the reader familiar with the basic knowledge of climate risk and key definitions.

For many professionals in the financial services and mortgage lending industries, climate risk analysis can be overwhelming at first. Most mortgage professionals have in-depth knowledge of financial products and their features. However, analysing buildings from a climate perspective and reviewing potential adaptation solutions that tie into for instance constructional features of a building, can be a novel perspective for some.

Before getting into the depths of the DNSH interpretation we therefore take the time to analyse some core principles, the background and best practices of climate risk analysis from several perspectives. Often, relatively larger financial institutions have developed in-house capabilities to analyse climate risk for their portfolio(s). As some financial institutions have been asked to participate in climate risk stress-tests by the ECB, they provide specific impact disclosure and model transition risks.

This document aims to primarily introduce the concept of climate risk, analyse the DNSH TSC and take stock of how these criteria could be applied to Dutch residential real estate. This version of DEEMF will not detail an all-encompassing deterministic approach on how to apply the DNSH TSC. This document will not delve into every intricate detail of such climate risk assessment. Instead, it will seek to provide a foundational understanding of the primary building blocks that constitute these assessments. To this end we have identified best practices and building blocks that can be applied by relevant stakeholders. The goal of the document is to make the reader familiar with:

1. The conduct of climate risk analysis.
2. The Do No Significant Harm (DNSH) wording of the EU Taxonomy.
3. Best practices and (regulatory and supervisory) guidance.
4. The (linguistic) interpretation and analysis of the DNSH wording in the context of residential mortgages.
5. The potential (data) (re)sources to apply to the Netherland.
6. Introduce methods and best practices to perform a CRVA.

By untangling these complex concepts into comprehensible segments, we aim to foster a nuanced understanding of how climate change can impact residential real estate, what the importance of accurate vulnerability and risk assessments is and how they can be effectively used to mitigate these impacts in the future.

More importantly, we aim to provide building blocks on how the DNSH analysis for appendix A can be approached pragmatically by market practitioners.

In the EEM NL Hub working group we concluded to focus on Appendix A for Section 7.7 first. To help steer this interpretation and application analysis we have created a schematic approach. For the analysis of the interpretation and application of substantial contribution criteria we have followed the approach depicted in Figure *6*.

Figure 6: The three-stage approach for practical use of the EU Taxonomy

We use a similar approach for the analysis of the DNSH TSC. The main difference is that we must introduce the concept of the climate risk modelling and its corresponding toolbox as an additional layer to these three perspectives.

Table 2 highlights the key perspectives and the questions we investigate in this document. In the row 'in the context of DNSH analysis' we detail the different perspectives with examples and relevant questions.

Table 2: The three-stage approach applied to DNSH

	Perspective 1	Perspective 2[5]	Perspective 3
In general	- Do we understand the wording of the EU Taxonomy? - Do we understand how we can apply this?	- Do we have clear data requirements? - Is the data to perform this analysis available? - Are there any data quality or handling considerations?	- Do we understand how to apply this analysis to a single mortgage loan or a portfolio of mortgage loans? - Do we understand how to infer conclusions – i.e. Taxonomy Alignment.
In the context of DNSH analysis	- Do we understand the wording of Appendix A? - Are there any (existing) best practices that are reminiscent of the analysis described? - Do we have best practices or existing guidance that are useful to apply? - Do we know which (physical) climate hazards	- Do we understand the data requirements (in theory)? - Do we understand which data is needed to identify climate risks? - Do we have a comprehensive overview of the necessary data requirements? - In quantitative (climate) risk and hazard assessment: do	- Do we know how to *link*, *join*, *merge* or *concatenate* climate risk data (sources) to mortgage portfolio data in practice? - With which frequency should the analysis be applied and or updated? - Is it clear how inference should be drawn after the

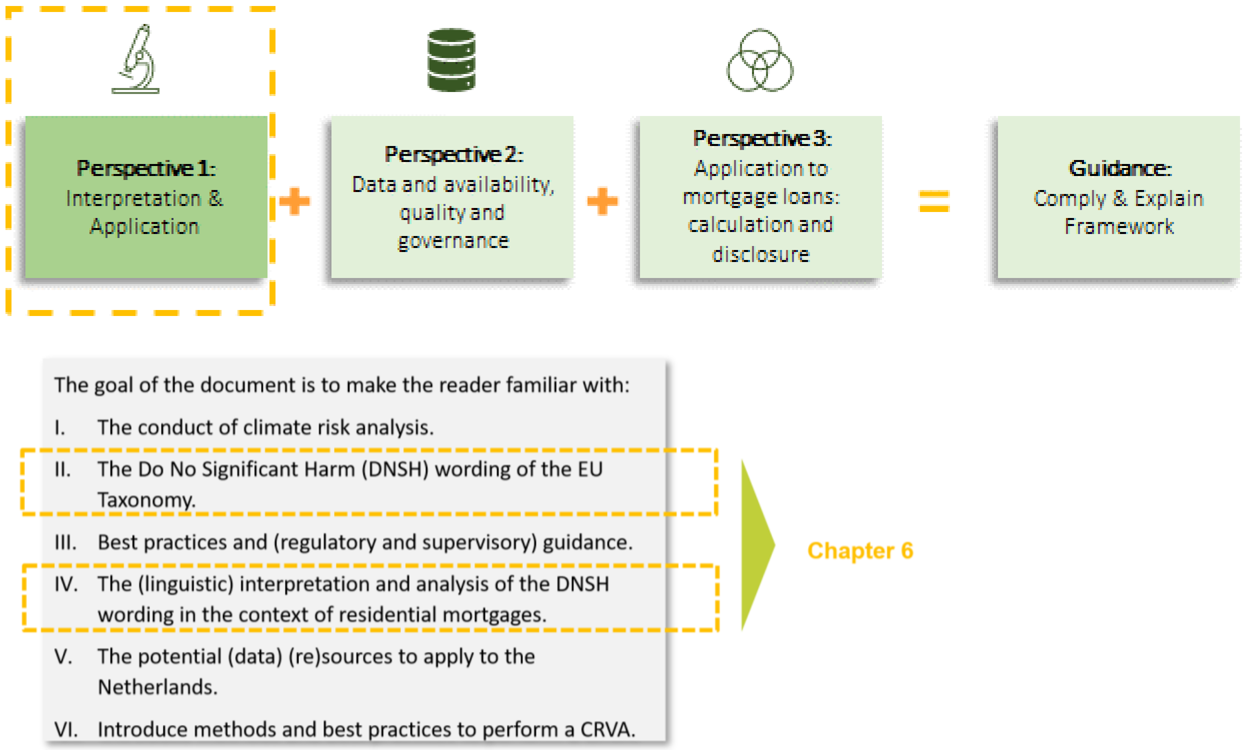
[5] General Data Protection Regulation (GDPR) considerations are not part of the scope of Perspective 2. Although extremely relevant and in our opinion an often-neglected issue, the EEM NL Hub is working on a separate document detailing GDPR considerations.

	or risks are relevant for the Netherlands? - Which hazards or climate risks are particularly relevant for (residential) real estate? - What are adaptation solutions and how can these be potentially employed in Dutch residential real estate? - How does adaptive capacity influence physical climate risk?	we know how to identify low, medium or high risk? - With different types of data (e.g. mortgage data vis-a-vis satellite imagery geospatial data), which data tools are needed to process this data? - Do we have a clear understanding of what data we are missing? - Is data documentation available?	CRVA assessment and what the consequences are in respect of the green asset ratio calculation?

In Figure 7 we have depicted the analytical scope of this document combined with the objectives of this analysis. Note that in this document, we only look at (parts of) perspective 1. Perspective 2 and 3 are needed for (actual) application (assessment) but are not within the scope of this document. This document provides an overview (item I, III, V and VI) of climate analysis, as depicted in the figure below. We look partially into the interpretation in perspective 1 (item II and IV). This version of the document is therefore theoretical in nature and does not provide guidance for the (full) pragmatic application of DNSH assessment.

In a subsequent document we aim to analyse and address perspectives 2 and 3, i.e. the pragmatic side, of Appendix A.

Figure 7: The analytical scope of this document based on the 3 perspectives.



2 Climate risk & Mortgage loans

2.1 Why climate risks are relevant for residential mortgage loans

As global temperatures increase, extreme weather events like heavy rainfall, storms and sea-level rise pose a significant threat to Dutch properties. In recent years, the Netherlands has experienced occurrences of extreme weather events that have been linked to climate change. In 2018, the Netherlands experienced a severe drought. The drought caused water levels in rivers and lakes to drop and led to water shortages for farmers and businesses. In 2021, the Netherlands experienced a series of heavy rains that caused widespread flooding. The flooding damaged properties and businesses and it forced people to evacuate their properties.

Recent research from the Royal Netherlands Meteorological Institute (KNMI) has highlighted that the risks of climate change for the Netherlands have increased more than previously anticipated. The Netherlands is located at the North Sea coast and the country is already experiencing sea level rise at an accelerated rate due to climate change. This is leading to an increased risk of flooding, which could damage or destroy residential properties.

These climate risks can have a significant impact on the Dutch residential real estate. Climate risk analysis involves assessing the potential impacts of climate change on various sectors, including real estate. By using the tools of data analytics, geographical mapping and climate projections, practitioners can evaluate the vulnerability of properties to climate-related hazards such as flooding, storm surges and rising sea levels. This analysis enables mortgage lenders to make more informed decisions to manage both climate and transition risks.

Traditionally, mortgage lending relied on metrics such as property valuation and borrower creditworthiness. However, as climate risks intensify, these conventional perspectives may no longer suffice in the future. Climate risk analysis offers mortgage lenders a comprehensive understanding of a property's vulnerability, allowing them to integrate climate risks into lending decisions. This could mean adjusting loan terms, insurance requirements, regulatory capital calculations or product offerings. By incorporating climate risk analysis, mortgage lenders can assess potential impacts and ensure the long-term sustainability of their business and portfolio(s). As of recent the ESA[6]'s and ECB have expressed their strong advice to the European financial sector to gather climate (risk) related data at origination of (mortgage) loans[7].

Climate risk insights not only benefits mortgage lenders but also has the ability to empower homeowners with renewed insights. Through this process, homeowners could (in the future) gain access to information about the (climate) vulnerabilities that their properties face. Armed with this knowledge, they can make informed decisions about property maintenance, insurance coverage and necessary (physical) adaptation solutions to enhance resilience. This can be in the form of relatively quick wins, such as taking measures to mitigate overheating via window shutters or installing energy efficient windows. Additionally, climate risk analysis may incentivise homeowners and (local) governments to invest in mitigation measures, such as flood barriers, improved drainage systems or elevating properties, reducing their vulnerability and safeguarding their properties.

Addressing climate risks in the residential mortgage sector requires collaboration between various stakeholders. Mortgage lenders, borrowers, policymakers, the construction sector and researchers should ideally work together to develop (more) standardised methodologies, data sharing mechanisms and guidelines for integrating climate risk considerations in to (residential) real estate. Additionally, policymakers can play a crucial role by incentivising climate-resilient construction (components), promoting energy efficient housing practices and integrating climate risk considerations into land-use planning and (future) revisions of the building code.

[6] European Supervisory Authorities (ESA's): The European Banking Authority (EBA), The European Securities and Markets Authority (ESMA) and The European Insurance and Occupational Pensions Authority (EIOPA.

[7] Joint ESAs-ECB Statement on disclosure on climate change for structured finance products.

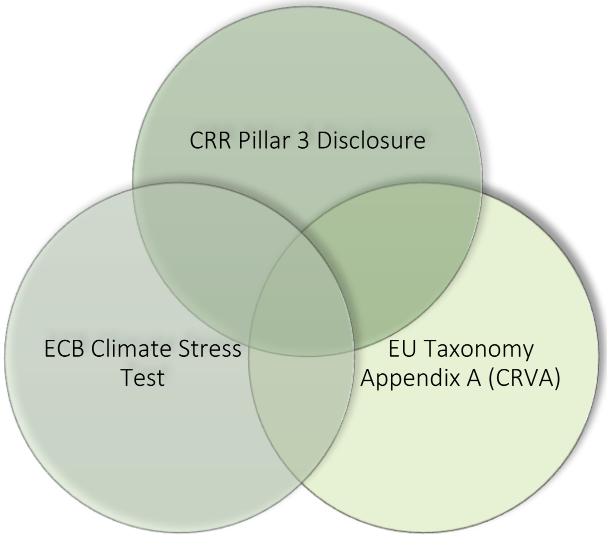
2.2 Climate risk and mortgage portfolio management

The Climate Risk and Vulnerability Assessment (CRVA) that has to be performed under the DNSH analysis (see Sections 6 and 8) has a degree of overlap with the analysis that has to be performed for 1) the ECB Climate Stress Test and 2) Capital Requirements Regulation (CRR) Pillar 3 Disclosure (see Figure 8 below).

Although there is no specific template or set format for CRVA compliance in existence, the climate risk assessment has overlap with for instance the ECB climate stress test. We want to highlight this overlap since the ECB is a supervisor, regulator and financial market authority and has expressed that EU Taxonomy alignment will become a fundamental part of their (monetary) framework in the future[8]. Over the past three years, the ECB has published several publications with guidance and best practices that they, as a supervisor expect financial institutions to adhere to when conducting climate analysis. In Section 5 we will take a closer look at some of these recommendations and guidance provided by the ECB.

The CRR places significant emphasis on disclosure requirements to enhance market discipline, protect investors and promote financial stability. Financial institutions subject to the CRR, including credit institutions and investment firms, are obliged to disclose a wide range of information. In addition, the Pillar 3 ESG Disclosure should be based on the definitions of the EU Taxonomy, thereby making the DNSH and CRVA an implicit part of its disclosure.

Figure 8: Mortgage climate risk in regulatory and supervisory frameworks.



One of the most significant common denominators across these three policies is the focus on transparency and disclosure. The CRR Pillar 3 disclosure provides a framework for banks to disclose information regarding their risk exposures, risk assessment processes and capital adequacy. Climate risk disclosures, although often implicit, play an increasingly important role in ensuring that financial institutions adequately assess and disclose the potential impact of climate-related risks on their operations, financial position and strategy. Institutions are expected to disclose information on their exposure to climate risks, including physical risks (such as extreme weather events) and transition risks (such as policy changes and market shifts due to climate-related factors). Similarly, the ECB Climate Stress Test measures the resilience of banks to climate-related risks, requiring them to disclose potential vulnerabilities.

The three policy areas encourage a proactive approach to managing climate-related risks (including for residential real estate). The CRR Pillar 3 disclosure promotes effective risk management by ensuring banks disclose and, therefore,

[8] https://www.ecb.europa.eu/press/pr/date/2021/html/ecb.pr210708_1~f104919225.en.html

thoroughly understand their risk exposures. Meanwhile, the ECB Climate Stress Test assesses the resilience of financial institutions to future climate-related risks, encouraging proactive measures. All three policy tools align with regulatory requirements to manage climate-related risks – in the broad sense. Although the CRR Pillar 3 Disclosure, ECB Climate Stress Test and EU Taxonomy disclosure each serve unique purposes and functions, they share key commonalities. They emphasise the importance of transparency and disclosure, proactive climate risk management, regulatory compliance and a forward-looking approach. These shared characteristics underscore the collective use case of looking into climate risks for residential mortgage loans.

ECB president Christine Lagarde in March 2023 has written the following comments[9] on the supervision of the BTAR and the GAR (see Box 1 for an explanation) for financial institutions:

- *"During the monetary policy strategy review that was concluded in 2021, the Governing Council of the ECB reflected on a broad range of possible instruments that could be used, within the ECB's mandate, to incorporate climate change considerations into the policy framework."*
- *"Among the many metrics provided by the Pillar 3 disclosures on ESG risks, the green asset ratio (GAR) and the banking book taxonomy alignment ratio (BTAR) will be particularly useful in providing aggregate measures of the progress banks make towards EU taxonomy alignment. However, reliance on such metrics will require a fine balance between the more focused scope of the GAR on exposure to large companies and the possible lower quality of data underpinning the BTAR, which are provided on a best-effort basis. That said, the ECB is actively following all climate-related regulatory initiatives and will continue assessing whether and how these might be useful for its monetary policy framework in the future."*
- *"As you well know, the ECB has already taken concrete measures, such as the tilting of our corporate bond holdings, the further incorporation of climate risk aspects into the collateral framework and the climate-related disclosure requirement for collateral, which will contribute to the greening of Eurosystem credit operations. The ECB's commitment within its mandate involves configuring its monetary policy instruments in a way that is most conducive to mitigating the impact of climate change."*
- *"We will continue to explore all viable options to green our monetary policy even further."*

Box 1: The Green Asset Ratio (GAR) & The Banking Book Taxonomy Alignment Ratio (BTAR).

The Green Asset Ratio (GAR) & The Banking Book Taxonomy Alignment Ratio (BTAR)

In the context of the EU Taxonomy, two key performance indicators (KPIs), the Green Asset Ratio (GAR) and the Banking Book Taxonomy Alignment Ratio (BTAR), serve as essential components of the Capital Requirements Regulation (CRR). These KPIs play an important role in assessing and reporting financial institutions' "green" exposures, which align with the EU Taxonomy[10].

The GAR is designed to provide transparency on the green exposures of different institutions. It includes loans and advances, debt securities and equity instruments that are not held for trading. BTAR, compared to GAR, includes a broader set of exposures such as those to EU non-financial corporations and non-EU non-financial corporations not subject to NFRD.

In terms of residential real estate, the GAR for retail exposures to residential real estate or house renovation loans is calculated as a proportion of loans to households collateralised by *residential immovable property* or granted for house renovation purposes that is Taxonomy Aligned.

[9] https://www.ecb.europa.eu/pub/pdf/scpops/ecb.op271~36775d43c8.en.pdf
[10] https://www.eba.europa.eu/implementing-technical-standards-its-prudential-disclosures-esg-risks-accordance-article-449a-crr

This alignment is in accordance with the technical screening criteria for buildings, namely renovation and acquisition and ownership. The GAR for this category only applies to investments relevant for Climate Change Mitigation.

Financial institutions are required to publish these ratios starting in 2024 for exposures up to year-end 2023 for GAR and up to June 2024 for BTAR. This requirement will foster transparency and comparability across institutions, thereby promoting the overall objective of the EU Taxonomy in driving investments towards environmentally sustainable activities.

Consequently, the application of GAR and BTAR in the context of residential real estate and the EU Taxonomy has significant implications for financial institutions. It helps them better understand and manage their green exposures, thereby aiding them in aligning their portfolios with EU sustainability goals and mitigating potential risks associated with climate change. This is particularly crucial for residential real estate given its substantial role in a bank's lending portfolio and its potential impact on climate change mitigation. Thus, understanding and implementing the DNSH TSC, BTAR and GAR can contribute to a more sustainable and resilient financial system.

2.3 Climate risk and the regulatory landscape

Table 3 highlights some key (European) regulations that contain references to 1) the EU Taxonomy (and thus the DNSH TSC) and 2) climate risk assessments. Please note that this is not an exhaustive list, but rather a selection of key regulations that are (potentially) relevant for financial institutions that grant or invest in residential mortgage loans.

Table 3: Key regulations

Regulation	Description	References to EU Taxonomy	Climate Risk references
Capital Requirements Regulation (CRR)	Climate risk is relevant for compliance with CRR Pillar 3 because it can have a significant impact on the financial soundness of credit institutions and investment firms. Pillar 3 disclosures set comparable quantitative disclosures on climate-change related transition and physical risks, including information on exposures towards carbon related assets and assets subject to chronic and acute climate change events. In addition, they include KPIs on institutions' assets financing activities that are environmentally sustainable according to the EU Taxonomy (GAR and BTAR), such as those consistent with the European Green Deal and the Paris agreement goals.	The CRR requires institutions to disclose information on their alignment with the EU Taxonomy, if applicable.	*Quantitative disclosures:* • GHG emissions: Institutions must disclose their total GHG emissions, as well as their emissions by sector and by activity. • KPIs and KRIs: Institutions must disclose the KPIs and KRIs they use to measure and manage climate-related risks. • Exposure to climate-related risks: Institutions must disclose their exposure to climate-related risks, including physical risks, transition risks and liability risks. *Qualitative disclosures:* • Governance arrangements: Institutions must disclose their governance arrangements for climate risk, including the roles and responsibilities of the board of directors and senior management.

			• Risk management processes: Institutions must disclose their risk management processes for climate risk, including how they identify, assess and mitigate climate-related risks. • Policies and procedures: Institutions must disclose their policies and procedures for climate risk, including how they manage climate-related risks in their lending, underwriting and investment activities
Sustainable Finance Disclosure Regulation (SFDR)	The SFDR is a regulation that requires financial market participants to disclose information on how they integrate sustainability risks and factors into their investment processes and products. The SFDR does not specifically mention climate risk, but it does require financial market participants to disclose information on how they manage environmental risks.	The SFDR requires financial market participants to disclose information on their alignment with the EU Taxonomy, if applicable.	The climate-related disclosures that are relevant for the SFDR are as follows: • Principal adverse impacts: Financial market participants must disclose how their investment decisions could have a negative impact on sustainability factors, such as climate change. • Alignment with the EU Taxonomy: Financial market participants must disclose whether their financial products are aligned with the EU Taxonomy, which is a classification system that defines environmentally sustainable activities. • Stewardship activities: Financial market participants must disclose how they integrate sustainability risks and factors into their stewardship activities, such as voting on shareholder resolutions.
Corporate Sustainability Reporting Directive (CSRD)	The CSRD is a directive that requires large companies and listed SMEs to report on their sustainability performance. The CSRD was adopted in 2021 and will come into force in 2023. The CSRD requires companies to report on a wide range of sustainability issues, including climate change, environmental impact, social responsibility and governance. The CSRD is expected to have a significant impact on the financial	The CSRD requires companies to disclose information on their alignment with the EU Taxonomy, if applicable.	The CSRD requires companies to disclose information on their climate-related risks and opportunities. The European Sustainability Reporting Standards (ESRS) are a set of sustainability reporting standards that are being developed by the European Commission. and are expected to be published in 2023. The ESRS will require companies to disclose information on a wide range of sustainability topics, including climate change.

	sector, as it will require financial institutions to disclose more information about their sustainability performance.		The ESRS will also require companies to disclose information on their exposure to climate-related risks, such as physical risks, transition risks and liability risks.
EU Green Bond Standard	The European Green Bond Standard is a set of criteria for green bonds. Green bonds are debt instruments that are issued to finance environmentally sustainable projects.	The standard requires green bonds to be aligned with the EU Taxonomy.	As the EU Green Bond use of proceeds should be based on the EU Taxonomy and the TSC, the DNSH criteria and thus the CRVA is a direct component of the EU Green Bond Standards.

2.4 Climate risk and mortgage funding

(Green) bonds are an important funding instrument for real estate financing in Europe. Several green bond standards have been developed to ensure the credibility, transparency, and environmental impact of these investments. While climate risk may not be the primary focus of these standards, they often include elements that implicitly or explicitly address climate risk. Some examples of green bond standards and how they incorporate climate risk are given in Table 4.

Table 4: Overview of Green Bond Standards.

Green Bond Standard	Description	Incorporation of Climate Risk
ICMA Green Bond Principles (GBP)	The GBP, established by the International Capital Market Association, is a voluntary set of guidelines that recommend transparency and disclosure and promote integrity in the green bond market. They identify four core components: Use of Proceeds, Process for Project Evaluation and Selection, Management of Proceeds and Reporting.	The GBP do not directly address climate risk but do so indirectly by suggesting eligible green project categories such as renewable energy, pollution prevention and control, energy efficiency, clean transportation and climate change adaptation – all of which contribute to climate change mitigation or adaptation efforts.
Climate Bonds Initiative (CBI) Climate Bonds Standard	The CBI Climate Bonds Standard is a science-based, sector-specific screening tool for investors and governments which allows them to assess the environmental integrity of bonds claiming to be green and funding the low-carbon future.	The CBI Standard directly addresses climate risk. It is specifically designed for bonds that finance projects with clear environmental benefits related to climate change mitigation or adaptation. The standard provides sector-specific eligibility criteria, thereby making it a more detailed and focused framework for addressing climate risk.
European Union (EU) Green Bond Standard	The EU Green Bond Standard is a voluntary framework that aims to enhance the	The EU Green Bond Standard requires that the financed projects contribute to one or more of the environmental objectives defined in the EU

	effectiveness, transparency, and credibility of the green bond market in the EU. It aligns with the EU Taxonomy, which classifies environmentally sustainable economic activities.	Taxonomy, which include climate change mitigation and adaptation. By focusing on investments that align with the EU Taxonomy's environmental objectives, the standard directly incorporates climate risk.

2.5 Impact of climate risk on residential buildings, mortgage loans and occupants.

Table *5* contains an overview of the potential consequences of (physical) climate risk to residential buildings, borrowers and mortgage lenders. We deem it necessary to assess these potential consequences as, of part of the CRVA where we need to identify which physical climate risks *may* affect the performance of the economic activity during its expected lifetime.

Table 5: Potential consequences of physical climate risks.

Stakeholder	Potential consequence of physical climate risk(s).
Homeowner (borrower)	Liveability and Comfort: Climate-related events like heatwaves, floods, storms and wildfires can severely affect and disrupt the liveability and comfort of a property. For example, extreme heat could make a property uncomfortable or even unliveable without air conditioning. Flooding might force residents to evacuate their property for a period of time. These disruptions can also lead to mental and emotional stress.
	Health Risks: Climate change can also pose direct and indirect health risks. For example, extreme heat can cause heat-related illnesses, while poor air quality due to wildfires can lead to respiratory issues. Flooding can lead to mold growth in properties, which also contributes to respiratory problems and other health issues. Increased prevalence of disease spreaders like ticks and mosquitoes due to warmer climates is another indirect health risk.
	Maintenance Costs: Properties exposed to climate risks might require more frequent maintenance and repair, leading to increased costs over time. This could include repairing storm or flood damage, managing erosion, or upgrading the property to withstand future events (such as installing flood barriers or fire-resistant materials).
	Community and Social Networks: Climate change can also disrupt communities and social networks. If climate risks make an area unliveable, residents may be forced to move, leaving behind neighbours, friends and community support networks.
Building (unit)	**Physical Damage:** The most direct impact of climate risk on residential real estate is through physical damage caused by climate-related events. These can include storms, floods, wildfires, or sea-level rise, which can damage or destroy properties. This not only results in immediate loss in value, but also makes certain areas less attractive to buyers, potentially leading to long-term depreciation of the property value.
	Insurance Costs: As climate-related risks increase, insurance companies may raise premiums or even refuse to insure properties in high-risk areas. This can impact the affordability of properties in these areas and reduce their value.
	Regulatory Changes: (Local) Governments may introduce regulations to limit construction in high-risk areas or to enforce stricter building codes that require properties to be more resilient to climate

	change. This can increase the cost of construction or renovations, affecting the profitability of real estate development. For instance: Bats can be in a wall cavity. Because bats are protected animals in the Netherlands, it is forbidden to disturb their habitat or kill them. The insulation company must take this into account when insulating the cavity.
	Market Perception: As awareness of climate change grows, buyers may become more hesitant to purchase properties in areas perceived as high risk, even if they haven't been directly impacted by climate-related disasters. This could reduce demand and lead to a decrease in property values. This pattern is more directly visible in the fact that (potential) property buyers are more inclined to take into consideration the energy efficiency of the property[11].
	Migration Patterns: Over time, climate risk may influence where people choose to live. If certain areas become too risky or uninhabitable due to climate change, we might see population shifts that could dramatically impact local real estate markets. This can create opportunities in some areas and challenges in others.
	Collateral Value: The value of the property serves as collateral for the mortgage. If climate risk causes the value of a property to decrease, the collateral value of the mortgage is reduced. This is a significant risk for mortgage lenders, especially if the borrower defaults and the mortgage lender is required to sell the property to recover the loan.
	Loan-to-Value Ratio: Climate risk could impact the loan-to-value ratio (LTV). For example, if climate risk leads to a decrease in property values in a certain area, the loan might end up being larger than the property's value, resulting in a LTV ratio of more than 100%. This poses a higher risk for mortgage lenders as they may not be able to recover the full loan amount in the event of a foreclosure.
Mortgage Lender	**Default Risk:** If a property is damaged due to a climate event such as a flood or wildfire, the homeowner may not be able to afford repairs and could default on their mortgage. This risk can be especially high if the homeowner is not adequately insured, or if insurance companies refuse to cover climate-related damage.
	Secondary Market Impact: Mortgage lenders often sell loans to other investors in the secondary market. If these investors start to perceive climate risk as a significant factor, they might be less willing to buy mortgage loans associated with properties in high-risk areas. This could limit the liquidity of these mortgage loans and potentially increase the costs for mortgage lenders originating these loans.
	Credit Risk: This is the risk that homeowners will not be able to repay their mortgage loans. If a property is damaged or destroyed by a climate-related event, or if its value declines due to perceived climate risks, homeowners may default on their mortgage loans. This risk can be heightened if insurance coverage is not sufficient or is unavailable.
	Market Risk: Climate risk can affect the overall value of residential real estate in a given region, leading to a decline in the value of a financial institution's mortgage portfolio. This, in turn, can affect the institution's financial stability and profitability.
	Liquidity Risk: Mortgage loans are often bundled and sold as securities in secondary markets. If investors become wary of climate risks associated with certain properties or regions, it could become more difficult for financial institutions to sell these securities, reducing liquidity and potentially increasing the cost of lending.

[11] https://nos.nl/artikel/2450539-prijsverschil-tussen-huis-met-laag-of-hoog-energielabel-algauw-halve-ton

	Operational Risk: Financial institutions may need to adjust their operations to account for climate risks, including modifying their risk assessment and underwriting processes, investing in new data and analytics capabilities and training staff. These changes can entail significant costs and operational challenges.
	Reputational Risk: Financial institutions are under increasing pressure from customers, investors and regulators to address climate risk. Failure to manage these risks effectively could damage a firm's reputation and lead to loss of business.

3 Climate Risk Concepts

The study of climate risk analysis for mortgage loans is complex, involving various fields like environmental science and economics. It has its own vocabulary with many specific concepts and terms. These definitions are essential for analysing and applying climate risk analysis in practice. It helps us understand the scientific literature and policy documents about climate change. Making climate risk assessment tangible will not only help in conforming EU Taxonomy based disclosures but will valuably contribute towards the objectives of the EU's Green Deal.

3.1 Climate and Weather

Weather refers to short-term atmospheric conditions like temperature, humidity, wind speed and precipitation, in a specific location at a given moment. On the other hand, climate describes the long-term patterns of weather in a particular region, typically averaged over a period of thirty years or more. While weather can change quickly and unpredictably, climate represents the usual state of the weather in a region and changes gradually over much longer periods.

The climate is a statistical description of weather in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period for averaging these variables is thirty years, as defined by the World Meteorological Organization. The relevant quantities are most often near-surface variables such as temperature, precipitation and wind[12].

3.2 Climate risks and hazards

Climate risk and climate hazard are two interconnected terms used in the context of climate change and its impact on various sectors, including real estate. Understanding the difference between these terms is important for assessing and managing the potential implications of climate change on residential and commercial properties.

Climate Hazard: A climate hazard refers to a physical event or phenomenon associated with climate change that has the potential to cause harm or damage to people, property, or the environment[13]. Climate hazards can be acute, occurring as discrete events (e.g., storms, floods, wildfires), or chronic, manifesting as long-term trends (e.g., sea-level rise, increasing temperatures).

Climate Risk: Climate risk, on the other hand, is the likelihood and magnitude of negative consequences resulting from the interaction between a climate hazard and the vulnerability and exposure of a particular system or asset, such as real estate[14]. As we shall see in Section 4 climate risk can be represented as the result of hazard, vulnerability, and exposure.

[12] IPCC 2014
[13] Intergovernmental Panel on Climate Change (IPCC). (2014). Climate Change 2014: Impacts, Adaptation and Vulnerability.
[14] United Nations Framework Convention on Climate Change (UNFCCC). (n.d.). Climate Risk. Retrieved from https://unfccc.int/topics/adaptation-and-resilience/the-big-picture/climate-risk

Table *6* provides examples of climate hazards and risks that could be relevant to (residential) real estate. In Sections 7 and 8 we propose the climate hazards and risks to consider for the Netherlands.

Table 6: Examples of Climate Hazards and Risks Relevant to residential real estate.

Climate Hazard	Examples of Climate Risks for Residential Real Estate
Extreme precipitation	Increased risk of flooding, leading to property damage and reduced property values; increased risk of landslides and soil erosion, impacting the structural integrity of properties and infrastructure.
Rising sea levels	Increased risk of coastal flooding, leading to property damage and reduced property values; increased erosion, threatening the stability of coastal properties; saltwater intrusion, affecting freshwater supplies and damaging infrastructure.
Heatwaves	Higher energy costs for cooling, reducing property desirability and value; increased health risks for residents, particularly the elderly and vulnerable populations; potential exacerbation of urban heat island effects, leading to reduced quality of life and property values in densely populated areas.
Wildfires	Increased risk of property damage or destruction; higher insurance premiums and potential for insurance unavailability; reduced property values in high-risk areas.
Droughts	Reduced water availability, leading to water restrictions and negatively affecting property values; increased risk of wildfires; potential impacts on landscaping and vegetation, affecting property aesthetics and value.

3.3 Physical risks versus Transition risks

This section aims to explore the distinction between physical risks and transition risks, to provide examples relevant to Dutch real estate and to discuss the influence of climate change.

Physical Risks

Physical risks refer to the direct impacts of climate change on properties and infrastructure, such as damage or destruction due to extreme weather events, sea-level rise, or other environmental shifts. In the context of Dutch real estate, the following examples can be considered:

1. **Flooding**: As a low-lying country with a significant portion of its land below sea level, the Netherlands is particularly vulnerable to flooding. Rising sea levels and increasing precipitation can lead to more frequent and severe flooding, posing a threat to both residential and commercial properties.
2. **Subsidence**: Soil subsidence, a prevalent issue in the Netherlands, is exacerbated by climate change. This phenomenon can result in uneven ground settling, causing damage to foundations and infrastructure, such as roads, pipelines and sewage systems.
3. **Coastal Erosion**: Climate change-induced sea-level rise and storms can accelerate coastal erosion, threatening properties, and infrastructure along the Dutch coastline.

Transition Risks

Transition risks in residential real estate primarily stem from the shift towards a low-carbon and climate-resilient economy. For instance, the introduction of stricter building regulations can necessitate costly retrofitting to improve energy efficiency. Changes in consumer preferences, with increasing demand for energy efficient properties, could lead to devaluation of non-sustainable properties. Transition to renewable energy sources might render houses reliant on fossil fuels less attractive or obsolete, potentially inducing the *risk of stranded assets*.

An example of policy that affects transition risks is the revision of the Energy Performance of Buildings Directive (EPBD). The Directive proposes minimum energy performance standards, pushing for a gradual transition to a zero-emission building stock by 2050.

Climate change intensifies both physical and transition risks, making it increasingly important for stakeholders in the real estate sector to conduct comprehensive risk assessments. A thorough analysis should consider the specific location of a property, its vulnerability to physical risks and its potential exposure to transition risks. By understanding these risks, investors and developers can make informed decisions.

3.4 Chronic and acute Climate Risks

Climate risks can be broadly categorised into two types: *chronic* and *acute*. Recognising the differences between chronic and acute climate risks is important for assessing the potential impacts on residential real estate from an EU Taxonomy perspective. Table *7* provides examples of both chronic and acute climate hazards relevant for Dutch residential real estate.

Chronic Climate Risks: Chronic risks are long-term, gradual changes in climate conditions that can have lasting effects on human systems, including residential real estate. These risks often result from slow-onset events, such as rising sea levels or increasing average temperatures and can lead to progressive impacts on property values, infrastructure and quality of life.

Acute Climate Risks: Acute risks are short-term, sudden and extreme climate events that can cause significant damage to property and infrastructure. These risks often result from extreme weather events, such as hurricanes, floods, or wildfires and can lead to immediate impacts on property values, (human) safety and insurance costs.

Table 7: Examples of Chronic and Acute Climate Hazards Relevant to Residential Real Estate in the Netherlands.

Type of Climate Hazard	Climate Hazard	Climate Risk Examples for Real Estate
Chronic	Rising sea levels	Gradual property damage and reduced property values in coastal areas; increased risk of flooding and erosion, threatening the stability of coastal properties; saltwater intrusion, affecting freshwater supplies and damaging infrastructure; potential need for costly adaptation measures, such as sea walls and improved drainage systems.
	Increasing average temperatures	Higher energy costs for cooling, reducing property desirability and value; potential exacerbation of urban heat island effects, leading to reduced quality of life and property values in densely populated areas; increased risk of heat-related health issues, particularly for the elderly and vulnerable populations.
	Long-term changes in precipitation	Increased risk of river flooding and surface water flooding, leading to property damage, reduced property values and higher insurance premiums; potential need for investments in flood protection measures and improved drainage systems.

Acute	Storm surges	Immediate property damage and destruction in coastal and low-lying areas; temporary or permanent displacement of residents; increased insurance premiums and potential for insurance unavailability; reduced property values in high-risk areas; potential need for investments in coastal defences and flood protection measures.
	Extreme precipitation	Immediate property damage due to flooding and water infiltration; increased risk of mold and water damage; reduced property values in flood-prone areas; increased insurance premiums; potential need for investments in improved drainage systems and flood protection measures.
	Heatwaves	Increased energy costs for cooling, leading to reduced property desirability and value; potential exacerbation of urban heat island effects, leading to reduced quality of life and property values in densely populated areas; increased risk of heat-related health issues, particularly for the elderly and vulnerable populations.
	Droughts	Reduced water availability, leading to water restrictions and negatively affecting property values; potential impacts on landscaping and vegetation, affecting property aesthetics and value; increased risk of soil subsidence, leading to structural damage and reduced property values; potential need for investments in water-saving measures and alternative water sources, such as rainwater harvesting systems.

Exacerbation of Chronic Climate Risks by Climate Change

As climate change continues to impact global weather patterns and environmental conditions, both chronic and acute climate risks are becoming increasingly severe. Chronic climate risks, which stem from long-term, gradual changes in climate conditions, are being exacerbated by climate change in various ways, some examples include:

- **Rising sea levels**: As a result of melting ice sheets and thermal expansion, sea levels are rising globally, leading to increased coastal flooding and erosion[15]. This poses significant risks to coastal real estate, particularly in low-lying areas.
- **Increasing average temperatures**: Global temperatures are rising due to the enhanced greenhouse effect, leading to more frequent and intense heatwaves[16]. This can result in higher energy costs for cooling and exacerbate urban heat island effects[17], impacting real estate values and quality of life.
- **Long-term changes in precipitation patterns**: Climate change is causing shifts in precipitation patterns, resulting in more frequent and intense precipitation events in some regions and droughts in others[18]. These changes can lead to increased flood risks, water scarcity and potential damage to property and infrastructure.

[15] IPCC. (2019). Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC). Retrieved from
[16] IPCC. (2018). Global Warming of 1.5°C. An IPCC Special Report. Retrieved from https://www.ipcc.ch/sr15/
[17] the (urban) heat island effect occurs when the temperature in an urban area is typically higher than in the surrounding rural areas.
[18] Trenberth, K. E. (2011). Changes in precipitation with climate change. Climate Research, 47(1-2), 123-138. Retrieved from https://www.int-res.com/abstracts/cr/v47/n1-2/p123-138/

Exacerbation of Acute Climate Risks by Climate Change

Acute climate risks, which arise from sudden and extreme climate events, are also being intensified by climate change. Some examples include:

- **Storm surges and hurricanes**: Climate change is expected to lead to stronger storms and more intense hurricanes due to higher sea surface temperatures and changes in atmospheric circulation[19]. This can result in increased property damage, insurance costs and risks to human safety.
- **Extreme precipitation events**: Warmer temperatures increase the atmosphere's capacity to hold moisture, leading to more intense and frequent heavy precipitation events[20]. This can result in increased flood risks and property damage.
- **Wildfires**: Climate change is contributing to longer and more severe wildfire seasons due to higher temperatures, increased droughts and changing vegetation patterns[21]. This can lead to increased property damage, insurance costs and threats to human safety.

Implications for Real Estate

The exacerbation of chronic and acute climate risks by climate change has potential implications for the real estate sector:

1. **Property values**: Properties in high-risk areas, such as coastal regions or wildfire-prone zones, may experience reduced property values due to increased risks associated with climate change.
2. **Insurance premiums**: Homeowners and investors may face higher insurance premiums or potential unavailability of insurance in high-risk areas.
3. **Adaptation and mitigation costs**: Property owners may need to invest in adaptation and mitigation measures, such as improved drainage systems, sea walls, or fire-resistant materials, to protect their properties from climate risks.
4. **Land-use planning and policy**: Policymakers will need to consider the increasing climate risks when developing land-use plans and zoning regulations to minimize exposure and vulnerability of properties to climate hazards.

3.5 Interaction of Climate Risks

Climate risks can interact in complex ways, with the potential to amplify their individual impacts and create cascading effects on various sectors, including real estate. The IPCC notes that '*Complex risks result from multiple climate hazards occurring concurrently and from multiple risks interacting, compounding overall risk and resulting in risks transmitting through interconnected systems and across regions*[22]'. In the Netherlands these interactions can have significant implications for residential and commercial properties. Some potential examples of interacting climate risks that are relevant for the Netherlands are included in Table *8*.

[19] Knutson, T. R., Sirutis, J. J., Vecchi, G. A., Garner, S., Zhao, M., Kim, H. S., ... & Villarini, G. (2013). Dynamical downscaling projections of twenty-first-century Atlantic hurricane activity: CMIP3 and CMIP5 model-based scenarios. Journal of Climate, 26(17), 6591-6617. Retrieved from https://journals.ametsoc.org/view/journals/clim/26/17/jcli-d-12-00539.1.xml
[20] Trenberth, K. E., Dai, A., Rasmussen, R. M., & Parsons, D. B. (2003). The changing character of precipitation. Bulletin of the American Meteorological Society, 84(9), 1205-1217. Retrieved from https://journals.ametsoc.org/view/journals/bams/84/9/bams-84-9-1205.xml
[21] Abatzoglou, J. T., & Williams, A. P. (2016). Impact of anthropogenic climate change on wildfire across western US forests. Proceedings of the National Academy of Sciences, 113(42), 11770-11775. Retrieved from https://www.pnas.org/content/113/42/11770
[22] Working Group II (WGII) contribution to the Sixth Assessment Report (AR6) of the IPCC.

Table 8: Overview of the interactions between different climate risks and their potential impacts on real estate.

Interaction	Description	Potential Impacts on Real Estate
Sea-level rise & extreme precipitation events	Rising sea levels and increasingly intense precipitation events can exacerbate the risk of coastal and inland flooding. Higher sea levels can reduce the effectiveness of drainage systems and impede the discharge of river water.	• More frequent and severe flooding events. • Extensive property damage. • Higher insurance premiums. • Long-term declines in property values.
Heatwaves & urban heat island effect	The increasing frequency and intensity of heatwaves, coupled with the urban heat island effect, can create compounding risks for real estate in densely populated areas. The urban heat island effect occurs when built-up areas experience higher temperatures than their rural surroundings due to heat-absorbing surfaces and reduced vegetation cover.	• Higher energy consumption for cooling. • Reduced indoor comfort. • Increased health risks for vulnerable populations. • Increased demand for energy-efficient and climate-resilient buildings.
Subsidence & flooding	Land subsidence due to groundwater extraction or soil compaction can interact with the risks of flooding caused by sea-level rise and extreme precipitation events. Subsidence can make properties more vulnerable to flooding by lowering the ground level relative to sea level or flood defences. It can also cause damage to building foundations and infrastructure.	• Increased vulnerability to flooding. • Damage to building foundations and infrastructure. • Increased repair and maintenance costs. • Reduced property values • Potential loss of insurability.
Socioeconomic factors & climate risks	Climate risks can interact with socioeconomic factors, creating disproportionate impacts on certain populations and regions. For instance, low-income households or communities may have limited access to resources for adaptation and recovery, making them more vulnerable to the effects of climate hazards such as flooding or heatwaves. These disparities can exacerbate existing social inequalities and contribute to urban sprawl, as people may seek to relocate to areas with lower climate risks.	• Disproportionate impacts on vulnerable populations. • Exacerbation of existing social inequalities. • Urban sprawl as people relocate to areas with lower climate risks. • Increased demand for affordable and climate-resilient housing.

4 Elements of Climate Risk Assessment

4.1 Introduction

In this section we will explore the different elements of climate risk assessment. The multiplication of hazard, exposure and vulnerability gives us a more precise measure of the specific climate risk that a property faces. The physical climate risk can be represented[23] as depicted in Figure *9*:

Figure 9: Representation of physical climate risk

Risk = Hazard X (spatial) Exposure X Vulnerability

1. **Hazard:** A hazard refers to a potential event or phenomenon that may cause harm or loss. In the context of climate risk, hazards are typically extreme weather events or long-term shifts in climate conditions caused by climate change. The intensity, frequency and duration of these hazards are important factors in determining the (actual) level of risk. See Sections 4.2 and 4.3.

2. **Exposure:** Exposure refers to the presence of people, livelihoods, species, ecosystems, environmental functions, services, resources or infrastructure in places and settings that could be adversely affected by a climate hazard. If a property or community is located in an area that is likely to be affected by a climate hazard, it is said to be exposed to that hazard. High exposure does not necessarily translate to high risk, however, as the level of risk also depends on the vulnerability of the exposed elements. See also Section 4.4.

3. **Vulnerability:** Vulnerability refers to the propensity or tendency to be adversely affected by a climate hazard. This includes sensitivity or susceptibility to harm and lack of capacity to cope and adapt. Vulnerability can depend on a variety of factors, such as the design and condition of physical structures, the socio-economic status of individuals or communities and the effectiveness of relevant policies and institutions. For example, a building that is not designed to withstand high temperatures is more vulnerable to heatwaves, while a community with limited resources may be more vulnerable to flooding because they have less capacity to recover from a flood event. See also Section 4.5.

Together, these three components determine the level of climate risk. A climate hazard represents the physical event or phenomenon associated with climate (change), while climate risk refers to the potential negative consequences of these hazards on a specific system or asset, considering their vulnerability and exposure. In the context of real estate, understanding the difference between climate risk and hazard is important for assessing and managing the potential impacts of climate change on properties and their occupants.

The risk is generally higher if the hazard is intense and frequent, if there are many exposed elements (people, assets, etc.) and if these elements are highly vulnerable to the hazard. Understanding these components can help to assess and manage their climate risks effectively. For instance, mitigating measures can be taken to reduce exposure, this is known as the incorporation of adaptive capacity.

[23] We adhere to the representation of risk formulated by the IPCC in both AR(5) and AR(6) as: 'In the context of climate change, risk can arise from the dynamic interactions among climate-related hazards, the exposure and vulnerability'.

4.2 Principles of hazard assessment

Hazard assessment is typically a starting point for analysing climate risk, providing the basis for evaluating the potential threats posed by climate change. This section explores the principles guiding the assessment of climate hazards, focusing on their relevance to residential real estate. Hazard assessment involves the identification and evaluation of potential threats posed by climate change. It characterizes the nature, magnitude, frequency and location of these hazards, often by using historical climate data and future climate projections.

Hazard assessment relies (heavily) on data and models. Historical climate data helps assess past patterns and trends, while climate models provide projections for future conditions. Hazard assessment involves dealing with unknowns. Since we cannot predict the future with (absolute) certainty, hazards are often expressed in probabilistic terms, such as the "100-year flood" or the "1-in-20-year heatwave." It's important to understand these probabilities and the inherent uncertainties in the models and data applied.

The relevance of a hazard to a particular property is dependent on the scale at which it occurs. Some hazards, like sea-level rise, occur at larger scales and over longer timeframes, while others, like flash floods or heatwaves, can occur at very local scales and over shorter periods. The spatial and temporal scales of assessment should ideally align with the scales at which the hazards occur. Table *9* presents an (elaborate) overview of steps to that could be taken when performing a hazard assessment[24]. In the table we presented examples that are relevant for the Dutch context.

Table 9: Overview of how the process of assessing climate hazards can be performed, including relevant examples for the Netherlands.

#	Step	Description	Application to the Netherlands	Examples in a Dutch Context
1	*Define the Geographic Scope*	Determine the area of interest.	Choose the area in the Netherlands you are interested in, such as e.g. Amsterdam, the province of Zeeland, or the entire country.	
2	*Understand the Regional Climate*	Learn about the regional climate characteristics including historical patterns and future projections.	Understand the Netherlands' climate characteristics, such as its temperate maritime climate, influenced by the North Sea and Atlantic Ocean.	The Netherlands has a temperate maritime climate, with mild summers and cool winters. In recent years the Netherlands is experiencing significant warming, increased precipitation, and a rise in sea level.
3	*Collect Historical Climate Data*	Gather data on past climate conditions.	Data from the Royal Netherlands Meteorological Institute (KNMI), which provides comprehensive historical climate data for the Netherlands.	The Netherlands has a history of managing water and preventing floods. Historical data could include past incidents of flooding, storm surges from the North Sea and the effectiveness of the existing flood defence systems. Additionally, there is frequency data available on weather patterns, including temperature, rainfall, and wind data.

[24] Table 9 describes the possible steps: it is a synthesis of common approaches. Some steps can be regarded as optional.

4	*Understand the Local Environment*	Learn about the local geographical and environmental characteristics.	Understand the Netherlands' unique environmental characteristics, such as its low-lying topography, extensive coastlines, and large number of rivers, which can all contribute to climate hazards like sea-level rise and flooding.	Approximately 26% of the Netherlands is below sea level, protected by dikes and other water management systems. Coastal areas are vulnerable to sea-level rise, while riverine areas are prone to flooding.
5	*Identify Location-Specific Hazards*	Determine which hazards are specifically relevant to the defined area.	Identify which hazards are particularly relevant to the area in the Netherlands you have defined, such as sea-level rise and storm surge for coastal regions, or river flooding for regions near major waterways.	Coastal regions in the Netherlands are particularly vulnerable to sea-level rise and storm surge, while areas near rivers are susceptible to flooding due to increased rainfall and potential dike breaches.
6	*Analyse Climate Trends*	Look at how climate variables have been changing over time.	Use the KNMI data to analyse trends in temperature, precipitation, sea levels and extreme weather events in the Netherlands.	The KNMI has documented a significant increase in average temperature, more frequent and intense heatwaves, increased precipitation, and rising sea levels.
7	*Use Climate Projections*	Use climate models to project future changes.	Use climate projections provided by KNMI or international bodies like the IPCC. These can provide information about how variables like temperature, sea level and precipitation might change in the future.	Climate projections from the KNMI suggest further increases in temperature, more extreme heat events, increased winter precipitation, potential decreases in summer precipitation and continued sea-level rise.
8	*Identify Potential Hazards*	Based on the data and projections, identify potential climate hazards.	Given the Netherlands' geography and climate trends, potential hazards might include sea-level rise, increased precipitation leading to flooding and more intense and frequent heatwaves.	The major climate hazards for the Netherlands include sea-level rise, river, and coastal flooding due to increased precipitation and storm surges and heatwaves.
9	*(optional)* *Consult Experts and Local Knowledge*[25]	Speak with local residents, community leaders and experts[26].	Consult for instance Dutch climate scientists, local planning departments and residents. Local knowledge can be particularly valuable in understanding how climate hazards might affect specific areas.	

[25] A study published in the journal Nature Climate Change titled "Integrating local and scientific knowledge for environmental management" (Raymond et al., 2010) showed that combining scientific data with local knowledge can lead to better outcomes in managing climate-related risks.
[26] The Intergovernmental Panel on Climate Change (IPCC) recognizes the importance of including local and indigenous knowledge in climate assessments. In its Fifth Assessment Report, it states: "Complementing scientific with local and indigenous knowledge enables a more complete understanding of the complex, diverse and place-specific interactions among climate, nature and humans over various temporal and spatial scales" (IPCC AR5 WGII, Chapter 12).

10	*Create an overview of relevant physical hazards*	By creating an overview of relevant physical hazards, we can gain a comprehensive understanding of the range and nature of threats that buildings may encounter in a changing climate.		

In the context of the EU Taxonomy CRVA it can be useful to take the overview created in step 10 of Table *9* and break these hazards down into chronic and acute hazards.

4.3 Climate Modelling & Hazard Assessment

Climate models are mathematical representations of the Earth's climate system, which include the atmosphere, oceans, land surface and cryosphere (ice and snow). They are built on principles of physics and are used to simulate past, present, and future climate conditions. Projections play a central role in assessing exposure to climate risks, offering a glimpse into what the future might hold for residential real estate under various scenarios. Box *2* contains some additional information on climate scenarios and projections.

Box 2: Climate scenario and projections

A climate scenario refers to a plausible representation of the future climate system based on a set of assumptions about various factors that influence climate. These scenarios are constructed by considering a range of factors, including greenhouse gas emissions, land use changes, population growth, technological advancements and socio-economic developments. Climate scenarios typically have a time horizon of 50 to 100 years. This sets them apart from e.g. weather forecasts (up to 15 days ahead). Scenarios are potential visions for the future, not predictions. No probabilities are explicitly assigned to individual scenarios. Climate scenarios typically only make statements about average weather conditions and the likelihood of extreme weather in the long term.

As a result of climate change, the average climate is changing, as well as the likelihood of extremes. Furthermore, extremes can change differently than averages. For example, the probability of extreme precipitation may increase while the average precipitation decreases. Therefore, scenarios for a future climate should provide information about both the average change and the change in extremes.

Climate projection models are (data-driven) models that estimate future climate conditions, like temperature, precipitation and sea-level, under different greenhouse gas emission scenarios. These scenarios, such as Representative Concentration Pathways (RCPs) and Shared Socioeconomic Pathways (SSPs) see section on IPCC Climate projections, are based on a range of potential socio-economic and policy developments and their corresponding greenhouse gas emission trajectories.

There are several types of climate models, each with a specific level of detail and complexity:

- Global Climate Models (GCMs): These models simulate the entire Earth's climate and are used to make long-term climate projections. They are often used by the IPCC for their climate assessments.
- Regional Climate Models (RCMs): These models provide more detailed climate projections for specific regions. They are often used for regional and local climate impact assessments.
- Downscaled Climate Models: Downscaling is a technique used to generate more localised climate projections from GCMs or RCMs. This allows for a more precise understanding of climate hazards at the local level.

Often, regional and downscaled climate models facilitate a more granular level of detail (resolution). Climate projections provide insights into potential future hazards a property may be exposed to. For instance, in an area projected to have increased precipitation, the risk of flooding could be heightened. Similarly, areas projected to experience higher temperatures could face an increased risk of heatwaves or wildfires. Understanding these projected changes is essential for gauging a property's future exposure. Not only can climate projections provide information on what types of hazards might occur, they can also shed light on the potential severity and frequency of those hazards.

Analysing historical climate data can reveal trends over time. Rising average temperatures, more frequent heatwaves, increasingly intense storms, or shifting precipitation patterns are all trends that can inform exposure assessment and can help predict future risk. By studying past climate events, we can understand the types of hazards a property or area might be (recurrently) exposed to. Historical climate data provides information about the severity and frequency of past hazards. For instance, if an area has frequently experienced flooding in the past, it suggests a substantial exposure to this type of hazard. Knowing the maximum flood level reached in previous years or the highest temperatures ever recorded can help identify the potential range of climate hazards that a property might be exposed to or distil a trend based on which future occurrences might be predicted.

Understanding the historical context also involves considering any adaptation measures previously taken. Has a flood-prone area implemented improved drainage systems or built flood barriers based on past experiences? Such measures can reduce exposure and should be incorporated into the assessment.

4.4 Principles of Exposure Assessment

Assessing climate risk exposure for real estate involves understanding the potential *impact* of climate change on properties. In climate risk analysis, exposure refers to the degree to which a system is subject to harm due to climatic events or trends. For (residential) real estate, the system in question is typically a building unit or a portfolio of building units. The potential harm could be direct, such as physical damage to the property, or indirect, like a decrease in property value. This section provides an overview of the key principles involved in assessing exposure to climate risks.

This stage generally focuses on the physical characteristics of the hazards and the physical presence of the assets (in this case, buildings) in those hazard-prone areas. It involves identifying which assets are in the areas that could be physically affected by climate hazards. Table *10* presents elements that can be caried out in the assessment of exposure. The key question being answered here is: "*What is at risk*?".

Identifying Exposed Properties

The first step in the exposure assessment process is to identify the properties that are located in areas prone to climate hazards. This involves mapping the geographical location (also known as geospatial analysis) of the properties and overlaying this with maps of climate hazard zones. Such hazard maps can be based on a combination of historical data, such as past occurrences of floods or wildfires, as well as future projections, such as expected sea level rise or changes in temperature and precipitation patterns due to climate change.

Exposure can change over time as climate conditions, land use, population patterns and other factors change. For example, a property that is not currently exposed to coastal flooding could become exposed in the future due to sea-level rise. Therefore, it's crucial to consider both current and future exposure. As exposure can change over time (specifically when considering different climate scenarios) it is good practice to regularly update the exposure assessment to reflect these possible changes.

Table 10: Elements of exposure assessment.

#	Steps	Description
0	Identify Relevant Climate Hazards	Once the potential hazards have been identified, determine which hazards are relevant in what area.
1	Collateral Identification	Identify and compile a list of the properties or buildings that you need to assess. The address of the property is a key data point.
2	Map (plot) Exposure	Using geographical information system (GIS) tools[27], create maps that show the building's exposure to the identified hazards. Identifying and understanding the geographical location of a property is an important step to assess the potential exposure of physical climate risks for real estate. A property located in a coastal area might be exposed to risks like sea-level rise or hurricanes, while a property in a mountainous region might face exposure to landslides or wildfires. GIS (Geographic Information Systems) technology can provide detailed geographical data that can help in assessing this exposure.
3	Characterize the geographic Environment	Understanding geographical nuances is important when assessing exposure to climate risks. The geographical location of a property can influences both the types of hazards it is exposed to and the severity of those hazards. See Table *11* for examples of exposure assessment elements towards buildings in a Dutch context. Certain characteristics of a property can increase its exposure to specific hazards. For instance, a property at a lower elevation might be more exposed to flood risk, while a property with large windows facing the sun might be more exposed to heat risk.
4	Evaluate the Proximity to Hazards	Determine how close the properties are to areas likely to be affected by the identified hazards.
5	Create an Exposure overview	Combine all the above steps to form a comprehensive profile of each property's exposure to the identified climate hazards. Each property would have a unique exposure profile based on its characteristics, proximity to hazards, potential impacts and historical event data.

[27] See Section 7.8

Table 11: Examples of geographical considerations relevant for exposure assessment of buildings.

Geographic Consideration	Description	Impact on Buildings
Sea Level and Coastal Features	The Netherlands has an extensive coastline and much of the country is at or below sea level.	*Buildings located close to the sea may be at risk of coastal flooding and erosion, especially with rising sea levels. These may include residential properties, commercial buildings and critical infrastructure like power plants. In* Box *3*: Normaal Amsterdams Pijl we refer to a common system to assess water levels in the Netherlands.
River Proximity	Many parts of the Netherlands are near major river floodplains, like the Rhine and Meuse.	Buildings located near these rivers are at risk of river flooding, particularly during heavy rainfall events or snowmelt upstream. This includes both residential and commercial properties.
Land Subsidence	Some areas, especially in the western provinces, are prone to land subsidence. Droughts can exacerbate these problems.	Land subsidence can lead to structural issues in buildings, such as cracked foundations and uneven floors. This is particularly a concern for older buildings, which may not have been designed to cope with such conditions.
Urban Heat Islands	Densely populated urban areas can be significantly warmer than surrounding rural areas.	Buildings in urban areas may be more exposed to heat stress, which can increase cooling costs and negatively affect the health of inhabitants. This is particularly relevant for residential properties and buildings that house vulnerable populations.
Drainage and Water Management Infrastructure	The Netherlands has a complex system of dikes, canals and pumps designed to manage water levels and prevent flooding.	The condition and capacity of this infrastructure can affect the flood risk for nearby buildings. If the infrastructure is not maintained or upgraded to handle future climate conditions, buildings that were previously safe may become exposed to flooding.
Wind Exposure	The flat and coastal nature of the Netherlands means that it can be exposed to strong winds and storms.	Buildings, particularly high-rise structures or those with large surface areas exposed to the wind, may be at risk of wind damage. Buildings in coastal areas may also be at risk from storm surges associated with strong winds.
Soil Type	The Netherlands has diverse soil types, which can affect flood risk and building stability.	Certain soil types, such as clay or peat, can contribute to land subsidence or flooding, affecting building stability. Buildings in these areas may require special design considerations or mitigation measures.

Box 3: Normaal Amsterdams Pijl

Normaal Amsterdams Pijl (NAP) is a reference point used to measure (water) levels and elevation in the Netherlands. Originating in the 17th century, NAP provides a consistent baseline for construction, water management and urban planning in the city. NAP is not only used in Amsterdam but serves as the standard altitude reference system throughout the entirety of the Netherlands and it can also be relevant for climate risk assessments[28]:

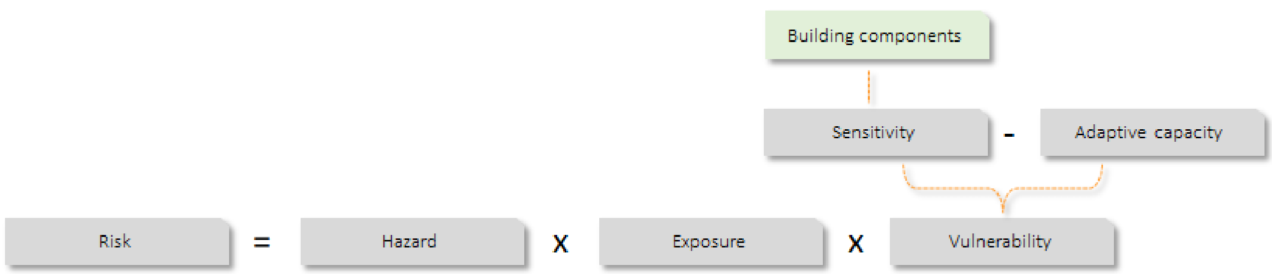
- National water elevation reference: NAP serves as the national water level reference system in the Netherlands, providing a consistent baseline. It serves as a standardised zero point for construction, infrastructure development, land management and water management projects across the entire country.
- Given the Netherlands' geography with a significant portion of the land located below sea level, NAP plays a crucial role in water management. It provides a reference point to monitor and regulate water levels, ensuring effective flood control, drainage and protection against sea-level rise.
- In climate risk analysis, NAP serves as a reference point. When evaluating climate hazards such as sea-level rise, storm surges, or river flooding, NAP is used to assess vulnerabilities and potential impacts on coastal areas and low-lying regions. It helps in quantifying the exposure of areas and objects to climate-related risks and supports decision-making processes for adaptation measures.

4.5 Principles of vulnerability assessment

Vulnerability assessment allows us to identify and prioritise buildings that are most at risk from climate hazards. By understanding the vulnerabilities, one can allocate resources efficiently and effectively in the most critical (spatial) areas. The most recent IPCC AR6 reports notes on the definition of vulnerability: "*The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity (the degree to which a system or species is affected, either adversely or beneficially, by climate variability or change) or susceptibility to harm and lack of capacity to cope and adapt*." In the context of (residential) real estate, this could relate to factors like building design and features, the use of climate-resilient materials, or the capacity of residents to respond to climate hazards. For instance, a building with poor insulation may be more sensitive to heatwaves, while one located in a low-lying area might be more sensitive to flooding, specifically in certain regions in the Netherlands.

In essence we must investigate how sensitive the buildings are to damage from the earlier identified hazards in a given area. This can depend on many factors, including the building's design, materials, location, and demographic information such as the population density in the area. Vulnerability is typically quantified through a combination of indicators, reflecting different aspects such as sensitivity, impact and (ideally) also adaptive capacity. In Box *4* we explain these concepts further. In Figure *10* we have portrayed the vulnerability assessment, as part of physical climate risk representation, reflecting the sensitivity and adaptive capacity of the asset (the building) to the identified hazards.

Figure 10: Risk representation with sensitivity and adaptive capacity



[28] Specifically as the term ''NAP' is a very common term that Dutch citizens learn in primary school as a measure to gauge water levels.

Table *12* provides an overview of (potential) steps that can be taken in vulnerability assessment, including the concepts of adaptive capacity, sensitivity, and impact. The key question here is: "*How severe could the impacts be*?"

Box 4: Vulnerability and the concepts of Adaptive Capacity, Sensitivity, and Impact.

Incorporating adaptive capacity, sensitivity and impacts into vulnerability assessments can help to create a comprehensive overview to understanding the full extent of potential climate change risks.

Adaptive Capacity

Adaptive capacity refers to the ability of a system to adjust and cope with climate change impacts, which in turn influences the system's overall vulnerability to these changes. A higher adaptive capacity implies less vulnerability to change. This capacity can be tied to both the inherent properties of the system and the potential for human adaptation. By including adaptive capacity in vulnerability assessments, it is possible to identify areas where improvements or interventions could significantly reduce vulnerability.

Sensitivity

Sensitivity is the degree to which a system will respond to climate change. This can be direct, such as a building's ability to withstand certain temperature thresholds, or indirect, such as changes in human behaviour due to climate change that affect the use or maintenance of the building. High sensitivity implies that a system or feature is more likely to be vulnerable to future climate change. Including sensitivity in vulnerability assessments allows for a better understanding of the potential impacts of climate change and can help guide mitigation or adaptation strategies[29].

Impact

Potential impacts of climate change are a function of exposure and sensitivity. These impacts can be thought of as theoretical scenarios of what could happen under certain conditions of climate change. By including potential impacts in vulnerability assessments, it is possible to understand the range of scenarios that could occur under different climate conditions. This is particularly relevant when looking at climate change projections. Impact is a function of exposure and sensitivity and provides a picture of the potential effects of climate change on a given system or entity (i.e. a building). Note: in most cases, adaptive capacity is not taken into account in impact assessment!

[29] https://reports.peakdistrict.gov.uk/ccva/docs/appendix/ipcc.html

Table 12: Vulnerability assessment steps.

#	Step	Description
1	Analyse Vulnerabilities	Continuing from the exposure assessment: by assessing the physical vulnerability of buildings to the identified climate hazards. Consider building characteristics such as age, construction materials, design, structural integrity, and maintenance history. Assess the building envelope, including walls, roofs, windows, and insulation, to understand its thermal performance and ability to withstand climate variations. In Box 5: Building characteristics and vulnerability we have given examples of building characteristics and why these could mater for vulnerability assessment.
2	**Assess sensitivity**	Use quantitative metrics to assess sensitivity if possible. Measuring the sensitivity of buildings to climate hazards requires the use of quantitative of metrics that provide objective and comparable assessments. These metrics help identify vulnerable buildings, prioritize adaptation measures, and inform decision-making for climate risk management. Quantitative approaches can include for instance: damage functions, vulnerability indices, risk score or proprietary geographic Information Systems (GIS) mapping. See Table 13 for examples.
3	Evaluate Adaptive Capacity	Assess the adaptive capacity of the buildings, governments, and communities to respond and adapt to climate hazards. In Section 4.6 examples of adaptive capacity are given. Make a distinction between existing adaptation measures and planned adaptation measures.
4	Evaluate the Vulnerability Profile	Use the information about potential impacts, sensitivity, and adaptive capacity to assess the overall vulnerability. Assess potential vulnerabilities of the building to extreme climate events, such as storms, heatwaves, or flooding. Identify weaknesses or risks associated with the building's design, location, or systems in relation to these events. Combine the information gathered in the previous steps to create a comprehensive vulnerability overview. Ideally a vulnerability profile for each building can be created.

Box 5: Building characteristics and vulnerability.

Building characteristics and vulnerability: The characteristics of a building play a crucial role in determining its vulnerability to climate-related hazards.

- Age and Construction Standards: Older buildings may have been constructed under less stringent building codes and may not be designed to withstand certain types of climate risks. For example, a property that was built decades ago might not be as resistant to heat as a newer property that has been built to modern standards. Older properties may also have aging infrastructure like roofing, plumbing and electrical systems that are more susceptible to damage from extreme weather.

- Building Materials: In the Netherlands, historically, buildings are often constructed with brick, which has good thermal properties and can help keep interiors cool during hot summers and warm during chilly winters. However, brick buildings may be susceptible to damage from prolonged periods of heavy rain, which can lead to dampness and mold growth.

- Design and Architecture: The design of a building can also influence its climate resilience. In the case of apartments, those with shared walls (as in a row house) may be better insulated against temperature extremes due to the reduced exposed surface area. Balconies or terraces could also be a risk factor if they are not properly waterproofed, leading to potential water damage during periods of heavy rain.

- Insulation and Ventilation: Given the changing climate and the increasing frequency of heatwaves, proper insulation and ventilation are crucial for maintaining comfortable indoor temperatures and good air quality.

In multi-story apartment buildings, higher floors can be particularly vulnerable to overheating during heatwaves due to the rising hot air. Similarly, poor ventilation could exacerbate heat risks and contribute to poor indoor air quality, particularly in areas prone to the urban heat islands effect.

- **Maintenance**: Regular maintenance can affect a building's vulnerability. Buildings that are not well-maintained might be more prone to damage from a variety of climate-related risks. For example, a roof that is in poor repair might be more likely to leak during heavy rain, while a property with poorly maintained vegetation around it might be more at risk from wildfires.

Measuring the sensitivity of buildings to climate hazards involves the creation of quantitative metrics that offer objective and comparable assessments. These metrics serve as valuable tools for identifying vulnerable buildings, prioritizing adaptation measures, and making informed decisions in climate risk analysis. Several quantitative approaches are highlighted below in Table *13*.

Table 13: Quantification or Qualification of Sensitivity.

Metric	Description	Examples
Damage Functions	Damage functions are mathematical models that estimate the expected damage or loss to a building based on the intensity of a climate hazard. These functions typically relate the hazard intensity (e.g., flood depth, wind speed, temperature) to the degree of damage to the building or its components (e.g., structural damage, content loss, operational disruptions). For example, in flood risk assessments, damage functions may consider factors such as the building's elevation, construction materials, and flood duration to estimate the extent of damage. These functions can be derived from historical data, empirical observations, or numerical simulations and can vary depending on the specific climate hazard.	Using historical flood data and simulations, **Deltares** developed damage functions to estimate the potential damage to buildings in various flood-prone regions of the Netherlands. These functions consider factors such as building elevation, construction materials, and flood duration.
Vulnerability Indices	Vulnerability indices provide an overall measure of a building's sensitivity to multiple climate hazards, integrating various vulnerability factors into a single numerical score. These factors may include building characteristics, exposure levels, adaptive capacity, and socioeconomic considerations. Developing a vulnerability index involves assigning weights to each vulnerability factor based on its relative importance. The index then combines the weighted factors to create a single score that reflects the building's overall sensitivity. Higher vulnerability index values indicate higher sensitivity to climate hazards. For example, a vulnerability index for a building may include factors such as age, construction materials, location, and the presence of critical infrastructure. Each factor would be assigned a weight based on its significance in determining the building's sensitivity.	**Deltares** and **TNO** (the Dutch Organization for Applied Scientific Research) have published research on vulnerability in the past.

Risk Scores	Risk scores combine measures of exposure, sensitivity, and adaptive capacity to assess the overall risk posed by climate hazards to a building. Risk scores enable direct comparisons between different buildings and help prioritize adaptation efforts. The risk score is calculated by multiplying the exposure level (likelihood of being impacted by a climate hazard) by the sensitivity score (e.g., vulnerability index) and then adjusting for the building's adaptive capacity (ability to cope with and recover from climate impacts). For example, a building with high exposure to flooding, high sensitivity (as indicated by a high vulnerability index), but also with strong adaptive measures in place, would have a different risk score than a building with similar exposure and sensitivity but lacking adaptive capacity.	**DGBC** (Dutch Green Building Council) has published a report[30], with input from Deltares, where a method is described to assess vulnerability and sensitivity via a risk score.
Proprietary analysis / GIS Mapping	Geographic Information Systems (GIS) play a vital role in quantifying building sensitivity at a spatial level. GIS allows the integration of various data layers, such as building characteristics, hazard maps, and vulnerability indices, into a single platform. By spatially visualizing qualitative data elements, practitioners can identify high-risk areas, assess sensitivity, and investigate the (influence of) adaptive capacity.	

4.6 Adaptation Capacity as part of the Risk Equation

Adaptation capacity relates to (proactive) measures taken to reduce the impact of hazards on an asset. In the context of real estate, these can include measures at various scales, from individual buildings to national plans, aimed at enhancing the resilience of these structures to climate-related hazards. When adaptation measures are implemented, they can reduce the vulnerability by increasing the capacity of the building or its surroundings to adapt to climate hazards.

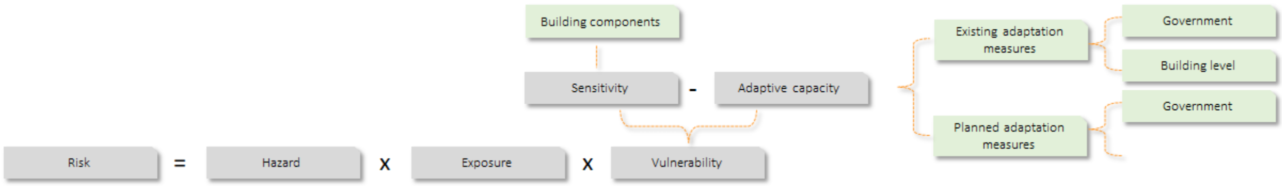
For instance, adaptation capacity in real estate could involve improving building codes for better resilience against storms or floods, or designing and constructing buildings with features that can help manage heat. Additional, adaptation measures provided at a national scale, such as dike raising could have an impact on the adaptive capacity and thus the overall vulnerability.

Also, recognising already implemented adaptation measures[31] are important as they can significantly reduce a building's vulnerability. Understanding what measures have been implemented can aid in assessing a building's overall (climate hazard) resilience. Specifically government-led climate adaptation measures can influence the risk profile of properties. Note that we use the term ‘adaptive capacity’ deliberately instead of the term adaptive solutions. As we will use the later term as a form of adaptation measures that are not part of the initial climate risk and vulnerability assessment.

In Figure 11 we depict a stylised model of the elements of physical climate risk (assessment) including adaptive capacity. In this section we consider the elements of adaptive capacity and its potential impact on the overall physical climate risk assessment.

[30] https://www.dgbc.nl/publicaties/framework-climate-adaptive-buildings-63
[31] Such as the installation of cooling or heating systems, the presence of flood barriers, or the use of fire-resistant materials.

Figure 11: Representation of components of Physical Climate Risk Assessment.



The implementation of adaptation measures can effectively reduce the overall climate risk by lowering the vulnerability. In Box *6* we have highlighted the guidance of the IPCC and ISO on adaptive capacity. Adaptive capacity can and should be evaluated at multiple levels or scales. It's an important aspect of vulnerability because it reflects the ability of a system to adjust, cope with and recover from the impacts of climate hazards. Note that adaptive capacity can not only influence the vulnerability but also the exposure and hazard.

By incorporating adaptation capacity, we can obtain a more nuanced and accurate analysis of the potential impacts of climate change on real estate assets. This, in turn, can inform more effective strategies for managing and reducing climate risk in the real estate sector. The IPCC notes on the adaptation capacity: *'The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences'*. Specifically, the ability of what the IPCC refers to as *systems* or *institutions* is to be considered in the context of adaptive capacity for climate risks towards buildings.

In the context of climate risk assessment, understanding the influence of climate adaptive capacity on the three main components of climate risk (hazard, exposure, and vulnerability) is important. Below, we explore how adaptive capacity and adaptive measures can shape each component of climate risk representation:

- Influence on *Hazard*: Adaptive measures play a crucial role in influencing the magnitude and frequency of climate hazards. By implementing proactive measures, such as constructing flood protection systems or implementing sustainable land management practices, the likelihood and severity of climate hazards can be reduced. Additionally, actions like afforestation and urban heat island mitigation can modify local climatic conditions, mitigating the risk of extreme heatwaves or wildfires.
- Influence on *Exposure*: Climate adaptive capacity has a direct impact on exposure to climate hazards. By implementing adaptive measures and informed urban planning, communities can steer development away from high-risk areas, reducing the exposure of buildings, infrastructure, and populations to flood zones, landslides, or coastal erosion. Climate-resilient infrastructure designs, such as elevated buildings in flood-prone regions or reinforced structures against extreme wind events, further limit exposure to climate hazards.
- Influence on *Vulnerability*: Climate adaptive capacity significantly influences vulnerability to climate hazards. Measures aimed at enhancing the ability of systems and communities to cope with and recover from climate impacts can reduce vulnerability. Improving early warning systems, implementing disaster response mechanisms, and promoting climate-resilient building designs and retrofitting all contribute to decreasing the vulnerability of buildings and communities. Moreover, socioeconomic, and governance-related adaptive measures, such as improving access to education, healthcare, and social safety nets, enhance community resilience and reduce overall vulnerability to climate risks.

By acknowledging and identifying the influence of adaptive capacity on each component of the climate risk representation, we can make informed decisions and prioritize adaptive measures that address vulnerabilities and protect our built environment and communities from climate hazards.

Box 6: Adaptive Capacity according to IPCC and ISO.

<table>
<tr><td>
IPCC and ISO on Adaptive Capacity (or the lack thereof)
ISO 14091 mentions that the main components of climate risk assessment are given by:
a) the hazard;
b) the exposure of a given system to the hazard;
c) the sensitivity of the system to the hazard;
d) the (potential) climate change impact, i.e. risk without adaptation;
e) the risk with adaptation (in the future).
The norm states that 'Future potential climate change impacts can be modified by the adaptive capacity of a system. The system's adaptive capacity influences the degree to which the potential impact becomes a tangible risk. The vulnerability of the exposed system can be expressed as a combination of an organization's sensitivity and its lack of adaptive capacity'.
An IPPC repot notes: "The adaptive capacity of coastal communities to cope with the effects of severe climate impacts declines if there is a lack of physical, economic and institutional capacities to reduce climate-related risks and hence the vulnerability of high-risk communities and groups" [32]
</td></tr>
</table>

The European Commission notes[33]: *"For a building's CVRA, this step should consider how likely it is that the impacts identified in (e.g. damage to the roof) will occur over the lifespan of the building, considering any steps that have been taken to avoid the impact. <u>This method would allow for assessment of both existing and planned buildings and provide a more realistic assessment of risk</u>. <u>Any existing or planned climate adaptation measures would reduce the likelihood of impact.</u> For example, it could be highly likely that there will be a heavy rainfall event during the lifetime of the building, but it could be unlikely the building will flood during a heavy rainfall event due to flood mitigation measures[34].".*

In Table *14* we depict three scales at which you can assess adaptive capacity and we provide some examples.

Table 14: Adaptive capacity examples on different scales.

Scale	Level	Examples in the Netherlands
Government (National)	National policies, resources, and capabilities	The Dutch government has several programs and systems in place that address climate adaptation on a national scale: • The Netherlands has a National Adaptation Strategy that includes measures for promoting climate-resilient buildings, such as national building codes and guidelines. This is the overarching Dutch strategy concerning climate adaptation. NAS identifies the main climate risks for the Netherlands and outlines a plan for tackling these risks. See Box 7 for more information. • National Delta Programme: This program focuses on protecting the Netherlands against flooding, ensuring sufficient freshwater supplies and creating a climate-proof and water-resilient layout. See Box 8 for more information.

[32] https://archive.ipcc.ch/publications_and_data/ar4/wg2/en/ch6s6-6-4.html
[33] Described in the context of Climate Vulnerability Assessment (CRVA).
[34] EU-level technical guidance on adapting buildings to climate change (2023).

		• National strategy for climate adaptive buildings Phase 1 (2022-2024): *De Rijksinzet op weg naar groene, klimaatbestendige steden en dorpen.* See Box *9* more information. • The WaterWet (Water Act) is a significant law in the Netherlands, serving as a comprehensive legislative framework for water management and protection against water-related risks. See • • Box *10* for more information.
Local (Community / Municipal)	Local policies, resources and capabilities	Cities like Amsterdam and Rotterdam have local climate adaptation plans that include measures for buildings, such as local building regulations and initiatives to promote green roofs or other climate-resilient building features. Local emergency services are also an important factor in the adaptive capacity at a community level.
Building (Individual / Asset)	Specific building characteristics and resources	Individual buildings in the Netherlands may have specific features that increase their adaptive capacity, such as elevation to protect against flooding or the use of climate-resilient materials. The availability and effectiveness of these features can vary widely depending on factors like the building's age, design and maintenance practices. In Box 11 we provide an example of an (institutional) measure, the TO-Juli, a metric that has been incorporated in the energy performance measurement methodology NTA 8800 in the Netherlands. It is specifically designed to capture the risk of 'overheating'.

Box 7: National Climate Adaptation Strategy of the Netherlands

National Climate Adaptation Strategy of the Netherlands

The National Climate Adaptation Strategy (NAS) is the Dutch governmental strategy to climate adaptation. It was initially released in 2016 and details the main climate risks for the Netherlands, outlining the course for addressing these risks. The climate trends identified by the NAS (National Adaptation Strategy) are all relevant for the built environment. Therefore, in this NAS update of 2019, the decision was made to designate the built environment as a focus point. This includes not only buildings and their surroundings (existing and new construction) but also the (value)chain of parties in the construction sector.

The relevance of the NAS to the real estate sector stems from its influence on policy and actions aimed at enhancing the resilience of the Netherlands to climate change. A prime example is its impact on the Delta Programme, specifically the Spatial Adaptation sub-programme. The Delta Programme, a nationwide scheme to climate-proof the Netherlands and make it water-resilient by 2050, complements the NAS This initiative sets forth spatial planning measures designed to equip the country to cope with the anticipated rise in heat, drought, intense precipitation and flooding. Consequently, the NAS and related programmes have implications for land use planning, building regulations, infrastructure investments and other elements crucial to the real estate industry.

The Ministry of the Interior Affairs and Kingdom Relations (BZK) is initiating a number of activities to promote climate-resilient construction. The focus is on climate effects and activities that complement or add value to ongoing activities related to the built environment, for example, in the Spatial Adaptation Delta Plan.

BZK initiated preparations for a climate adaptation *dialogue* on the built environment. The dialogue aimed to raise awareness of the consequences of climate change for the built environment and to identify potential opportunities and barriers, such as uncertainties in laws and regulations, guidelines and frameworks. The consideration of measures and instruments includes the concept of "linking," which involves connecting climate adaptation with energy transition and circular construction. The idea is that by paying attention to this linking concept, projects can reinforce each other.

The government participates in a number of interconnected pilot projects in leading cities to identify uncertainties and barriers to climate adaptation in the built environment, such as in laws and regulations. Solutions to these uncertainties or barriers can lead to new agreements between property owners, such as housing associations or homeowners' associations, municipalities, water boards (*Waterschappen*), residents and other stakeholders.

Box 8: National Delta Programme.

National Delta Programme

The National Delta Programme is a Dutch initiative aiming to protect the Netherlands from flooding, ensure freshwater availability and promote climate resilience. The programme, led by the Delta Commissioner, involves collaboration across multiple levels of government and stakeholder organizations. The initiative became necessary due to increasing sea levels, land subsidence, increasing torrential rainstorms and rising temperatures. The programme aims for the Netherlands to be climate-resilient and water-robust by 2050, introducing new flood risk management standards and strategies for spatial planning. It consists of Delta Decisions (national frameworks), Preferred Strategies (custom measures) and Delta Plans (concrete implementation measures). The 2023 Delta Programme report emphasizes the need for spatial planning based on water and soil conditions and mentions ongoing improvement projects for flood defences.

Box 9: National strategy for climate adaptive buildings Phase 1 (2022-2024): De Rijksinzet op weg naar groene, klimaatbestendige steden en dorpen.

National strategy for climate adaptive buildings Phase 1 (2022-2024): De Rijksinzet op weg naar groene, klimaatbestendige steden en dorpen

Climate change is putting the liveability of cities and villages under pressure, causing more frequent damage to houses and buildings due to heavy rainfall, storms and longer periods of heat and drought. This changing weather pattern also impacts people's health and well-being, with vulnerable groups being at a higher risk of illness and death[35].

The *'Nationale aanpak Klimaatadaptatie gebouwde omgeving'* is a Dutch national plan for climate adaptation in the built environment for the period of 2022-2024. The urgency to adapt the built environment to changing climate conditions, such as more frequent severe rain, extreme heat, and drought, is increasing. This plan was presented by the ministers of Housing and Spatial Planning, Infrastructure and Water Management and Nature & Nitrogen.

The plan outlines that many parties are already working hard on climate adaptation, but much more needs to be done to prepare the built environment in the Netherlands for extreme weather and future climate scenarios. It sets out

[35] Nationale aanpak Klimaatadaptatie gebouwde omgeving Fase 1: 2022-2024 De Rijksinzet op weg naar groene, klimaatbestendige steden en dorpen

objectives and intermediate goals for new construction and existing buildings as the first step in this acceleration. These goals are set with the aim of having a climate-resilient built environment by 2050.

New buildings need to consider weather extremes in their design, such as extended roofs to prevent sun exposure, sun blinds for large glass surfaces and the reuse of rainwater. Also, a green and water-rich public area is needed for cooling and to capture and hold heavy rainwater. Existing buildings also need adaptations such as better sun blinds, more greenery and capturing water where it does not cause damage.

Climate adaptation is a joint task of the national government and local authorities in collaboration with many other parties. In the National Adaptation Strategy (NAS) and the Delta Programme for Spatial Adaptation (DPRA), the governments have jointly formulated the following goal for climate adaptation by 2050: *"The built environment in the Netherlands is designed to be water-resilient and climate-proof by 2050."*

In this national approach, this goal is translated for the impact of the four climate effects on the built environment as follows:

- Intense rainfall leads to minimal inconvenience for people, minimal damage to buildings and minimal damage to public spaces in the built environment.
- The risk of flooding is considered acceptable if it results in minimal loss of human life and limited damage to buildings and their surroundings.
- During heatwaves, the living environment remains healthy and attractive, both within buildings and in public spaces, with minimal damage to health and energy consumption.
- Prolonged drought results in minimal desiccation of green areas or structural damage to buildings and foundations and sufficient drinking water is available (partly achieved by reducing the demand for drinking water in the built environment).

As a policy goal has been formulated for 2050:

'By 2050, the Netherlands will be climate-proof and water-resilient. In (re)developments, efforts will be made to prevent an increase in the risk of damage and casualties from flooding or extreme weather, to the extent reasonably feasible. Adequate space will be maintained and reserved for future water safety measures'.

<u>The two interim goals are:</u>

1. New developments: Climate adaptation is integrated as a standard practice in new developments, including both site selection and spatial planning, as well as building methods for new construction and transformation.
   - Local municipalities, provinces, regional water authorities ('waterschappen') and the national government are collaborating to determine the areas in the Netherlands where additional space should be reserved for water buffering to address waterlogging and drought, as well as for future dike reinforcements due to increased river discharge, expected sea-level rise and measures to mitigate land subsidence.
   - The Delta Programme, the Sea Level Rise Knowledge Programme and the Water and Soil Policy Process are conducting research in this regard, which serves as essential input for refining the National Spatial Strategy (NOVI).
   - Local municipalities, provinces and the national government base their location choices for new construction plans on the water and soil system. They must provide a reasoned explanation of how they have taken climate change and land subsidence into account.

     <u>Concerning Spatial planning and building code</u>

- Climate adaptation is fully considered in area development and is standard practice in the design of new construction.
- Starting from 2025, a percentage of the developed area will be flexibly designed (e.g., flexible housing or nature areas) and can be utilised in the future, for example, for additional water storage.
- Heat: all new residential building (units) meet the TO-juli (see Box *11*) requirement and the living environment remains attractive and healthy during heatwaves through adequate flowing water, shade and greenery. The latter is a shared responsibility of builders, clients and municipalities.
- The above interim goals will be further elaborated in the national benchmark for a green, climate-adaptive built environment and in the Water and Soil Policy Process.

2. Existing built environment: All municipalities assess the areas within their jurisdiction where the greatest challenges may arise due to climate change, encompassing both public spaces and buildings. As part of the process of standardizing stress test assumptions, it will be determined if this can be incorporated within the framework of the Delta Programme for Spatial Adaptation (DPRA) during the upcoming round of stress tests in 2025. Municipalities will discuss the outcomes of the stress tests with relevant stakeholders (risk dialogues) and inform property owners and residents about the major vulnerabilities. They will develop an implementation agenda for addressing the most significant challenges.
    - In collaboration with regional water authorities (‘*waterschappen*’) and provinces, municipalities have gained further insight in 2025 – during the second round of stress tests – regarding:
        - The areas in existing buildings and public spaces that face the greatest risks of waterlogging/flooding.
        - The locations of the most heat-sensitive areas in public spaces, as well as the areas where the most heat-vulnerable buildings and vulnerable groups are located, in cooperation with property owners.
        - The areas experiencing the most significant challenges due to drought (including foundation damage, harm to green spaces and water quality), including future risks.

        This will be further worked out in the process of standardizing stress test assumptions.
    - By 2027, municipalities will have a climate adaptation implementation plan that includes:
        - Measures to address the most high-risk areas for waterlogging and flooding in public spaces, in collaboration with water boards and property owners.
        - Measures to address the most heat-sensitive areas in public spaces.
        - An approach to resolve the most significant challenges in public spaces, as well as monitoring foundation damage and preventing further building damage in the highest-risk areas, in collaboration with major property owners.
        - The heat resilience plan will focus on vulnerable groups (such as the elderly) and vulnerable areas (such as densely populated, heavily urbanised neighbourhoods).

The report states that in its vision for 2027: major property owners will have developed an approach for buildings facing the greatest climate risks. The government will assess the extent to which this can align with the EU Taxonomy and determine if additional agreements with market parties and housing associations are necessary[36].

[36] Nationale aanpak Klimaatadaptatie gebouwde omgeving Fase 1: 2022-2024 De Rijksinzet op weg naar groene, klimaatbestendige steden en dorpen.

Box 10: The WaterWet and its (legal) commitments for the year 2050.

The WaterWet and its (legal) commitments for the year 2050

The WaterWet (Water Act) is a law in the Netherlands, serving as a legislative framework for water management and protection against water-related risks. Enacted in 2009, the Water Act outlines the roles and responsibilities of different authorities and stakeholders involved in water management, ensuring a coherent approach to sustainable water use and flood protection. Under the Water Act, guidelines for water quality, flood resilience, and water infrastructure development are established. The goals and ambitions of the WaterWet for 2050 are:

1. Enhancing flood protection measures and developing resilient infrastructure to safeguard Dutch residential areas from inundation and extreme weather events.
2. Promoting sustainable urban planning and integrating nature-based solutions to create climate-resilient neighbourhoods and infrastructure.
3. Establishing a circular water economy by implementing water recycling, rainwater harvesting, and sustainable drainage systems to reduce water demand and ensure sustainable water management for future generations.

The law plays a pivotal role in supporting the implementation of water-related initiatives and policies in the Netherlands, safeguarding water resources and enhancing climate resilience in the face of changing environmental conditions[37].

Box 11: TO-Juli metric in NTA 8800.

TO-Juli is a metric introduced in the NTA 8800 methodology, which is used for energy performance assessment of buildings in the Netherlands. TO-Juli focuses specifically on the risk of overheating within buildings, which is relevant if we want to analyse for instance the effects of climate change and heat. It is used to analyse and assess the potential risk of overheating in buildings under future (climate) scenarios.

TO-Juli considers the outdoor temperature during the summer period and calculates the number of hours that the indoor temperature exceeds a predefined threshold. The metric takes into account both the magnitude and duration of high indoor temperatures, providing a comprehensive indicator of overheating risk. The calculation of TO-Juli involves several steps:

1. **Simulation**: Building simulation software is used to model the building's thermal performance and simulate its response to outdoor temperature variations. This involves considering factors such as building orientation, construction materials, insulation, shading and HVAC systems.
2. **Climate data**: Historical or projected future climate data is used as input for the simulation. This includes outdoor temperature data for the summer period, typically May to September.
3. **Thermal comfort threshold**: A thermal comfort threshold, defined by a maximum allowable indoor temperature, is selected. This threshold is typically set at 26°C or 28°C, depending on the specific requirements and standards.
4. **Calculation**: The simulation calculates the number of hours during the summer period when the indoor temperature exceeds the thermal comfort threshold. These hours are summed to obtain the TO-Juli value.

[37] https://www.helpdeskwater.nl/onderwerpen/waterveiligheid/primaire/normen/

5 Climate risk literature and best practices

5.1 Literature

Several international organisations have developed best practices for climate risk modelling, enabling decision-makers to better understand and manage the potential impacts of climate change. This section provides an overview of the literature, climate risk best practices and relevant guidelines published by regulators, supervisors and other organisations and how they can be applied to analyse climate risks relevant for real estate and mortgage loans. It is important to analyse these best practices and guidance, as 'best practices' are not only part of the *DNSH wording* but should also be applied in practice by financial institutions in the Netherlands according to the Dutch Central Bank (DNB)[38].

At the *core* of the literature review is the reflection and acknowledgement which impact humans and business can have on climate change and what potential consequences lack of action can have. As many of the climate risk guidance & best practices for financial institutions is centred around the effort and impact organisations and humans have it serves as a good starting point. Box 12 lists some observations from the IPCC Sixth Assessment Report (AR6), explaining the urgency of limiting global warming to 1.5 degrees Celsius and investing in adaptation measures.

Box 12: Some observations from the IPCC Sixth Assessment Report (AR6).

Some recent (AR6) IPCC observations:

- 'Human activities, principally through emissions of greenhouse gases, have unequivocally caused global warming, with global surface temperature reaching 1.1°C above 1850–1900 in 2011–2020. Global greenhouse gas emissions have continued to increase, with unequal historical and ongoing contributions arising from unsustainable energy use, land use and land-use change, lifestyles and patterns of consumption and production across regions, between and within countries and among individuals (high confidence).'
- 'The scientific evidence is unequivocal: climate change is a threat to human wellbeing and the health of the planet. Any further delay in concerted global action will miss the brief, rapidly closing window to secure a livable future.[39]'
- 'Global warming, reaching 1.5°C in the near-term[40], would cause unavoidable increases in multiple *climate hazards* and present multiple risks to ecosystems and humans (very high confidence). The level of risk will depend on concurrent near-term trends in *vulnerability*, *exposure*, level of socioeconomic development and adaptation (high confidence). Near term actions that limit global warming to close to 1.5°C would substantially reduce projected losses and damages related to climate change in human systems and ecosystems, compared to higher warming levels, but cannot eliminate them all (very high confidence).'
- Adaptation planning and implementation have continued to increase across all regions (very high confidence). Growing public and political awareness of climate impacts and risks has resulted in at least 170 countries and many cities including adaptation in their climate policies and planning processes (high confidence). Decision support tools and climate services are increasingly being used (very high confidence). Pilot projects and local experiments are being implemented in different sectors (high confidence).

On the role of buildings the IPCC notes:

[38] https://www.dnb.nl/algemeen-nieuws/nieuwsberichten-2023/financiele-sector-aan-de-slag-met-klimaat-en-milieugids/
[39] Working Group II (WGII) contribution to the Sixth Assessment Report (AR6) of the IPCC
[40] In IPCC WII near-term means (2021 – 2040).

- ‘In modelled global scenarios, existing buildings, if retrofitted and buildings yet to be built, are projected to approach net zero GHG emissions in 2050 if policy packages, which combine ambitious sufficiency, efficiency and renewable energy measures, are effectively implemented and barriers to decarbonisation are removed. Integrated design approaches to the construction and retrofit of buildings have led to increasing examples of zero energy or zero carbon buildings in several regions. However, the low renovation rates and low ambition of retrofitted buildings have hindered the decrease of emissions[41]’
- ‘By 2050, bottom-up studies show that up to 61% (8.2 GtCO2) of global building emissions could be mitigated. Policies that avoid the demand for energy and materials contribute 10% to this potential, energy efficiency policies contribute 42% and renewable energy policies 9%. The largest share of the mitigation potential of new buildings is available in developing countries while in developed countries the highest mitigation potential is within the retrofit of existing buildings. The 2020–2030 decade is critical for accelerating the learning of know-how, building the technical and institutional capacity, setting the appropriate governance structures, ensuring the flow of finance and in developing the skills needed to fully capture the mitigation potential of buildings. (high confidence)[42].’
- ‘Integrated design approaches to the construction and retrofit of buildings have led to increasing examples of zero energy or zero carbon buildings in several regions. However, the low renovation rates and low ambition of retrofitted buildings have hindered the decrease of emissions. Mitigation interventions at the design stage include buildings typology, form and multi-functionality to allow for adjusting the size of buildings to the evolving needs of their users and repurposing unused existing buildings to avoid using GHG-intensive materials and additional land.’
- ‘Mitigation interventions include: at the construction phase, low-emission construction materials, highly efficient building envelope and the integration of renewable energy solutions (such as Integration of renewable energy solutions refers to the integration of solutions such as solar photovoltaics, small wind turbines, solar thermal collectors and biomass boilers); at the use phase, highly efficient appliances/equipment, the optimisation of the use of buildings and their supply with low-emission energy sources; and at the disposal phase, recycling and re-using construction materials.’

Potential Consequences of Inaction

Failure to engage in climate change mitigation or adaptation strategies could lead to adverse consequences for the Netherlands, including:

- Increased flood risk: Without effective adaptation measures, such as enhancing flood defences and improving spatial planning, the Netherlands could face more frequent and severe flooding events, endangering lives, property, and the economy.
- Loss of agricultural land: Rising sea levels, combined with increased salinization of soils, could lead to the loss of valuable agricultural land, threatening the country's food security and agricultural sector.
- Damage to infrastructure: Climate-related events, such as storms, floods, and heatwaves, can cause significant damage to infrastructure, including transportation networks, energy systems and public buildings.
- Public health impacts: Prolonged heatwaves, extreme rainfall events and flooding can have severe consequences for public health, ranging from heat stress to waterborne diseases and respiratory issues.

[41] IPCC AR6 WGIII Summary For Policymakers
[42] idem

5.2 IPCC Climate Projections

The Intergovernmental Panel on Climate Change (IPCC) is the leading global body for assessing the science related to climate change. It was established in 1988 by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) to provide policymakers with regular scientific assessments on climate change, its implications, and potential future risks. Its most recent climate projections underscore the urgency of addressing climate change and the need for organisations across sectors to adapt accordingly.

The IPCC recommendations are focussed on global strategies rather than specific advice for sectors like the real estate sector. Key recommendations include: reducing emissions, scaling up adaptation efforts and exploring ecosystem-based adaptation. The report acknowledges that some climate impacts are already irreversible.

<u>The Four Representative Concentration Pathways</u>

The IPCC designs various scenarios known as Representative Concentration Pathways (RCPs) and Shared Socioeconomic Pathways (SSPs), projecting different outcomes based on greenhouse gas concentrations and socioeconomic variables, respectively. The former pathways are particularly relevant in the context of DNSH analysis. These scenarios are instrumental in climate vulnerability and risk assessments as they provide a range of possible future climate conditions under different levels of greenhouse gas emissions. These conditions include changes in temperature, precipitation and sea-level rise.

In order to obtain climate change projections, the climate models use information described in scenarios of GHG and air pollutant emissions and land use patterns. These scenarios help scientists, policymakers and stakeholders understand the potential impacts of various levels of greenhouse gas (GHG) emissions on our climate system.

The RCPs are four distinct GHG concentration trajectories, each associated with a specific radiative forcing[43] level by the year 2100. The four RCPs are portrayed in Table 15.

[43] According to Wikipedia: Radiative forcing measures the difference between incoming solar radiation and outgoing longwave radiation and is used as an indicator of the net energy imbalance in the Earth's atmosphere.

Table 15: RCP Scenarios.

RCP Scenario	Description[44]	Key features
RCP2.6 **(Low Emissions)**	RCP2.6 represents a future where aggressive mitigation measures are implemented, leading to a peak in GHG emissions around 2020, followed by a rapid decline. According to the IPCC, RCP 2.6 requires that methane emissions (CH4) go to approximately half the CH4 levels of 2020 and that sulphur dioxide (SO2) emissions decline to approximately 10% of those of 1980–1990. Like all the other RCPs, RCP 2.6 requires negative CO2 emissions (such as CO2 absorption by trees). RCP 2.6 is likely to keep global temperature rise below 2 °C (pre-industrial levels) by 2100.	• Rapid transition to renewable energy sources. • Effective carbon capture and storage technologies. • Strong international cooperation and climate policies. • Sustainable land use and agricultural practices.
RCP4.5 **(Medium Emissions)**	In RCP4.5, GHG emissions peak around 2040 and decline moderately afterward. RCP 4.5 is more likely than not to result in global temperature rise between 2 °C and 3 °C, by 2100 with a mean sea level rise 35% higher than that of RCP 2.6. Many plant and animal species will be unable to adapt to the effects of RCP 4.5 and higher RCPs. The radiative forcing in this scenario reaches 4.5 W/m² by 2100, with global temperature increases between 2-3°C above pre-industrial levels.	• Gradual transition to low-carbon energy sources. • Some implementations of carbon capture and storage technologies. • Moderate climate policies and international cooperation. • Progress in sustainable land use and agriculture.
RCP6.0 **(Medium to High Emissions)**	RCP6.0 is characterised by a slower transition to low-carbon energy sources, with GHG emissions peaking around 2080 and a radiative forcing of 6.0 W/m² by 2100. In this scenario, global temperature increases range from 3-4°C above pre-industrial levels.	• Slow and uneven adoption of renewable energy sources. • Limited use of carbon capture and storage technologies. • Weak climate policies and fragmented international cooperation. • Mixed success in sustainable land use and agriculture.
RCP8.5 **(High Emissions)**	RCP8.5 represents a business-as-usual scenario, with a continued reliance on fossil fuels and minimal efforts to reduce GHG emissions. The radiative forcing in this scenario reaches 8.5 W/m² by 2100, resulting in global temperature increases of over 4°C above pre-industrial levels.	• Continued dependence on fossil fuels. • Limited adoption of carbon capture and storage technologies. • Ineffective climate policies and poor international cooperation. • Unsustainable land use and agricultural practices.

[44] Source: https://ar5-syr.ipcc.ch/topic_futurechanges.php

5.3 KNMI

The Royal Netherlands Meteorological Institute (KNMI) is the national institution in the field of climate science and meteorology in the Netherlands. An important aspect of KNMI's work is the development and execution of climate projections to better understand future climate change and its consequences, specifically for the Netherlands. In this section we discuss the climate projections of KNMI and how they relate to the advice of the Intergovernmental Panel on Climate Change (IPCC).

KNMI Climate Projections

KNMI develops and maintains climate projections to provide insights into potential future climate changes in the Netherlands and surrounding regions. These projections are based on advanced climate models and are regularly updated to incorporate the latest scientific insights and developments. Some key aspects of KNMI's climate projections are:

- Scenario approach: KNMI climate scenarios describe different future climate conditions based on diverse assumptions about greenhouse gas emissions and climate sensitivity. This allows policymakers and stakeholders to explore the potential consequences of different climate pathways and develop appropriate adaptation and mitigation strategies.
- Regional focus: KNMI climate projections focus on the Netherlands and surrounding regions. This enables KNMI to provide more detailed and tailored information about the impacts of climate change at the local and regional levels, such as sea-level rise, changing precipitation patterns and extreme weather conditions.
- Communication and collaboration: KNMI collaborates with national and international partners, such as the IPCC, to share and disseminate knowledge and information about climate change. Additionally, KNMI is committed to clear communication of climate projections to a wide range of stakeholders, including policymakers, businesses and the public.

Connection to IPCC Advice

KNMI is active both nationally and internationally in climate research and contributes to the reports of the IPCC. While the climate projections of KNMI and the IPCC have different geographic scales and focus areas, there are some important similarities and complementarities between the two approaches:

1. Scientific basis: Both institutions base their climate projections on the latest scientific knowledge and advanced climate models. The KNMI climate projections can be seen as a refinement of the global climate projections of the IPCC, with a specific focus on the Netherlands and surrounding regions.
2. Scenario approach: Both the IPCC and KNMI use scenarios to explore different future climate conditions. KNMI bases its scenarios on the global scenarios of the IPCC, such as the Representative Concentration Pathways (RCPs) and Shared Socioeconomic Pathways (SSPs) and adapts them for regional applications.
3. Adaptation and mitigation: The climate projections of KNMI and the IPCC inform policymakers and stakeholders about the consequences of climate change and the need for adaptation and mitigation measures. The regional focus of KNMI allows the institute to provide more specific and tailored information that is relevant for local and national decision-making.
4. Collaboration and knowledge exchange: KNMI actively contributes to the work of the IPCC by participating in research groups, sharing data, and assessing scientific literature. This collaboration ensures that the climate projections of KNMI and the IPCC complement and reinforce each other.

The climate projections of KNMI and the IPCC are closely interconnected and complement each other. Both institutions provide valuable insights into the potential consequences of climate change and the need to take adaptation and mitigation measures.

5.4 Network for Greening the Financial System

The Network for Greening the Financial System (NGFS) is an internal a network of central banks and financial supervisors that aims to accelerate the scaling up of green finance. The NGFS Climate Scenarios are a set of scenarios developed by the NGFS, a group of central banks and financial regulators from various countries. These scenarios aim to provide a framework for assessing climate-related risks and opportunities for the financial sector. They consider different pathways for the transition to a low-carbon economy, considering potential physical and transition risks.

They provide a common and up-to-date reference point for understanding how climate change (physical risk) and climate policy and technology trends (transition risk) could evolve under different future scenarios. The scenarios explore a range of outcomes:

- Orderly scenarios assume climate policies are introduced early and become gradually more stringent. Both physical and transition risks are relatively subdued.
- Disorderly scenarios explore higher transition risk due to policies being delayed or divergent across countries and sectors. Carbon prices are typically higher for a given temperature outcome.
- Hot house world scenarios assume that some climate policies are implemented in some jurisdictions, but global efforts are insufficient to halt significant global warming. Critical temperature thresholds are exceeded, leading to severe physical risks and irreversible impacts like sea-level rise.
- Too little, too late scenarios would assume that a late transition fails to limit physical risks. While no scenarios have been specifically designed for this purpose, this space can be explored by assuming higher physical risk outcomes for the disorderly scenarios.

The scenarios draw primarily on existing mitigation and adaptation pathways assessed by the Intergovernmental Panel on Climate Change (IPCC) reports[45].

5.5 TCFD guidance on physical climate risks and opportunities

The Task Force on Climate-related Financial Disclosures (TCFD)[46] has published guidance on the assessment of physical climate risks and opportunities. The TCFD recommendations identify climate-related physical risks as being one of the two main types of risks that financial and non-financial corporations should disclose, including both acute (event-driven) and chronic risks (those due to longer-term shifts in climate patterns). Some recommendations relevant for climate risk assessment include[47]:

- *Describe the organization’s processes for identifying and assessing climate-related risks.*
- *Describe how processes for identifying, assessing, and managing climate-related risks are integrated into the organization’s overall risk management.*

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[45] Network for Greening the Financial System Technical document Guide to climate scenario analysis for central banks and supervisors June 2020.

[46] The Task Force on Climate-related Financial Disclosures (TCFD) is an initiative established by the Financial Stability Board (FSB) at the request of the G20. The task force's mission is to develop voluntary, consistent climate-related financial risk disclosures for use by companies in providing information to investors, mortgage lenders, insurers and other stakeholders.

[47] Source: https://www.fsb-tcfd.org/recommendations/

- *Disclose the metrics used by the organization to assess climate-related risks and opportunities in line with its strategy and risk management process.*
- *Describe the climate-related risks and opportunities the organization has identified over the short, medium and long term.*

5.6 European Central Bank – Climate Stress Tests

In recent years, the European Central Bank (ECB) has taken significant effort to address climate-related risk within the financial sector. Recognising the threat that climate change poses to financial stability, the ECB has implemented a series of climate stress tests, urging banks to integrate climate-related risks into their risk management processes. In this context, one sector that stands out in its susceptibility to climate-related risks is residential real estate.

The ECB's climate stress test is a comprehensive assessment designed to evaluate a bank's ability to withstand various climate risk scenarios. These scenarios encompass both physical risks, such as extreme weather events and transitional risks, such as a sharp increase in the price of carbon over the next three years[48]. In Box *13* we explore the ECB climate stress test(s).

The stress test seeks to examine a bank's climate risk metrics, including the volume of greenhouse gas emissions they finance. More importantly, it requires banks to evaluate their response to common transition scenarios over the next 30 years. Such a long-term perspective is essential in understanding the systemic impacts of climate change and structuring adequate responses.

Climate stress testing exercises have become an increasingly frequent applied tool for supervisors to evaluate the effects of climate-related risks on the banking system. Banks themselves are increasingly using these exercises to enhance their required disclosures and strategic decision-making in relation to climate risk management. Not only from a governance and prudential perspective but also, for instance, from a data (handling) perspective.

When it comes to the residential real estate sector, the relevance of the ECB's climate stress test becomes even more pronounced. Residential real estate assets are inherently vulnerable to physical climate risks, including floods, fires and extreme weather events. Moreover, the transition to a low-carbon economy may impact the value of properties based on their energy efficiency or (in)ability to adopt to climate hazards.

As such, the ECB's climate stress test urges banks to collect and estimate climate-relevant data about their residential real estate portfolios. This includes data on the geolocation of properties and Energy Performance Certificates (EPCs) for real estate, among others[49]. As mentioned in Section 2, recently the ESA's and ECB have expressed their strong advice to the European financial sector to **gather climate (risk) related data at origination of mortgage loans and loans**.

[48] https://greencentralbanking.com/2021/10/19/ecb-bank-climate-stress-test-methodology/
[49] https://www.moodysanalytics.com/regulatory-news/dec-19-22-ecb-report-sets-out-good-practices-for-climate-stress-testing

Box 13: ECB Climate Stress Test.

In 2022, the European Central Bank (ECB) conducted a climate risk stress test of the Eurosystem balance sheet as part of its plan to incorporate climate change considerations into its monetary policy strategy. The objective was to analyse the sensitivity of the Eurosystem's financial risk profile to climate change and to improve the Eurosystem's climate risk assessment capabilities. The scope of the test covered several monetary policy portfolios, including corporate bonds, covered bonds, asset-backed securities (ABSs) and collateralised credit operations[50].

The stress test utilised scenarios developed by the Network of Central Banks and Supervisors for Greening the Financial System (NGFS) and the ECB. Three long-term scenarios were used, projecting macro-financial and climate variables over 30 years. These scenarios varied based on the extent of climate policy implementation, primarily through a carbon tax and the different types of climate risk expected to materialize as a result. These included a "hot house world" scenario involving severe physical risk but no transition risk due to the lack of climate policies; a "disorderly transition" scenario where climate policies are delayed, leading to severe transition risk but limited physical risk; and an "orderly transition" scenario where climate policies are implemented promptly. Two additional short-term scenarios were also considered, one involving severe physical hazards over one year and another involving sharp increases in carbon prices over three years.

The results showed that both types of climate risk—transition risk and physical risk—had a significant impact on the risk profile of the Eurosystem balance sheet. The disorderly transition and hot house world scenarios produced risk estimates that were between 20% and 30% higher than those under the orderly transition scenario. The hot house world scenario indicated a higher risk impact, showing that physical risk had a more significant impact on the Eurosystem balance sheet than transition risk. The results of the stress test showed that the value of real estate assets could decline by up to 10% in the business-as-usual scenario and by up to 20% in the transition scenario.

Both covered bonds and ABSs showed a higher relative risk increase under the hot house world scenario than under the disorderly transition scenario. **Covered bonds and ABS's secured by real estate were particularly exposed to fluctuations in housing market valuations**, emphasizing the importance of the house price channel in the transmission of climate risk. Going forward, the ECB plans to conduct regular climate risk stress tests, with climate risk considerations becoming an integral part of the risk management framework. The ECB's climate stress test has highlighted the need for banks and other financial institutions to take steps to manage climate risks.

5.7 European Central Bank Climate risk recommendations for real estate

The European Central Bank released a report in December 2022 that provided guidance for banks on how to improve their climate stress testing capabilities. This was based on best practices identified during the 2022 ECB Climate Stress Test. The report presents a variety of best practices obtained during an in-depth assessment of information provided by banks. It outlines the criteria used to identify these practices and details the advanced approaches taken for internal climate risk stress testing frameworks. The report[51] covers various aspects such as the scope of the frameworks, the choice of scenarios and the balance sheet assumptions used. It also discusses the advanced approaches used by banks to collect climate-relevant data and the proxy methods developed to estimate such data. The data categories covered in the report include the allocation of banks' income to industrial sectors, the geolocation of counterparties and of collateral from real estate portfolios, data on greenhouse gas emissions of counterparties and data on Energy Performance Certificates (EPCs) for real estate. In addition, the report stated the recommendations that climate and environmental risks should be integrated in loan pricing frameworks and reflected in valuation and management of collateral.

[50] https://www.ecb.europa.eu/pub/economic-bulletin/focus/2023/html/ecb.ebbox202302_06~0e721fa2e8.en.html
[51] ECB report on good practices for climate stress testing, 2022

The ECB notes that banks that are more advanced in their data sourcing approaches and estimation methodologies for climate data are also more advanced with respect to quantifying the impact of climate-related risk on their exposures. However, many credit risk parameters projected by banks were found to be insensitive to the climate risk shocks depicted in the scenarios. Good practices mainly focus on transition risk and the transmission to the probability of default, while only a few institutions have developed approaches to quantify the impact of transition risk on loss given default.

The ECB identified the integration of physical risk into credit risk models as an area where banks need to step up their efforts. To assist with this, the report provides good practices to help banks and supervisors prepare for future climate stress test exercises. The ECB expects banks to further develop their climate stress test frameworks and their data and analytical capabilities and to progress beyond the examples of good practices provided in the report.

The report notes[52]:

- "*To quantify the financial risk implications of acute physical risks, highly granular data at the exposure level are required. This holds true for exposures to corporates with respect to the location of firms' activities as well as for the location of collateral and financed real estate exposure. Collateral plays an important role in mitigating losses for banks but may itself be subject to damage or loss of value.*"
- "*Good practice entails the availability of geolocation data at loan level in internal systems.*"

5.8 Dutch Central Bank – Best Practice Guidance for Climate Scenarios

'Being prepared for risks is not a voluntary matter', is stated in the opening remarks of the recently published Dutch Central Bank (DNB) guide[53] for managing climate- and environmental risks. Financial institutions are legally obliged[54] in the Netherlands to manage risks that are relevant to them, including Environmental, Social and Governance (ESG) risks. The guide states that '*It is crucial for the sector to take action because the investments and holdings of financial institutions are increasingly exposed to the direct physical risks of climate change and environmental degradation, as well as the risks associated with the transition to a climate-neutral society*'.

DNB expects at the very least that an institution analyses the extent to which climate and environmental risks are material for the institution. This means that an institution maps out these risks and assesses their materiality. Subsequently, the institution is required to manage the material risks. Through the *Guide*, DNB highlights four areas of focus that may be relevant for achieving comprehensive management of climate and environmental risks by financial institutions. These areas of focus pertain to (1) business model and strategy, (2) governance, (3) risk management and (4) information provision. DNB follows the recommendation of the Network for Greening the Financial System (NGFS) to establish supervisory expectations on these areas.

DNB has provided for on the assessment of materiality (of climate and environmental risks) for financial institutions, see Box 14. In Box *15* and Table *16* we have summarised the DNB observations on climate risk management for financial institutions.

[52] ECB report on good practices for climate stress testing, December 2022
[53] DNB: Gids voor de beheersing van klimaat- en milieurisico's Maart 2023
[54] Op grond van artikel 3:17 van de Wet op het financieel toezicht (Wft) en artikel 143 van de Pensioenwet (Pw) zijn Nederlandse financiële ondernemingen respectievelijk pensioenfondsen verplicht te beschikken over een beheerste en integere bedrijfsvoering. Daarnaast is voor verschillende sectoren specifieke, nadere regelgeving van kracht ten aanzien van de beheersing van prudentiële risico's.

Box 14: DNB: Considerations for materiality assessment.

DNB: Considerations for materiality assessment.

1. **Make a distinction between physical and transition risk factors.** Examples of physical risk factors include drought, floods, loss of biodiversity and water stress. Transition risk factors include policy, technology and market sentiment.
2. **Impact on areas of prudential risk**: The institution identifies how the above-mentioned physical and transition risk factors can have an impact on the risk domains used by the institution, such as credit, market, liquidity, operational/reputational, business model and strategic risk.
3. **Incorporate Different time horizons**: A distinction can be made between short-term (0-5 years), medium-term (5-10 years) and long-term (>10 years).
4. **Qualitative and quantitative analysis methods:** Examples of quantitative methods include exposure and/or concentration analysis, scenario analysis, sensitivity analysis, portfolio alignment assessment and ratings or climate scores from external data providers. Qualitative methods include, for example, a 'heat map' and qualitative scenario analysis.
5. **Materiality assessment**: By combining information on probability and impact for different time horizons, the institution can assess materiality. This assessment is institution-specific and depends on the characteristics of the business model, operational environment and risk profile of the institution. It is important for institutions to document the outcomes of this analysis. This way, the institution can provide an explanation if climate and environmental risks are found not to be material.

Box 15: DNB observations on climate risk management for financial institutions.

DNB observations on climate risk management for financial institutions:

- Scenario analyses and stress tests can be useful tools given the uncertainties and complexities associated with climate and environmental risks in both the short and long term.
  - For the shorter regular planning horizon, these tools can be used to assess the impact of these risks on (required) capital. "Business impact" analyses and "business continuity" tests can also be employed to test the resilience of critical operational processes due to climate and environmental risks.
  - Longer-term scenario analyses are particularly useful for evaluating the resilience of the business model. For example, scenarios involving temperature increases of 1.5 versus 3 or more degrees Celsius, or scenarios in which the transition to a sustainable economy does not proceed in an orderly manner. These analyses can be qualitative in nature and provide input for strategic planning and decision-making.
- Based on risk appetite, tolerances can be established for exposures to sectors or geographic areas that are highly sensitive to climate and environmental risks and thus pose market or counterparty risks. To monitor risk appetite, it is important to clearly define tolerances and, where possible, measure them using indicators. To form a comprehensive risk picture, it may be necessary to define multiple indicators for a risk. These could include indicators related to concentration risks in investments and loans or indicators that reflect the potential impact of physical risks on outsourcing.
- Where quantitative data is lacking, qualitative indicators based on expert judgment can be used. Probability and impact analyses can be used to assess whether the identified risk level falls within the risk tolerance and thus the risk appetite for each risk indicator.

- If the potential impact of climate and environmental risks exceeds the established risk tolerance, it is important to indicate how these risks will be mitigated within a specified timeframe. It is advisable to evaluate the effectiveness of the mitigation measures, make them measurable whenever possible and monitor them.

Table 16: DNB: Points of attention for developing and conducting scenario analyses.

Phase	Action	DNB Guidance[55]
1	Determine Goal	**Insight:** into long-term risks to the business model or short-term financial risks. **Input:** for risk management or for strategic policy discussions.
2	Chose Scenario	**Type:** (depends on the objective): qualitative or quantitative, trend, exploratory or stress. **Number:** 2 or more, including 1.5 degrees temperature increase
3	Assumptions, magnitude and parameters	**Assumptions:** proprietary or aligned with recognised third parties (NGFS, KNMI, among others). **Magnitude:** choice of emissions, temperature increase. **Parameters**: type of transition (orderly and timely, disorderly, or no transition). Adopt prudent assumptions in a stress scenario.
4	Time horizon	**Short-term:** (up to 5 years) and **medium-term** (5 to 10 years) **horizon** for financial risks and impact on the solidity of the institution. **Long-term horizon:** (>10 years) for qualitative assessments of impact on the business environment and business model.
5	Method and conduct	**Method:** calculation model or narrative behind the scenarios. **Approach:** involving stakeholders, workshops with experts.

[55] Adapted from: DNB *Gids voor de beheersing van klimaat- en milieurisico's Maart 2023*, page 6.

6 Analysis of DNSH wording in the EU Taxonomy

6.1 Appendix A – Generic criteria for DNSH to climate change adaptation

In Figure *12* below, the wording of Appendix A is depicted. In Section 6.3 we will analyse this wording from the perspective of Section 7.7 (Acquisition and ownership of buildings) of the Climate Delegated Act. We present a linguistic decomposition and establish (working) assumptions for key definitions and synthesise core building blocks.

The latter is important as Appendix A does not simply list a single 'check' or 'criterium' but a describes a sequence of 'steps' to be performed as part of the DNSH analysis. Moreover, these steps have different subsequent steps depending on certain 'key' definitions. A decision tree can be distilled from the wording of Appendix A: highlighting an intricate array of potential decisions that depend not only on certain definitions but also the perspective of the economic activity (i.e. Section 7.7) itself.

Note: In the previous section we described that additional DNSH TSC can be applicable per economic activity. It is important to note however that in most cases the climate delegated act refers to the DNSH TSC in the (literal) annex of the text. Therefore, it is important to observe that these DNSH TSC have been designed and formulated, purposefully, in a generic manner – not detailing a specific economic activity at first hand. Upon closer inspection of the (literal) wording one can see implicit reference to the wording of the economic activity at hand.

Note 2: Technical Screening Criteria for the other remaining objectives have been published, via the Environmental Delegated Act. Upon first inspection, the generic DNSH criterium towards climate change adaptation, from the perspective of environmental objectives 3 – 6 are identical to that of environmental objective 1: Climate Change Mitigation.

Figure 12: EU Taxonomy DNSH wording for Appendix A.

APPENDIX A: GENERIC CRITERIA FOR DNSH TO CLIMATE CHANGE ADAPTATION

I. Criteria

The physical climate risks that are material to the activity have been identified from those listed in the table in Section II of this Appendix by performing a robust climate risk and vulnerability assessment with the following steps:

(a) screening of the activity to identify which physical climate risks from the list in Section II of this Appendix may affect the performance of the economic activity during its expected lifetime;

(b) where the activity is assessed to be at risk from one or more of the physical climate risks listed in Section II of this Appendix, a climate risk and vulnerability assessment to assess the materiality of the physical climate risks on the economic activity;

(c) an assessment of adaptation solutions that can reduce the identified physical climate risk.

The climate risk and vulnerability assessment is proportionate to the scale of the activity and its expected lifespan, such that:

(a) for activities with an expected lifespan of less than 10 years, the assessment is performed, at least by using climate projections at the smallest appropriate scale;

(b) for all other activities, the assessment is performed using the highest available resolution, state-of-the-art climate projections across the existing range of future scenarios[320] consistent with the expected lifetime of the activity, including, at least, 10 to 30 year climate projections scenarios for major investments.

The climate projections and assessment of impacts are based on best practice and available guidance and take into account the state-of-the-art science for vulnerability and risk analysis and related methodologies in line with the most recent Intergovernmental Panel on Climate Change reports[321], scientific peer-reviewed publications, and open source[322] or paying models.

For existing activities and new activities using existing physical assets, the economic operator implements physical and non-physical solutions ('adaptation solutions'), over a period of time of up to five years, that reduce the most important identified physical climate risks that are material to that activity. An adaptation plan for the implementation of those solutions is drawn up accordingly.

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320 Future scenarios include Intergovernmental Panel on Climate Change representative concentration pathways RCP2.6, RCP4.5, RCP6.0 and RCP8.5.

321 Assessments Reports on Climate Change: Impacts, Adaptation and Vulnerability, published periodically by the Intergovernmental Panel on Climate Change (IPCC), the United Nations body for assessing the science related to climate change produces, https://www.ipcc.ch/reports/.

322 Such as Copernicus services managed by the European Commission.

For new activities and existing activities using newly-built physical assets, the economic operator integrates the adaptation solutions that reduce the most important identified physical climate risks that are material to that activity at the time of design and construction and has implemented them before the start of operations.

The adaptation solutions implemented do not adversely affect the adaptation efforts or the level of resilience to physical climate risks of other people, of nature, of cultural heritage, of assets and of other economic activities; are consistent with local, sectoral, regional or national adaptation strategies and plans; and consider the use of nature-based solutions[323] or rely on blue or green infrastructure[324] to the extent possible.

II. Classification of climate-related hazards[325]

	Temperature-related	**Wind-related**	**Water-related**	**Solid mass-related**
Chronic	Changing temperature (air, freshwater, marine water)	Changing wind patterns	Changing precipitation patterns and types (rain, hail, snow/ice)	Coastal erosion
	Heat stress		Precipitation or hydrological variability	Soil degradation
	Temperature variability		Ocean acidification	Soil erosion
	Permafrost thawing		Saline intrusion	Solifluction
			Sea level rise	
			Water stress	
Acute	Heat wave	Cyclone, hurricane, typhoon	Drought	Avalanche
	Cold wave/frost	Storm (including blizzards, dust and sandstorms)	Heavy precipitation (rain, hail, snow/ice)	Landslide
	Wildfire	Tornado	Flood (coastal,	Subsidence

323 Nature-based solutions are defined as 'solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions'. Therefore, nature-based solutions benefit biodiversity and support the delivery of a range of ecosystem services. (version of [adoption date]: https://ec.europa.eu/research/environment/index.cfm?pg=nbs).

324 See Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Green Infrastructure (GI) — Enhancing Europe's Natural Capital (COM/2013/0249 final).

325 The list of climate-related hazards in this table is non-exhaustive, and constitutes only an indicative list of most widespread hazards that are to be taken into account as a minimum in the climate risk and vulnerability assessment.

6.2 EU Guidance and Q&A

Regulations serve as the foundation for compliance, the accompanying guidance and Q&A's provide valuable insights, interpretations, and clarifications that help stakeholders navigate the complexities of EU law. Analysing the latest guidance and Q&A's allows stakeholders to access sector-specific information that goes beyond the general provisions of regulations. Analysing these documents helps stakeholders navigate potential ambiguities and apply the regulations correctly, minimising the risk of misinterpretation or non-compliance due to uncertainties.

In December 2022 the European Commission published the '*Draft Commission notice on interpretation and implementation of certain legal provisions of the EU Taxonomy Climate Delegated Act*', informally known as the Q&A document.

The Q&A document describes answers to questions on different sections of the CDA including additional guidance for the DNSH TSC. Although the Q&A document lists that its content has been approved by the European Commission 'in principle', there are some important disclaimers listed in the introduction of the document – on the status of this guidance[56].

The remainder of this chapter contains the Questions and Answers that the working group members of the EEM NL Hub deemed relevant in respect of the detailed analysis of the actual wording of the TSC for DNSH (presented in Section 2.3). And although useful guidance is provided in quite a few DNSH aspects, significant items remain open for interpretation and classification.

In the below tables we use the word 'answer' to relate to the guidance provided by the Q&A document.

[56] "*The replies to FAQs contained in this Notice clarify the provisions already contained in the applicable legislation. They do not extend in any way the rights and obligations deriving from such legislation nor introduce any additional requirements for the operators concerned and competent authorities. The FAQs are merely intended to assist financial and non-financial undertakings in the implementation of the relevant legal provisions. Only the Court of Justice of the European Union is competent to authoritatively interpret Union law. The views expressed in this Notice cannot prejudge the position that the Commission might take before the Union and national courts.*" page 2.

<table>
<tr><td>Reference</td><td>Excerpt</td></tr>
<tr><td>141</td><td>141. The substantial contribution criteria of the activity “Acquisition and ownership of buildings” in Section 7.7. state that ‘For buildings built after 31 December 2020, the building meets the criteria specified in Section 7.1 of this Annex that are relevant at the time of the acquisition’. Does this refer both to the substantial contribution and DNSH criteria of Section 7.1 (“Construction of new buildings”)?

As this text is included under the substantial contribution criteria, and there are specific criteria listed below for DNSH, the text refers only to the relevant criteria specified in Section 7.1. for substantial contribution to climate change mitigation. Where the DNSH criteria under Section 7.7 indicate N/A it means there are no specific requirements for the respective environmental objective.</td></tr>
<tr><td>Interpretation of answer</td><td>When considering EU Taxonomy alignment under Section 7.7, for buildings built[57] after 31 December 2020, only the Substantial Contribution Criteria[58] as specified in Section 7.1 need to be complied with and not the DNSH TSC of Section 7.1.

Combined with the answer provided in FAQ 144 the financing of new constructions for residential homeowners can be regarded as an economic activity to be considered under Section 7.7. Therefore, irrespective of the fact that we are considering the purchase (acquisition) of an existing property or the financing of a new construction, only the DNSH TSC of Section 7.7 apply.</td></tr>
</table>

<table>
<tr><td>Reference</td><td>Excerpt</td></tr>
<tr><td>166</td><td>166. With the submission of the 6th IPCC Assessment Report, the IPCC presented new climate scenarios. Are these to be taken into account instead of the existing scenarios cited in the EU Taxonomy?

Criterion 3 of the substantial contribution criteria to climate change adaptation specifies that “climate projections and assessment of impacts are based on best practice and available guidance and take into account the state-of-the-art science for vulnerability and risk analysis and related methodologies in line with the most recent Intergovernmental Panel on Climate Change reports”.

Therefore, users should refer to the most recent IPCC Assessment Reports once they become available.</td></tr>
<tr><td>Interpretation of answer</td><td>The Climate Delegated Act refers to the climate projections made by the IPCC AR(5) report. Since then, a more recent version of this study has been published.

However, for the assessment of Dutch residential real estate it is important to (also) assess the projections made by the KNMI. The KNMI developed climate scenarios for the future climate change in the Netherlands. The most recent scenarios are the KNMI’14 scenarios and are based on the fifth Assessment Report of the IPCC[59]. We employ these scenarios as a new set of KNMI climate scenario data is due to be published in October of 2023.</td></tr>
</table>

[57] As highlighted in answer 106 and 143 the date of submission of the complete planning permission application is the relevant date for deciding which TSC apply.

[58] the energy performance of the building resulting from the construction, is at least 10 % lower than the threshold set for the nearly zero-energy building (NZEB) requirements, see answer 106 and 143 of the Q&A.

[59] At the moment of writing there are no KNMI projections available for the Netherlands that are based on AR(6). These are expected to be published in 2023Q3.

Reference	Excerpt
168	**168. Is it required to use all 4 IPCC pathways (RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5)? Do the outcomes of each analysis have to be assessed separately?** No, it is not required to use all 4 Intergovernmental Panel on Climate Change (IPCC) pathways. To start the assessment, it is important to see whether the activity that is subject to the climate risk and vulnerability assessment has been subject to impacts from some hazards in the past (e.g. sea-level rise). If this is not the case, following line with the precautionary principle, RCP 8.5 (i.e. low mitigation) should be always used. If positive, lower end scenarios, e.g. RCP 4.5 could be used. The outcomes of each analysis should be assessed separately.
Interpretation of answer	Two noticeable observations can be made: 1) it is mentioned that to assess if the activity has been subject to the impact of the relevant climate hazards in the past and 2) that if this is not the case, a conservative approach should be applied by employing the most severe climate scenario. It is not entirely clear what is meant with 'positive' (we assume not at high risk of RCP 8.5) one should look into less severe (higher mitigating) scenario's. In addition, this results in a cascade or decision tree: - Has the economic activity been influenced by the relevant hazards in the past? - If this is not the case, run the RCP 8.5 scenario. - If this is *positive* RCP 4.5 should be assessed. This answer should particularly be read in conjunction with FAQ 170.

Reference	Excerpt
170	**170. How does proportionality influence the scope of the robust climate risk and vulnerability assessment that has to be conducted as part of the DNSH climate change adaptation criteria?** The objective of the robust climate risk and vulnerability assessment is to identify significant physical climate risks to the performance of the economic activity. This assessment then forms the basis for the identification of suitable adaptation measures that are presented as part of an adaptation plan. According to the Climate Delegated Act, Annex 1, Appendix A, the climate risk and vulnerability assessment carried out should follow state-of-the-art methodology and take into account the most recent highest-resolution data available. The scope of the assessment, methods and data used to achieve this objective may vary to maintain proportionality. For example, in many cases it may be enough to use a pessimistic scenario, such as RCP 8.5, and not consider all four RCP scenarios, provided that the consideration of additional scenarios is unlikely to yield new insights relevant for the risk assessment.

	The depth of the assessment may also vary, as long as it is sufficient to identify the physical climate risks that are material to the activity. For example, the extent to which risks may exist in the supply chain or in upstream production processes and whether these aspects need to be considered in the assessment can be weighed up individually for each activity. Decisive factors for the proportionality of the selected assessment approach can be the size of the company, the type, scale and context of the activity, the business model or the position in the supply chain. For example, replacing windows in an office building to improve energy efficiency requires a less detailed climate risk assessment than building a dam to generate hydropower. The frequency of the climate risk and vulnerability assessment should also be proportionate to its objectives. Appropriate occasions for updates of the assessment and the resulting adaptation plan are changes that increase the exposure to the identified risks or that may pose new risks or significantly alter already identified risks to the performance of the economic activity, such as changes in: o the assessed economic activity, e.g. new suppliers or new production facilities; o the climate data basis of the assessment, e.g. unforeseen changes in climatic systems, changes in assumptions for climate models, or technological advances in climate modelling.
Interpretation of answer	Initially when reading Appendix A, one might consider the proportionality phrase in the context of the economic activity. In this answer, the proportionality concept seems to adhere to the rigour and scope of the considered climate scenarios. The illustration of the examples provided give an interesting view on the intentions of the European Commission. The example directly alludes to corporate financing: as in the example of business finance and the potential risks in the supply chain. In addition, the answer states that decisive factors are the size of the company, the type, scale and the context of the activity and the business model. All these factors are not relevant for the financing of the real estate to residential homeowners. Moreover, an example is provided for the use case of the economic activity of financing the replacement of windows in an office building as requiring less detailed climate risk assessment! Although the latter example is a corporate financing venture, it illustrates that 'less' detailed climate risk assessment is needed. Unfortunately no example or use case has been provided that would be relevant for residential real estate. Newly identified climate risks and its inherent exposures are triggers for updating the CRVA.

<table>
<tr><th>Reference</th><th>Excerpt</th></tr>
<tr><td>171</td><td>171. What documentation must be provided to meet DNSH requirements related to climate change adaptation?

To meet the requirements for DNSH to climate change adaptation for an economic activity for the purpose of the EU Taxonomy, it is essential to present a coherent adaptation plan if climate risks have been identified. The measures included in the plan should have been systematically assessed for their suitability to reduce the most important physical climate risks for the activity while meeting additional requirements outlined in the Climate Delegated Act. The adaptation plan should also include a timetable for implementing the measures and a documentation of measures already implemented. Adaptation measures have to be implemented for new assets at the time of completion and for existing assets within five years of the identification of the associated climate risks.

The most important physical climate risks have to be identified using a robust, comprehensible and proportionate climate risk and vulnerability assessment.</td></tr>
<tr><td>Interpretation of answer</td><td>No explicit disclosure formats or templates exist to date for the DNSH TSC of the EU Taxonomy. Therefore, it is important to understand the components that are needed to ‘prove’ alignment with the EU Taxonomy, specifically for the more abstract or generic criteria such as described in Appendix A.

We distil from FAQ 171 that a (coherent) adaptation plan is needed, which contains:
• The most important physical climate risks for the activity;
• A plan to reduce these aforementioned risks;
• A timetable – which described the 1) the measures already implemented and 2) a timetable of the implementation measures that are planned within the coming 5 years.

These components are described without additional details or requirements.</td></tr>
</table>

<table>
<tr><th>Reference</th><th>Excerpt</th></tr>
<tr><td>172 & 173</td><td>172. Will the use of existing environmental risk inventories (e.g. for floods, avalanches) with consideration of particularly relevant environmental risk scenarios (e.g. for temperature, precipitation, wind) suffice for the time being?

The existing environmental risk inventories that include the most important and relevant climate parameters are sufficient for the time being.

173. What are the minimum requirements for a climate risk and vulnerability assessment in terms of scope and level of details (materiality of risks etc.)?

• Lifespan
• All relevant objects of the economic activity should be considered
• A range of climate projections based on future scenarios
• Catalogue of climate-related “hazards that are to be taken into account as a minimum" (Climate Delegated Act, Annex I, Appendix A)</td></tr>
</table>

Interpretation of answer	The observation is made that not necessarily all potential (physical) climate risks have to be accounted for in the CRVA. Only the most 'important' and 'relevant' risks. Hoping that the answer to FAQ 173 would actually go into the scope and level of detailed that is necessary for a CRVA, the answers unfortunately fall short by only listing generic items that are mentioned in the Appendix A: - *Lifespan;* - *All relevant objects of the economic activity should be considered;* - *A range of climate projections based on future scenarios;* - *Catalogue of climate-related "hazards that are to be taken into account as a minimum" (Climate Delegated Act, Annex I, Appendix A).* This answer does not address: - The practical use of the "lifespan" assessment in terms of use and scope (would it relate to the financing, the lifespan of the economic activity or both). The third bullet: a range of climate projections could be regarded as somewhat contradicting to answer 168.

Reference	Excerpt
174 & 175	**174. Which standards need to be used to conduct a climate risk and vulnerability analysis (ISO, EU guidelines on climate resilience for infrastructure projects)? Are undertakings free to choose their own method?** There is no single method of developing the climate risk and vulnerability assessment. They can be based on a wide range of approaches to gather information, from data and model driven approaches (e.g., climate data, impact models) to more review, or expert-based approaches. However, an ISO-norm (ISO/DIS 14091: Adaptation to climate change — Guidelines on vulnerability, impacts and risk assessment)[61] transposed also as European standard and national standards in Member States, contains a selection of useful tools, covering the entire process of preparing, conducting, and communicating the results of the assessment. More specifically, these tools provide guidance on, e.g. developing impact chains, aggregating indicators and risk components, or assessing adaptive capacity. Recently, there is also a grant under preparation[62] with "*an operational, consistent and more advanced multi-risk assessment framework tool across scales and levels of governance that can be used by all regions and communities in Europe*" among the expected outcomes. **175. What is meant by 'state-of-the-art climate projections' referred to in the substantial contribution criteria to climate change adaptation?** Latest projections taking into account the evolving scientific knowledge (e.g. on tipping points).
Interpretation of answer	The answer provided refers to an ISO standard as a method to take into consideration. The ISO standard is partially publicly available although the components that describe the process of preparing, conducting, and communicating the results is only available behind a paywall. The former (public) section does provide useful 'standard' definitions (which often include references towards IPCC definitions). The later section that is behind the paywall is not in the scope of this analysis.

6.3 Linguistic Analysis

This section contains the analysis of key phrases of the wording in Appendix A and establishes (working) assumptions for the interpretation thereof. The EEM NL Hub WG has identified several key words and phrases as key to the understanding and application of Appendix A. These have been highlighted in bold in the text of this section.

Note that the proposed interpretation is the interpretation that is applicable in the context of financing residential real estate – more specifically to the economic activity of 'Acquisition and ownership of buildings'.

Box 16: A word on the interpretation.

A word on the interpretation.

Compared to the substantial contribution criteria of the EUT there is less wording in Appendix A that (directly) references to regulations or common practices in building codes. In the EEM NL Hub WG's assessments most of the key phrases allude to definitions and best practices commonly applied in the field of climate risk analysis.

Climate risk analysis can be regarded as a relatively new discipline in the financial services industry. The criteria listed in Appendix A are considered novel in nature and its criteria are ambitious and not self-evident to interpret in the context of residential real estate. The generic and sometimes abstract formulations that have been chosen by the European Commission can make practical application to (the financing of) residential real estate, challenging.

The interpretation proposed by the EEM NL Hub should be regarded as a first baseline reading and given the rapid developments in the field of climate risk analysis, subject to future change. This interpretation has come to fruition based on many meetings and discussions of the EEM NL Hub WG.

The European Commission has published some guidance, see Section 7 on CVRA and DNSH in context of residential real estate in particular, but this guidance is theoretical in nature.

Working assumptions have been established by consensus and have been drawn from existing experience in climate risk analysis, reasoning, and existing best practices. For the latter we have drawn inspiration from, amongst others, the ECB climate stress tests or sometimes analogies have been drawn from the field of credit risk modelling.

Table 17: Appendix A Wording.

Section	Wording
DNSH Appendix A	The **physical climate risks** that are **material** to the **activity** have been identified from those listed in the table **in Section II** of this Appendix by performing a robust **climate risk and vulnerability assessment** with the following steps: (a) screening of the activity to identify which physical climate risks from the list in Section II of this Appendix may affect the **performance of the economic activity** during its **expected lifetime**; (b) where the activity is assessed to be at risk from one or more of the physical climate risks listed in Section II of this Appendix, a climate risk and vulnerability assessment to assess the materiality of the physical climate risks on the economic activity; (c) an assessment of adaptation solutions that can reduce the identified physical climate risk.

Table 18: Interpretation of Appendix A wording.

Term or key phrase	Analysis	DEEMF Interpretation
physical climate risks	Physical climate risk refers to the risk of financial loss or other adverse impacts due to changes in climate patterns or extreme weather events, as a result of climate change. Physical climate risk can be divided into two main types: - Acute Physical Risk: These are risks that arise from extreme weather events that are becoming more frequent and severe due to climate change. - Chronic Physical Risk: These are risks that result from longer-term shifts in climate patterns. Physical climate risk is the result of assessing physical hazards, vulnerability and exposures to a certain economic activity. See Section 2 for a general introduction to the topic of climate risk and see Section 7 for an analysis of physical climate risks relevant for residential real estate in the Netherlands. Note: as Appendix A explicitly refers to physical climate risks, we omit transition (climate) risk(s) in the scope of this analysis.	Physical climate risk refers to the risk of financial loss or other adverse impacts due to changes in climate patterns or extreme weather events, as a result of climate change. An overview of relevant physical climate hazards and risks in the Netherlands is provided in Section 7.2.
Material	Materiality, in accounting and auditing, refers to the importance or significance of an item or piece of information in influencing the economic decisions of users of financial statements. It relates to the impact that an omission, misstatement, or disclosure of information can have on the judgment and decisions of the users of financial statements. Materiality can be assessed based on qualitative and quantitative factors. It helps determine what information should be included in a scenario analysis, focusing on information that is relevant and has a significant impact on the outcome. In climate risk analysis we de deem material all physical climate risks that have a <u>high</u> influence on the <u>performance</u> of the <u>activity</u>. Also see the analysis of *Performance of the economic activity* in a given scenario.	In short, we deem material what is of high risk (influence) on the performance of the activity. In practice we refer to *high* or material climate risks per given physical climate hazard. This amounts to certain quantifiable threshold value exceedances that are specific to certain climate hazards. We assume this relates to material impact to the physical building. In Section 5.8 we reference an analysis of the DNB method for assessing materiality.
Activity	The activity refers to the (financing of) the economic activity at hand in Section 7.7 of the Climate Delegated Act (in this context: acquisition and ownership of buildings).	The financing of the economic activity of acquisition and ownership of buildings.

	Note that we consider answer 141 and 144 of the Q&A document which prescribe that the financing of new constructions for homeowners can be regarded as a Section 7.7 activity.	
Climate risk and vulnerability assessment	Climate risk and vulnerability assessment (CRVA) refers to the process of climate risk analysis to assess if an economic activity is at risk from physical climate hazards. Although not very concrete or deterministically described in Appendix A, the criteria can be abstracted as a generic process, containing certain analytical components depending on the characteristics of the economic activity. In essence the CRVA can be regarded as a decision tree containing the various step(s) of the climate risk analysis, see Section 6.4. We regard climate risks as physical climate risks. Note that vulnerability is a core component of identifying physical climate risk analysis as: *climate risk is the result of assessing physical climate hazards, vulnerability and exposures.* We assume that the phrase *vulnerability* is not redundant as we assume it is to be understood in a process whereby: - In general: for a geographical area (i.e. the Netherlands) relevant physical climate risks are identified. - And specifically: the vulnerability is to be assessed, based upon the previous step, with regard to a portfolio of exposures. See Section 6.4 and Section 8 for a comprehensive overview of the steps and decision tree that make up the CRVA.	See process described Section 6.4 and Section 8 for a comprehensive overview of the steps and decision tree that make up the CRVA.
Performance of the economic activity	The economic activity is the acquisition and ownership of buildings. In short: the purchase of an existing property or the construction of new property for a homeowner. The financing of the economic activity is affected by the potential physical effects climate risk on the building unit. These risks can have performance implications for several categories: 1. The building unit; 2. The economic condition or creditworthiness of the homeowner; 3. The financial performance of the mortgage loan. 4. The financial institution	Impact on the building

	Table *5* illustrates an elaborate overview of these potential impacts. For this analysis we focus on quantifiable and measurable performance standards: - Collateral value - Loan-to-Value ratio - Credit risk	
Expected lifetime	The phrase should be regarded in the context of the wording 'may affect the performance of the economic activity during its lifetime'. The economic activity is the *financing of acquisition and ownership of buildings*. The question rises if we should regard the *expected lifetime* of: 1) the mortgage loan; 2) of the underlying (physical) asset – the building (unit); 3) or both. Expected lifetime: for (new) residential mortgage loans in most cases the legal original maturity is 360 months in the Netherlands. Expected Lifetime of building unit: in the Netherlands over 75% of the building stock has a construction date before 1990. We assume that the expected lifetime of a residential building, in its most conservative approach, is at least 75 years[60]. As we will see later, we need the expected lifetime to assess the relevant paths in the CRVA *decision tree*. Either way, in terms of interpretation 1, 2 or 3, the expected lifetime can be regarded as being in excess of 10 years. We assume that the expected lifetime of the economic activity that is financed is meant in this context: thus the expected lifetime of a building (unit) in the Netherlands. For pragmatic reasons, in this version of the framework, we do not take into account the construction year of the building to assess the buildings expected lifetime.	The expected lifetime of a building.

[60] Source: W/E rapport Richtsnoer 'Specifieke gebouwlevensduur' Aanvulling op de Bepalingsmethode Milieuprestatie Gebouwen en GWW-werken(MPG).

Table 19: Appendix A wording.

Section	Wording	Footnote
DNSH Appendix A Climate risk and vulnerability assessment	The climate risk and vulnerability assessment is **proportionate** to the scale of the activity and its expected lifespan, such that: (a) for activities with an **expected lifespan** of less than 10 years, the assessment is performed, at least by using **climate projections at the smallest appropriate scale**; (b) for all other activities, the assessment is performed using the **highest available resolution**, **state-of-the-art climate projections across the existing range of future scenarios**[320] consistent with the expected lifetime of the activity, including**, at least, 10 to 30 year climate projections scenarios** for **major investments**. The climate projections and assessment of **impacts are based on** best practice and available guidance and **take into account the state-of-the-art science** for vulnerability and risk analysis and related methodologies in line with the most recent Intergovernmental Panel on Climate Change reports[321], scientific peer-reviewed publications, and open source[322] or paying models.	[320] Future scenarios **include Intergovernmental Panel on Climate Change** representative concentration **pathways** RCP2.6, RCP4.5, RCP6.0 and RCP8.5. [321] Assessments Reports on Climate Change: Impacts, Adaptation and Vulnerability, published periodically by the Intergovernmental Panel on Climate Change (IPCC), the United Nations body for assessing the science related to climate change produces, https://www.ipcc.ch/reports/. [322] Such as Copernicus services managed by the European Commission.

Table 20: Interpretation of key wording of Appendix A.

Term or key phrase	Analysis	DEEMF Interpretation
Proportionate	In the context of accounting, proportionality refers to the principle of ensuring that the accounting treatment and financial reporting of an entity's transactions and events are commensurate with their significance and *materiality*. The principle of proportionality ensures that accounting information is presented in a manner that accurately represents the economic substance of the transactions and events while avoiding excessive complexity or unnecessary detail. Assessing proportionality in the context of climate risk involves evaluating the relationship between the potential impacts of climate-related risks and the measures or actions taken to mitigate or manage those risks (such as climate adaptation measures or	We are left with three partially overlapping references of the proportionality concept: i. The general concept in the context of climate risk: *evaluating the relationship between the potential impacts of climate-related risks and the measures or actions taken to mitigate or manage those risks.* This concept relates to proportionality of impact (effect).

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solutions). Proportionality can depend on many, sometimes subjective, factors such as: cost-benefit analysis, risk appetite, legal and regulatory requirement and stakeholder expectations (i.e. consumers).
Proportionality refers to the idea of fairness or balance in relation to the circumstances or criteria being considered. It involves determining whether the actions, measures, or decisions taken are appropriate and reasonably aligned with the situation at hand. Proportionality considers the relationship between the means used and the intended outcome or objective. It involves evaluating whether the actions or measures taken are suitable, necessary, and not excessive or disproportionate in relation to the desired outcome.
Interestingly, the Q&A (in FAQ 170) refers to the application of proportionality. The reader of Appendix A might regard the proportionality phrase in the context of the economic activity.
In the first part of the answer in the Q&A document, the proportionality concept seems to adhere to the rigour and scope of the climate scenarios that have to be considered. In the second half of the answer, examples of proportionality are given on the depth of the CRVA relative to the depth of the economic activity (building a factory vs replacing windows).
We are left with three partially overlapping references of the proportionality concept:

The general concept in the context of climate risk: evaluating the relationship between the potential impacts of climate-related risks and the measures or actions taken to mitigate or manage those risks.
Proportionality in the context of the scope of applicable climate scenarios in the CRVA.
Proportionality to the depth of the CRVA.

In the context of Section 7.7 we assume that the expected lifetime is in excess of 10 years and that the CRVA should be employed with option (b): with the use of 10 – 30 years climate projections.
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ii. Proportionality in the context of the scope of applicable climate scenarios in the CRVA.
iii. Proportionality to the depth of the CRVA (the magnitude of the economic activity).
We assume interpretation ii. and iii. apply.
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Expected lifespan	For the sake of pragmatic ability and simplicity we do not distinguish expected lifetime from expected lifespan, in our interpretation. We refer to our analysis of expected lifetime for our consensus interpretation.	Expected lifespan of the building.
climate projections at the smallest appropriate scale	To analyse data at the most granular (detailed) level possible. So analysing the effect of a physical climate hazard on the smallest (detailed) level as possible. The analogy with digital photography can be made: where we want to use the resolution (photo quality) that reflects the highest level of detail – to make detailed assessments of different regions in the Netherlands. See Section 7.8 for more background information on geospatial analysis and considerations.	With the highest level of detail (granular resolution) as (pragmatically) possible.
Highest available resolution, state-of-the-art climate projections	According to the answer in FAQ 175: *Latest projections taking into account the evolving scientific knowledge (e.g. on tipping points).* we assume that tipping points are taken into consideration in AR5 and AR6.	In practice we assume this means that Downscaled Climate Models (localised climate projections) are preferred over Regional Climate Models (RCMs) and Global Climate Models (GCMs), where possible.
across the existing range of future scenarios	The IPCC describes a scenario as "*a plausible description of how the future may develop based on a coherent and internally consistent set of assumptions about key driving forces and relationships*". We have considered the different scenarios which have been detailed in the footnote as the four IPCC representative concentration pathways. Where possible multiple scenarios should be taken into account. However, we are mindful of Answer 168 (of the Q&A) which reflects that not always all (climate) scenarios have to be considered. At least the most severe (least optimistic, thus reflecting poor climate mitigation) scenario – RCP 8.5 should be applied. This would be consistent with typical conducts in financial accounting where conservatism is applied as a form of prudence and caution towards uncertainties.	Considering the novelty of the CRVA assessments, our interpretation is that first those climate risks which are consistent with RCP 8.5 are to be analysed. Ideally, in line with DNB recommendations, at least 2 scenarios need to be applied.

	Considering the novelty of the CRVA assessments, we advise to first (and at least) of analyse climate risks which are consistent RCP 8.5. Ideally, in line with DNB recommendations, at least two scenarios need to be applied.	
major investments	There is no set definition of what constitutes a major investment in the context of consumer spending. An investment is typically considered major if it involves a substantial outlay of financial resources relative to a persons' financial capacity. The specific threshold for what constitutes a major investment can vary based on the context, but it generally represents a significant commitment of capital. The average purchase price of a residential property in the Netherlands equalled €432.000 in 2022, whereas the modal annual salary in the same year equated to €38.500. Mortgage loans offered by financial institutions are bound by national creditworthiness regulations (such as the NIBUD-Norm) and the (national implementation of) the Mortgage Credit Directive. Given that on average the acquisition of a property equals multiple annual salaries and given the fact that most of these are financed by a mortgage loan, we deem the purchase or acquisition of a property by a homeowner a major investment.	We consider the activity of Section 7.7 'Acquisition & Ownership of a building' to be a major investment.
Impacts	ISO 14091 provides a definition of the word 'impact' in the context of climate risk: *the term "impact" is used primarily to refer to the effects on natural and human systems of extreme weather and climate events and of climate change. Impacts generally refer to effects on lives, livelihoods, health, ecosystems, economies, societies, cultures, services and infrastructure due to the interaction of climate change or hazardous climate events occurring within a specific time period and the vulnerability* [https://www.iso.org/obp/ui/ - iso:std:iso:14091:ed-1:v1:en:term:3.12](https://www.iso.org/obp/ui/#iso:std:iso:14091:ed-1:v1:en:term:3.12) *of an exposed society or system. Impacts are also referred to as consequences and outcomes. The impacts of climate change on geophysical systems, including floods, droughts and*	The effect of physical climate events on buildings (within a specific time period).

	sea level rise, are a subset of impacts called "physical impacts".	
best practice and available guidance	There is no specific format for performing a CRVA. Several **organisations** and entities have provided guidance and best practices for performing climate risk assessments and creating climate scenarios. As highlighted in this document we refer to several best practices and guidelines published by (a.o.): the ECB, ESA's, TCFD, NGFS, ISO, DNB, DG Climate, The European Commission and the IPCC. It is important to note that these organisations provide frameworks, guidelines, and best practices, but the specific approach to climate risk assessments and scenario analysis may vary depending on the industry that it is applied in and potentially could have other (overlapping) regulatory requirements. We have considered the best practices and guidelines which we deem relevant for real estate and/or mortgage loans in the Netherlands. See Section 5 for an overview.	See Section 5 for an overview.

Table 21: Key phrases of Appendix A.

Section	Wording	Footnote
DNSH Appendix A Climate risk and vulnerability assessment	For **existing activities** and **new activities** using **existing physical assets**, the **economic operator implements physical and non-physical solutions ('adaptation solutions'), over a period of time of up to five years,** that reduce the most important identified physical climate risks that are material to that activity. An **adaptation plan** for the **implementation** of those solutions is drawn up accordingly. For new activities and existing activities using **newly-built physical assets**, the economic operator **integrates** the **adaptation solutions** that reduce the most important identified physical climate risks that are material to that activity **at the time of design and construction and has implemented them before the start of operations.** The adaptation solutions **implemented** do not adversely affect the adaptation efforts or the level of resilience to physical climate risks of other people, of nature, of cultural heritage, of assets and of other economic activities; are consistent with	[323] **Nature-based solutions** are defined as 'solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions'. Therefore, nature-based solutions benefit biodiversity and support the delivery of a range of

	local, sectoral, regional or national adaptation strategies and plans; and consider the use of nature-based solutions[323] or rely on blue or green infrastructure[324] to the extent possible.	ecosystem services. (version of [adoption date]: https://ec.europa.eu/research/environment/index.cfm?pg=nbs). [324] See Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Green Infrastructure (GI) — Enhancing Europe's Natural Capital (COM/2013/0249 final).

Table 22: Interpretation of Appendix A wording.

Term or key phrase	Analysis	DEEMF Interpretation
existing activities (using existing physical assets)	Economic activities that, at the moment of assessment, are already active (running or in progress). In this context we assume the existing activity *using existing physical assets* to be the ownership or acquisition of an existing (in-use) residential building (unit).	Financing of an already existing residential building (unit).
New activities (using existing physical assets)	In this context we assume the new activity *using existing physical assets* to be the new financing of a mortgage loan for an existing (in-use) residential building (unit).	New financing of a mortgage loan for an existing (in-use) residential building (unit).
Existing physical assets	Existing residential building units (that are in use).	Existing residential building units (that are in use).
Economic operator	No definition of the economic operator is provided in the Delegated Act or in corresponding guidance. This is unfortunate as the economic operator is responsible for the implementation of adaptation solutions. In general, both the mortgage lender and the borrower could be designated as economic operators (in a financial transaction). We	In the context of Appendix A, the borrower / homeowner is the economic operator.

	assume that the in the context of Appendix A, (primarily) the borrower and thus the homeowner is understood to be the economic operator as he is exercising ownership	
Physical and non-physical solutions ('adaptation solutions')	Physical and non-physical solutions, also known as adaptation solutions, are strategies employed to enhance the sustainability and resilience of buildings. Physical solutions refer to tangible infrastructure and design changes implemented to mitigate climate risks and improve building performance. Examples include retrofitting buildings with energy-efficient systems, installing heat-resistant doors and windows, and incorporating renewable energy technologies. On the other hand, non-physical solutions encompass management practices, occupant behaviour changes, and strategic planning aimed at optimising energy resources efficiently and reducing any environmental impact. These solutions involve implementing sustainable building management practices, promoting occupant behaviour change programs, and establishing disaster response and emergency management protocols. Both physical and non-physical solutions are useful tools for creating sustainable, (climate risk) resilient buildings that can adapt to the challenges posed by climate change. See Section 4 for an overview of both physical and non-physical solutions.	The CRVA distinguishes two types of adaptation solutions: Physical solutions refer to tangible infrastructure and design changes implemented to mitigate climate risks and improve building performance. Non-physical solutions encompass management practices, occupant behaviour changes, and strategic planning aimed at optimising energy resources efficiently and reducing environmental impact.
Implements	The term 'implementation', in general, refers to the process of putting plans, ideas, or strategies into action. It involves carrying out specific actions, steps, or measures to achieve a particular objective or goal. Implementation focuses on executing and operationalising plans or decisions and ensuring that they are effectively put into practice. It involves translating concepts or strategies into	Implementation refers to the measures described in the adaptation plan to be executed.

	tangible actions and often includes activities such as planning, organising, allocating resources, and monitoring progress. We assume that the implementation refers to the measures described in the adaptation *to be* executed.	
Over a period of time of up to five years		We assume that the adaptation plan, in its timeline should describe physical and non-physical solutions that can be implemented (with)in five years.
Adaptation plan	There is no standard or prescribed format what should be regarded as an adaptation plan for residential homeowners affected by climate risks. Taking analogies from adaptation plans in other professional fields we have identified several components that could be part of a (future) standardised climate risk adaptation plan for homeowners. These components could consist of a.o.: objective statement, tasks, responsibilities, timelines, costs, resources.	Taking analogies from adaptation plans in other professional fields we have identified several components that could be part of a (future) standardised climate risk adaptation plan for homeowners. These components could consist of a.o.: objective statement, tasks, responsibilities, timelines, costs, resources.
Newly-built physical assets	The economic activity of granting (originating) new financing via a mortgage loan for the construction or purchase of a new building units with the NTA 8800 status 'vergunningsaanvraag' or 'oplevering'.	An existing financing via a mortgage loan for the construction or purchase of a new building units with the NTA 8800 status 'vergunningsaanvraag' or 'oplevering'.
Existing activities using newly-built physical assets	Financing via a new (thus not active yet) mortgage loan for the construction or purchase of a new building unit with the NTA 8800 status 'vergunningsaanvraag' or 'oplevering'.	Active financing of a new mortgage loan for the construction or purchase of a new building unit with the NTA 8800 status 'vergunningsaanvraag' or 'oplevering'.
Integrates	Integration refers to the process of combining or merging different parts or elements into a unified whole. It involves bringing together separate components, systems, or entities to create a cohesive and interconnected system or	Integration refers to the measures described in the adaptation plan *having been* executed.

	structure. Integration aims to ensure smooth coordination, interoperability, and synergy between the various parts, enabling them to work together effectively and efficiently. Integration emphasizes the interconnectedness and seamless functioning of the combined elements. We assume that the integration refers to the measures described in the adaptation plan *having been* executed. Integration is not to be confused with implementation[61].	
Adaptation solutions	See description of *physical and non-physical solutions.* Note that adaptation solutions might differ in nature, not only the context, identified climate risks, geographic location or building type but also on the categorisation of existing or new (to be constructed) buildings. In the former case, the adaptation solutions might also be dependent upon building year.	See description of *physical and non-physical solutions.*
At the time of design and construction and has implemented them before the start of operations.	We assume that this should be interpreted as measures that have been *integrated* before the NTA 8800 status 'delivery' ("*oplevering*") has been reached. NB: somewhat confusing the European Commission mentions both the term *implements* and *integrates* in the same sentence. As the sentence describes newly built physical assets this could be an undeliberate inconsistency and *integration* is actually meant.	This should be interpreted as measures that have been *integrated* before the NTA 8800 status 'delivery' ("*oplevering*") has been reached.

[61] Integration focuses on combining and connecting separate elements to create a unified whole, while implementation involves executing and putting plans or strategies into action. Integration emphasizes cohesion and interconnectivity, whereas implementation emphasizes execution and realization of objectives.

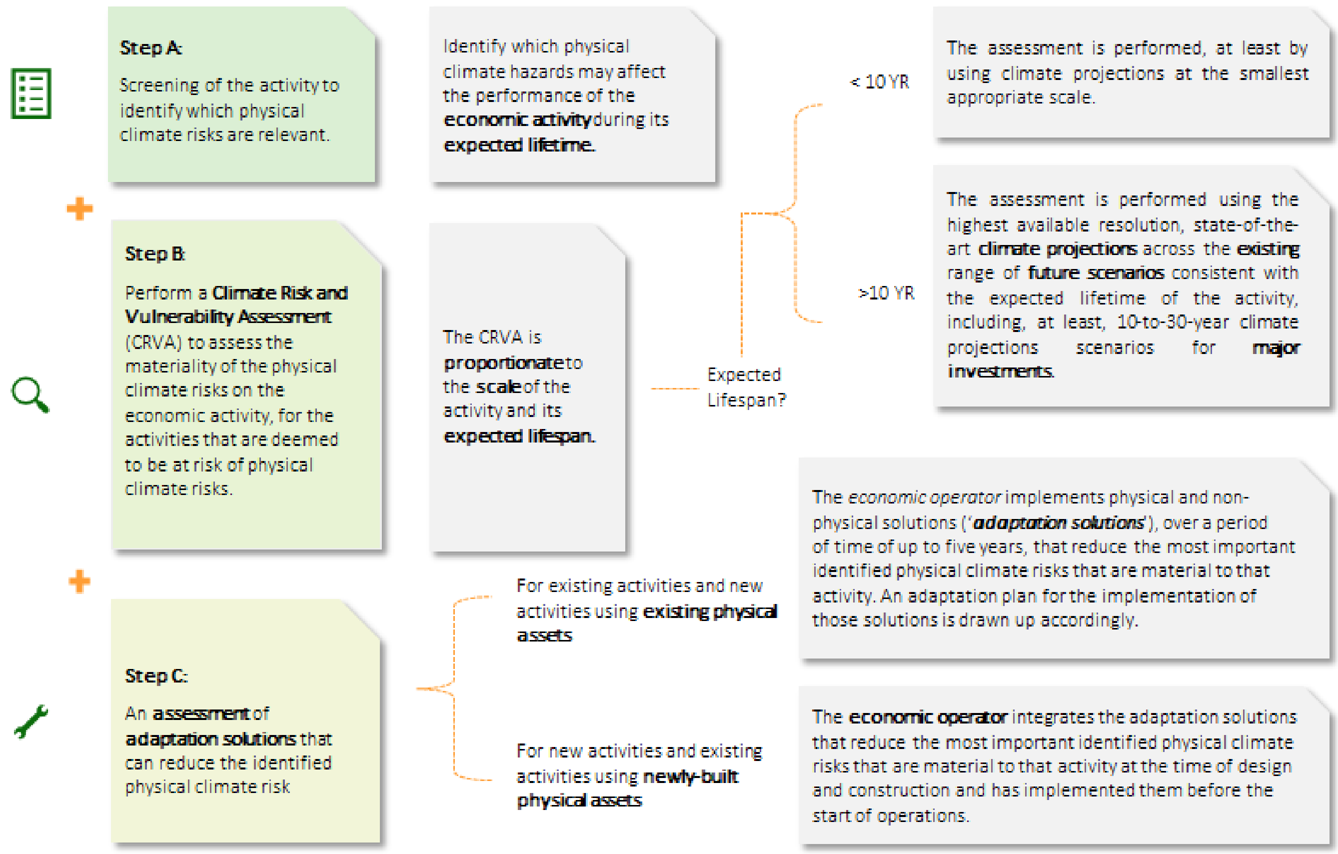
6.4 An overview of DNSH Appendix A.

In the previous section we have dissected the (individual) phrasing of Appendix A based on the EEM NL Hub WG's assessments and consensus. In this section we concatenate and simplify these key phrases with the aim of creating a comprehensible, practical, overview of the wording in Appendix A.

As mentioned in the Q&A document (answer 174) there is no (single) standard method of conducting a climate risk and vulnerability assessment. The European Commission acknowledges this and adds that these assessments can be based on a variety of methodologies and data sources.

Figure *13* lists a high-level decision tree on some of the key components of Appendix A. To perform a Taxonomy-Aligned climate risk assessment we have seen in the previous section that it is important to determine the lifespan of the (economic) activity. The economic activity at hand is one that falls under Section 7.7 of the CDA and we assume that the expected lifetime of that activity is more than 10 years.

Figure 13: DNSH Appendix A – Steps Overview.



7 Resources

In this section we list several useful resources, data sources and the analytical toolbox that can be applied when performing a climate risk and vulnerability assessment.

7.1 EU Climate Resources

Climate-ADAPT / EEA

The European Union (EU) Adaptation Strategy[62] is a framework designed to build the EU's resilience to the impacts of climate change. It is enacted through the European Climate Adaptation Platform, known as Climate-ADAPT, a partnership between the European Commission and the European Environment Agency (EEA). The platform aims to support Europe in adapting to climate change by providing access to data and information on expected climate changes in Europe. It details the current and future vulnerability of regions and sectors across the EU and lists resources on national and transnational adaptation strategies and actions and tools that support adaptation planning[63]. We recommend using the content on Climate-ADAPT as a resource for DNSH analysis. Below we list 3 use cases that explain where Climate-ADAPT could be a useful resource for the EU Taxonomy DNSH Analysis:

1. Country specific Climate Adaptation insights.

The Climate-ADAPT portal lists per EU country which physical climate hazards are relevant. The platform has been built and maintained, in part, on behalf of the European Commission, the entity that is also responsible for the wording of the EU Taxonomy (and thus Appendix A.). On the portal an overview of physical climate hazards is depicted that are relevant for the Netherlands including a comprehensive overview of links to (data) sources and relevant research.

2. Method to assess climate risks to real Estate.

With regard to residential buildings, Climate-ADAPT provides a method to assess climate risks to real estate. This method involves assessing the physical climate risk for real estate portfolios, which refers to the risk of loss of value of properties due to damage caused by climate change, such as extreme precipitation, natural fires, or flooding. The method is based on national data from the Climate Impact Atlas, an open platform that provides free access to data that can be used to create an initial, general picture of the risks within a property portfolio. Climate-ADAPT advises that (climate) data on a local level should also be assessed (such as the data from the KNMI) to properly assess the risk.

3. Adapting buildings to climate change.

On behalf of European Commission (DG Climate) two comprehensive reports have (recently) been published containing (EU level) *technical guidance on adapting buildings to climate change*. The report consists of two parts:

- EU-level technical guidance on adapting buildings to climate change: The technical guidance section begins by providing an overview of existing EU-level policies and standards related to building adaptation. It then summarizes the current status of structural design building standards at both European and national levels, with a particular focus on ensuring climate resilience in buildings. The section also includes an overview of climate vulnerabilities and risk assessment for buildings, along with a potential method for evaluating the climate resilience of buildings.

[62] https://climate.ec.europa.eu/eu-action/adaptation-climate-change/eu-adaptation-strategy_en
[63] https://climate-adapt.eea.europa.eu/en/about

- **EU-level technical guidance on adapting buildings to climate change – Best practice guidance:**
    - Provides technical guidance on climate-adaptation measures that are relevant for both new and existing buildings across the different climatic zones of Europe.
    - Presents adaptation solutions for the climate risks that affect the built environment.

This later resource is particularly useful as it details an approach of CRVA for buildings. We will lean heavily on this resource in Section 8.

Two observations about these reports are of particular interest:

1. It is explicitly stated that this EU-level guidance serves as a contribution to integrating the principle of climate resilience in buildings into the implementation of various EU Green Deal initiatives. These initiatives include the Renovation Wave, the New European Bauhaus, the Climate Adaptation Strategy, revisions of the Energy Performance of Buildings Directive and the Construction Products Regulation, the Level(s) sustainability framework for buildings, Green Public Procurement, the Construction Transition Pathway, *the EU taxonomy for sustainable activities* and EU funding programs like the Recovery and Resilience Facility, InvestEU and regional funding[64].
2. Both report have been written by Ramboll Nederland BV[65] and CE Delft[66] on behalf of the European Commission (DG Climate). This could be regarded as interesting from the EEM NL Hub's perspective as the reports contain multiple examples of adaptation solutions that are relevant for the buildings in the Netherlands.

7.2 Climate Hazards in the Netherlands

The Netherlands is susceptible to climate risks due to its low elevation, large population, high population density and extensive infrastructure along the coast. Key climate risks for the Netherlands include: sea-level rise, extreme rainfall and flooding and Heatwaves and droughts.

[64] https://climate-adapt.eea.europa.eu/en/metadata/guidances/eu-level-technical-guidance-on-adapting-buildings-to-climate-change/
[65] An engineering, architecture and consultancy company based in Delft, the Netherlands.
[66] CE Delft is research and consultancy firm focused on sustainability, based in Delft, the Netherlands.

Table *23* is a combination of the table provided on 1) general aspects of climate change impact and vulnerability assessment and 2) key future climate hazards, listed on Climate-ADAPT. The latter are highlighted in bold: indicating that these have been identified by as a 'key future climate hazard relevant for the Netherlands. The empty cells in the table depict that no hazard has been identified that is of relevance.

With an asterisk we have indicated climate hazards that are also part of the Climate Delegated Act list[67]. Therefor the hazards without asterisk are hazards that have been identified to be relevant for the Netherlands in addition to the 'minimum' list provided for in the EU Taxonomy.

[67] Of appendix A.

Table 23: Climate Hazards for the Netherlands.

Observed climate hazards for the Netherlands	Acute	Chronic
Temperature	• **Heat wave*** • Other • Wildfire* • Other: spread of species	• **Changing temperature (air freshwater marine water)*** • other • Other: spread of species
Wind		
Water	• **Drought*** • **Flood (coastal fluvial pluvial ground water)*** • **Heavy precipitation (rain hail snow/ice)***	• **Changing precipitation patterns and types (rain hail snow/ice)*** • Precipitation and/or hydrological variability* • Saline intrusion* • **Sea level rise*** • Water scarcity*
Solid Mass		• Coastal erosion* • Soil degradation (including desertification)*

7.3 KNMI projections

The KNMI releases new climate scenarios approximately every seven years. The next publication is expected in October of 2023. With the 'Klimaatsignaal'21' (Climate Signal '21), the KNMI provides an interim update, see Box *17*. 'Klimaatsignaal'21' is based on the sixth report of the Intergovernmental Panel on Climate Change (IPCC). The KNMI reports on how the climate in the Netherlands is changing at an increasingly rapid pace.

Box 17: 'Klimaatsignaal'21'

The 'Klimaatsignaal'21' report from the Royal Netherlands Meteorological Institute (KNMI) provides a detailed analysis of the climate risks for the Netherlands. Here are the key findings:

1. **Sea Level Rise**: The report suggests that sea levels are rising more rapidly than previously predicted. If greenhouse gas emissions are not reduced, the sea level along the Dutch coast could rise by 1.2 meters by 2100 compared to the beginning of the century. If the Antarctic ice sheet melts faster, a 2-meter rise is possible. This represents an upward revision from the 1-meter rise predicted by KNMI in 2014. On the long term, the difference in sea level rise between doing nothing and adhering to the Paris Climate Agreement could be many meters by 2300[68].
2. **Extreme Summer Storms and Droughts**: The research indicates that the heaviest summer storms are becoming more extreme, with an increased likelihood of downbursts. The chance of dry springs and summers has also increased, especially in the inland areas. The climate is becoming more similar to that of Southern Europe.
3. **Long-lasting Heat and Drought**: The report suggests a potential link between stronger warming of the Arctic and a higher chance of enduring heat and drought. This is because the jet stream may become weaker due to a decrease in temperature difference between the poles and the tropics, leading to longer periods with the same weather conditions.

[68] https://www.knmi.nl/kennis-en-datacentrum/achtergrond/knmi-klimaatsignaal-21

4. **Rivers**: The risk of low water levels in rivers is increasing during summer, while the chance of high-water levels is rising in winter.
5. **Urban Climate**: Cities, which are usually warmer than rural areas, will experience further warming due to global climate change. Moreover, extreme precipitation and drought pose an increasingly significant challenge for cities.

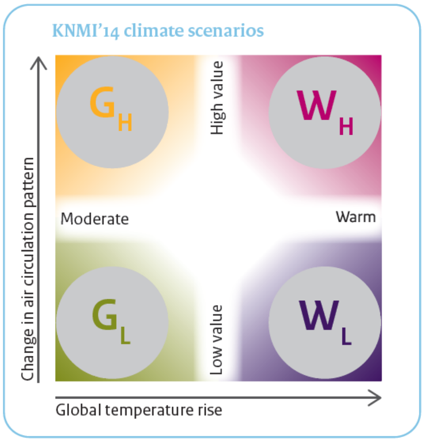
The report, based on the sixth IPCC report and supplemented with KNMI's observations and research, states that the warming of the Earth is human induced. With the current greenhouse gas emissions, the atmosphere is expected to contain so many greenhouse gases within 10 years that the 1.5 °C limit will probably be permanently exceeded.

7.4 KNMI Climate scenarios

The KNMI'14-klimaatscenario's are a comprehensive set of climate scenarios that describe plausible future climate conditions in the Netherlands. These scenarios were developed by the KNMI to support research, policymaking and planning processes related to climate change impact and adaptation.

The KNMI has developed four climate scenarios to project future climate change in the Netherlands by around 2050 and 2085. Known as the KNMI'14 climate scenarios, they offer a comprehensive understanding of changes in 12 key climate variables, including temperature, precipitation, and sea level. Each scenario presents a storyline that considers factors like CO2 emissions, resulting in varying outcomes. The scenarios differ in terms of global warming extent (Moderate or Warm) and potential changes in air circulation patterns (Low or High). In Figure 14 we copied[69] a figure depicting the Dutch climate scenarios.

Figure 14: KNMI'14 Climate scenarios.



The KNMI climate scenarios are based on the same sources as the IPCC, the United Nations' climate panel. The climate scenarios can be seen as a translation of the global IPCC scenarios to the Netherlands[70]. In October 2023, new climate scenarios, called KNMI'23 scenarios, are expected to be published[71].

[69] Copied from: KNMI. KNMI'14 Climate scenarios for the Netherlands (leaflet), Year: 2014, Pages: 2
[70] https://www.knmi.nl/kennis-en-datacentrum/uitleg/knmi-klimaatscenario-s
[71] Idem.

7.5 Klimaateffectatlas.nl

Klimaateffectatlas.nl is an online tool that provides visualizations of the potential impacts of climate change in the Netherlands. It provides a (first) impression of the effects that climate change can have now and in the future, including topics like flooding, water nuisance, drought and heat.

These impacts may include hotter summers, milder and wetter winters, rising sea levels and increasing weather extremes, all of which can pose significant risks to buildings. The atlas is divided into two main components: the “viewer” and the “map stories”, also known as map narratives (“*kaartverhalen*”). Both the *viewer* and *map stories* can be used to understand the potential effects (impact) of climate change in a particular area. The map stories give background information on the key maps, explaining what can be seen and how the information can be used.

Understanding these impacts at a local level is critical for effective planning and action. In the Netherlands, two resources, Klimaateffectatlas.nl and Klimaatschadeschatter.nl, provide valuable tools to aid in this understanding and inform decision-making.

The Klimaateffectatlas.nl incorporates the KNMI scenarios in the following ways:

- Climate data visualization: The platform provides interactive maps and visualizations that depict various climate variables and their projected changes based on the KNMI scenarios. Users can explore maps that show future changes in temperature, precipitation, sea level rise and other relevant climate parameters for different time horizons and emission scenarios.
- Data exploration and analysis: Users can access and analyse climate data specific to their location or area of interest. The platform allows for exploring and comparing different KNMI scenarios to understand the range of potential climate impacts. This facilitates evidence-based decision-making and helps stakeholders assess the vulnerability and risks associated with climate change in the area under consideration.
- Scenario-based planning: The Klimaateffectatlas.nl supports scenario-based planning by allowing users to assess the implications of different KNMI IPCC scenarios on spatial planning and development. By integrating the climate projections into the planning process, stakeholders can anticipate and adapt to potential future climate conditions, considering factors such as urban heat islands, flooding risks and changes in water availability.

7.6 Map narratives

Impacts of climate-related hazards can in some cases be direct, such as damage to buildings from flooding or storm events. Other impacts of climate-related hazards occur in succession or reinforce each other. Map narratives (“*kaartverhalen*”) can be used to analyse the impact of a hazard. The map narratives follow a *storytelling* approach that combines spatial information, data visualization and textual descriptions to communicate and analyse climate risks specific to buildings and their surroundings. It is a useful tool to assess cause & effect of climate hazards and potential risks. In addition, it provides valuable insights into climate mitigation and adaptation measures.

Use cases of map narratives:

- Map narratives can focus on building locations to assess their vulnerability to climate hazards. By integrating relevant data layers from the Klimaateffectatlas.nl, such as flood risk zones, heat stress indices, or sea-level rise projections, the narratives can provide an overview of specific risks faced by buildings in different locations.
- Through map narratives, climate risks can be visually depicted using interactive maps, charts, and diagrams. These visualizations can highlight exposure levels, vulnerability indicators, or projected changes in climate variables.

For example, heat vulnerability maps can show areas with high risk of overheating and flood risk maps can illustrate areas prone to inundation. Visual representations enhance the understanding of climate risks and aid in decision-making processes.

- By overlaying building locations, land use patterns, infrastructure networks and climate-related data, the narratives offer a visual representation of how climate hazards may impact the immediate surroundings of buildings. This helps identify potential sources of vulnerability, such as proximity to flood-prone areas or lack of green spaces for heat mitigation.

7.7 Klimaatschadeschatter

Klimaatschadeschatter.nl (climate risk estimator) is a tool that estimates the extent of damage that could be caused by water damage, heat, and drought in the Netherlands from 2018 to 2050 due to climate change. It provides an assessment of the expected costs of damage if no action towards climate adaptation is taken.

7.8 The Climate risk (and vulnerability) Toolbox

Climate data serves as indicators to indirectly assess climate-related hazards and risks. These indicators help in understanding and evaluating various hazards associated with climate change. Instead of directly assessing hazards like heatwaves, indicators such as the number of days with temperatures exceeding 30°C are used. These indicators provide insights into the likelihood and intensity of specific climate-related hazards.

The choice of indicators depends on the impacts being investigated. For example, when assessing the impact of heatwaves on human health, factors like nighttime cooling and the duration of the heatwave need to be considered. These factors significantly influence the severity of the impact. In such cases, a more suitable indicator might involve analysing the occurrence of a certain number of consecutive heat days coupled with tropical nights.

Assessing future climate hazards relies on climate projections, such as Representative Concentration Pathways (RCPs), using the highest available resolution. Local and regional climate risk assessments can contribute valuable information if they are based on relevant scenarios and high-resolution data.

Geospatial analysis, see Box *18* enables the assessment of climate-related hazards by offering quantitative and spatially detailed information. Through techniques like overlaying climate data onto maps, it becomes possible to visualize the distribution of temperature extremes, precipitation patterns, or sea-level rise in various regions. This visualization aids in identifying areas that are susceptible to specific hazards.

Box 18: Geospatial Analysis.

Geospatial analysis

Geospatial analysis is a data analysis technique that combines geographic information system (GIS) technology with spatial data to analyse and interpret information within a spatial context. It involves the collection, integration, manipulation, and visualisation of geographically referenced data to uncover patterns, relationships, and insights. In the context of climate-related hazards, geospatial analysis allows for the identification and analysis of various factors contributing to these hazards, such as topography, land cover, temperature, precipitation, and other relevant geospatial data layers.

7.9 Overview of (data) resources

Below we have created an overview of resources that we find useful to assess climate risk (and vulnerability) in the context of Dutch real estate:

1. **When establish the context**:
    - For insights on the Dutch context, you may want to look into the Dutch National Climate Adaptation Strategy (NAS) which provides an overview of the impacts of climate change in the Netherlands: Climate-ADAPT
    - For general guidance on conducting climate risk assessments, the TCFD (Task Force on Climate-related Financial Disclosures) Recommendations provide a useful framework.
2. **When Identify climate-related risks**:
    - The Royal Netherlands Meteorological Institute (KNMI) provides information on climate scenarios for the Netherlands.
    - The IPCC (Intergovernmental Panel on Climate Change) offers a global perspective on climate change and related risks.
    - Klimaateffectatlas (Climate Impact Atlas): Klimaateffectatlas provides detailed information about climate hazards and their projected changes in the future, helping you identify the risks that are most relevant to your properties.
3. **When assessing exposure**:
    - The Netherlands Environmental Assessment Agency (PBL) often provides data and assessments related to exposure of different sectors to climate change in the Netherlands.
    - ECB's guide on climate-related and environmental risks can help understand how exposure can be evaluated in financial risk assessments: ECB Guide
    - Klimaateffectatlas: can be used to assess the exposure.
    - BAG 3D: Geometric analysis of the building compound can help to assess vulnerability by taking into consideration for instance the level of elevation a certain apartment has in a building-complex.
4. **When Assessing vulnerability**:
    - A report from the PBL Netherlands Environmental Assessment Agency, "Climate adaptation in the Dutch delta. Strategic options for a climate-proof development of the Netherlands" provides useful insights: PBL Report
    - The European Environment Agency provides a methodology for urban vulnerability assessments that might be helpful: EEA Guide
    - Klimaateffectatlas : By overlaying information from the Atlas with data on your properties, you can get an idea of their vulnerability to these hazards. The Atlas can help you understand whether your properties are in areas that are particularly susceptible to certain hazards.
    - EP-Online: use energy performance related building (unit) metrics. For instance the TO-Juli indicator or building type can help us guide in the vulnerability assessment.
    - Kadaster: The land registry information, such as building year can help us identify certain vulnerable exposures.
    - Klimaatschadeschatter.nl: Klimaatschadeschatter.nl is a tool that estimates the extent of damage that could be caused by water damage, heat, and drought in the Netherlands from 2018 to 2050 due to climate change.
5. **When assessing adaptive capacity**

- See Section 4.6 for (policy) sources.

6. **When Evaluating risk**:

   - Again, the TCFD's guidance can be useful for this step, as it includes information on risk evaluation.

For a more specific methodology, the UNEP's "Climate Change Vulnerability Assessment: A Review of Conceptual Frameworks" offers an overview of different methods for evaluating climate risk: UNEP Report

8 DNSH: Climate Change Adaptation Steps

8.1 Introduction

In this section we further dissect the steps (A, B and C) that are listed in Figure 13. The method we describe in the following section is a synthesis of:

- DG Climate / European Commission guidance: EU-Level Technical Guidance for adapting buildings to climate change;
- *How to perform a robust climate risk and vulnerability* (by German Environment Agency);
- Technical guidance on the climate proofing of infrastructure in the period 2021-2027 (European Commission);
- Elements of previous sections in this report.

In the next section we describe a CRVA, that could be considered, a *best-off* of these CRVA approaches. We will lean on:

- Elements of climate risk assessment described in Section 2
- Consensus definitions as reflected in Section 6.
- The resources mentioned in Section 7.

The following sections of this chapter we will go into the steps of Figure 13, in particular steps A and B as these forms a crucial part of the analysis. At this point in time, the EEM NL Hub WG has not completed the analysis of step C (adaptation solutions) yet, so at this stage we only list a superficial overview.

Assumptions:

- We only assess the economic activity construction and ownership of buildings (Section 7.7 of the CDA).
- As described in Section 6 we assume that the expected lifetime is > 10 years for this economic activity (Acquisition and Ownership of Buildings);
- We do not make an explicit distinction between the financing newly built and existing buildings[72].

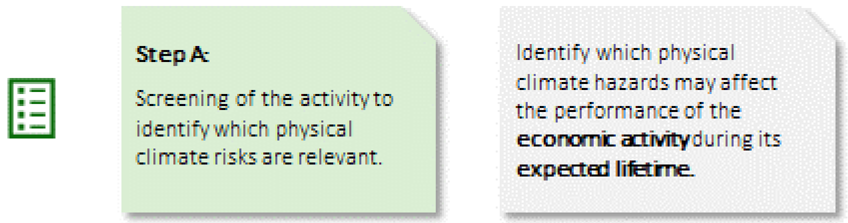
[72] Although this might be a useful refinement of the pragmatic analysis, specifically for step C.

8.2 Step A: Screening the activity.

In step A of Appendix A it is required to identify physical climate risks that may affect the performance the economic activity (Acquisition and Ownership of buildings). We must look into branch A of the decision tree as depicted in Figure *15*.

Section	Wording
DNSH Appendix A	The **physical climate risks** that are **material** to the **activity** have been identified from those listed in the table **in Section II** of this Appendix by performing a robust **climate risk and vulnerability assessment** with the following steps: (a) screening of the activity to identify which physical climate risks from the list in Section II of this Appendix may affect the **performance of the economic activity** during its **expected lifetime**;

Figure 15: Step A of the DNSH TSC.



<u>Commentary on EU Taxonomy Wording</u>:

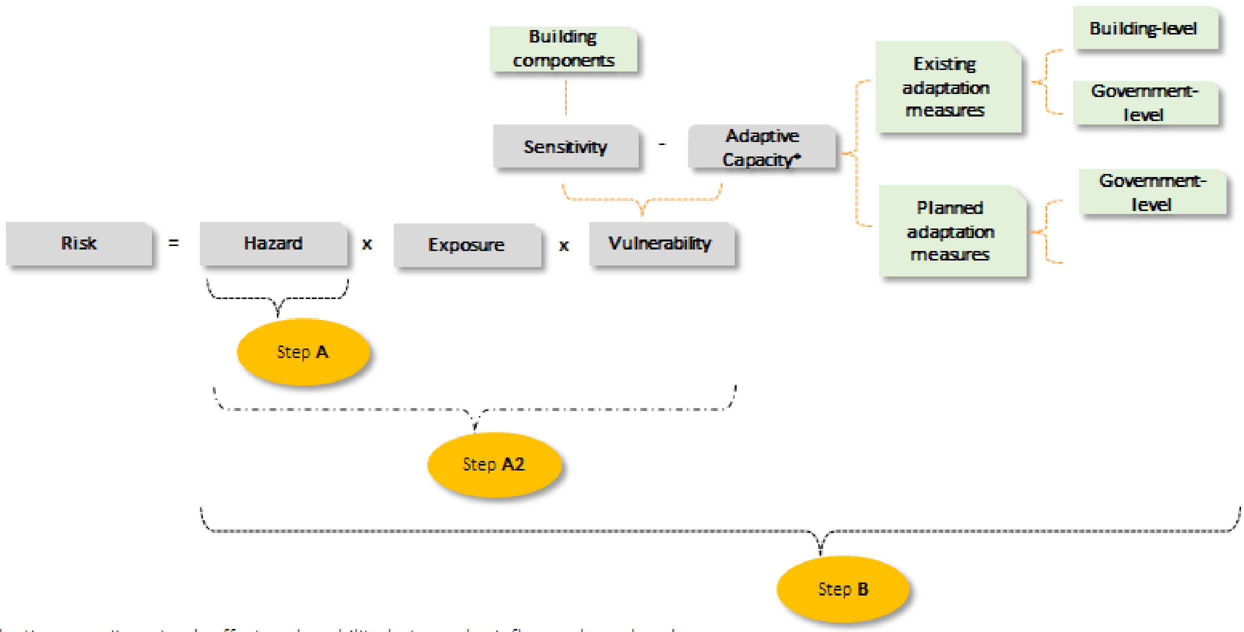
- *The physical climate risks that are material to the activity have been identified from those listed in the table in Section II of this Appendix.* The list provides hazards, not risks. We therefore assume that we have to induce (ourselves), based on the combination of the *list* and the economic activity at hand what the physical climate risks *may* (might) be.

The challenge is that we must assess which physical climate hazards *may affect the performance* of the building. Therefore looking at the risk representation in Figure *16*, it seems insufficient to just look at physical hazards in isolation (label step A) but we also have to look, to a degree, towards the components of exposure and vulnerability. As the latter two elements are needed to assess if it *may affect* the *performance*.

In this stage it is not necessary (yet) to do a full CRVA, contrary to Step B (represented with label B in the diagram). We have to look into elements of Step B, to assess if it *may* affect, the performance. This has been represented in the diagram by Step A2. In step A(2), also called the *screening phase*[73], we look into exposure and vulnerability as well.

[73] By the Technical guidance on the climate proofing of infrastructure in the period 2021-2027 (European Commission).

Figure 16: Risk representation.



* Adaptive capacity not only affects vulnerability but can also influence hazard and exposure

To start with the initial hazard assessment. We propose two possible methods:

1. Use a standard list of hazards that have, in general, been found to be of relevance (see Table 23) when considering physical climate risks for buildings (in the Netherlands).
2. Create a list of physical climate hazards from scratch.

We will describe both methods in this section. In Section 7.2 we have created a combined list with potential hazards consisting of i) the EU Taxonomy list amended by ii) specific hazards that are relevant for the Netherlands. the goal is to assess *if the economic activity (7.7) is at risk from one or more of the physical climate risks.*

Steps:

1. **Stating point: readily available list of hazards**

   We take into consideration:

   i. The list[74] provided in the EU Taxonomy of physical climate hazards and;

   ii. Identify if other physical climate hazards (not in the list) are also relevant.

   In Table 23 we list the identified physical climate hazards relevant for the Netherlands. We take the list of Climate-Adapt / EEA for the Netherlands as starting point for our selection as they have a solid meteorological and scientific base. In Section 7.2 we detail the rationale, (re)sources and data to back up the background of these findings. If you use this step proceed to step 3.

2. **(optional) Hazard Identification – from scratch:** Table 9 in the Section principals of hazard assessment we present steps to perform hazard analysis, from scratch, by performing the following steps:

   i. Define the Geographic Scope

[74] This list contains the most relevant physical climate hazards in Europe. The list contains both acute and chronic climate-related hazards.

ii. *Understand the Regional Climate*
iii. *Collect Historical Climate Data*
iv. *Understand the Local Environment*
v. *Identify Location-Specific Hazards*
vi. *Analyse Climate Trends*
vii. *Use Climate Projections*
viii. *Identify Potential Hazards*
ix. *(optional) Consult Experts and Local Knowledge*
x. *Create an overview of relevant physical hazards*

In Section 7.9 we detail some of the data sources and tools that can be applied specifically for the Netherlands in this context.

3. **Exposure assessment:** Obtain a geographic (spatial) overview of the exposure to relevant physical climate hazards and buildings (the economic activity). Once potential hazards are identified, geospatial analysis can evaluate the exposure of residential properties to these hazards. Determine the specific climate-related hazards to which the property *may* be exposed. This could be based on for instance weather data, as well as historic events at the location.

The exposure analysis involves understanding the geographical location, nature, timing, frequency and severity of such hazards. For instance, properties located within flood plains or along the coast may be more exposed to flood or sea-level rise risks. Geospatial analysis, see Section 7.8, can be used to map environmental hazards related to climate change.

At this stage one can filter out climate-related hazards that:

- Are irrelevant to the location of the building: if the hazard does not occur at the location of the building and/or;
- Cannot cause adverse effects on the building: if the hazard cannot cause negative impacts for the building that would lead to a significant impairment of the performance of the economic activity (7.7).

In essence, this assesses the question: *Is the occurrence of the climate-related hazard possible for the building at the given location and can it have negative impact? (Yes/No)*

Table 10 in Section 4.4 details the steps that can be taken to perform an exposure assessment.

i. Collateral Identification
ii. Map (plot) Exposure
iii. Characterize the geographic Environment.
iv. Evaluate the Proximity to Hazards
v. Create an Exposure overview

An assessment of how the climate will change over the appropriate timescale (e.g. lifespan of the building) can then be undertaken, for comparison with the current baseline in order to identify trends[75]. Not a full CRVA analysis must be performed here. The key word is 'indicative' exposure, see Figure 17.

[75] *Technical* guidance on the climate proofing of infrastructure in the period 2021-2027 (European Commission).

Figure 17: Exposure analysis assessment for the screening of climate risks[76].

EXPOSURE ANALYSIS

Indicative exposure table: *(example)*	Climate variables and hazards: Flood	Heat	...	Drought
Current climate	Medium	Low	...	Low
Future climate	High	Medium	...	Low
Highest score, current+future	High	Medium	...	Low

The output of the exposure analysis may be summarised in a table with the exposure ranking of the relevant climate variables and hazards for the selected location, irrespective of the project type, and divided in current and future climate. For both the sensitivity and exposure analysis, the scoring system should be carefully defined and explained, and the given scores should be justified.

In Section 7.5 we detail some of the data sources and useful tools.

Considerations:

- It is recommended that the exposure analysis is based on the highest resolution data possible, as described in Section 6 we interpret this as employing regional – KNMI based data sources, such as those provided on *klimaateffectatlas*.

4. **Vulnerability Assessment**: we have to investigate how susceptible the building is to damage from the hazards identified before. This can depend on many factors, including the building's design, materials, location and demographic information such as the population density in the area. We therefore have to assess the sensitivity (only) for the hazards that are found to be relevant in the previous steps. Sources like *klimaatschadeschatter* and *klimaateffectatlas* can be used obtain an indicative (over)view of the potential vulnerability of physical climate hazards for buildings. in Section 4.5 details the steps that can be taken to perform a vulnerability assessment. Vulnerability should be assessed separately for each relevant hazard. As described in Section 4.5 the question to answer in this step is: "*How severe could the impacts be*?"

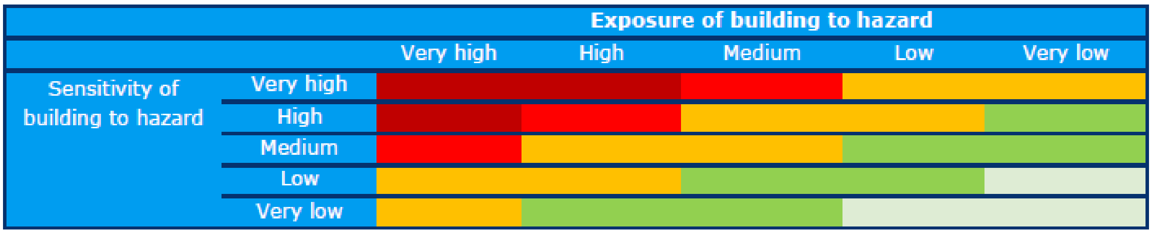
   i. Determine Sensitivity
   ii. Analyse Vulnerabilities
   iii. Evaluate Adaptive Capacity
   iv. Evaluate the Vulnerability Profile

5. **Assess if the economic activity is at risk of more (physical) climate hazards.**

   For buildings in areas that are found to be vulnerable to climate hazards a CRVA must be conducted. Both DG Climate and the EC suggest creating a table indicating the exposure and sensitivity of a building. The analysis should be carried out per relevant hazard. We currently do not have guidance for practical risk assessments ((very) low to (very) high). Figure 18 depicts an example of such an assessment for a hazard.

[76] *Adopted from page 30 of Technical* guidance on the climate proofing of infrastructure in the period 2021-2027 (European Commission).

Figure 18: Adapted from EU-level technical guidance on adapting buildings.



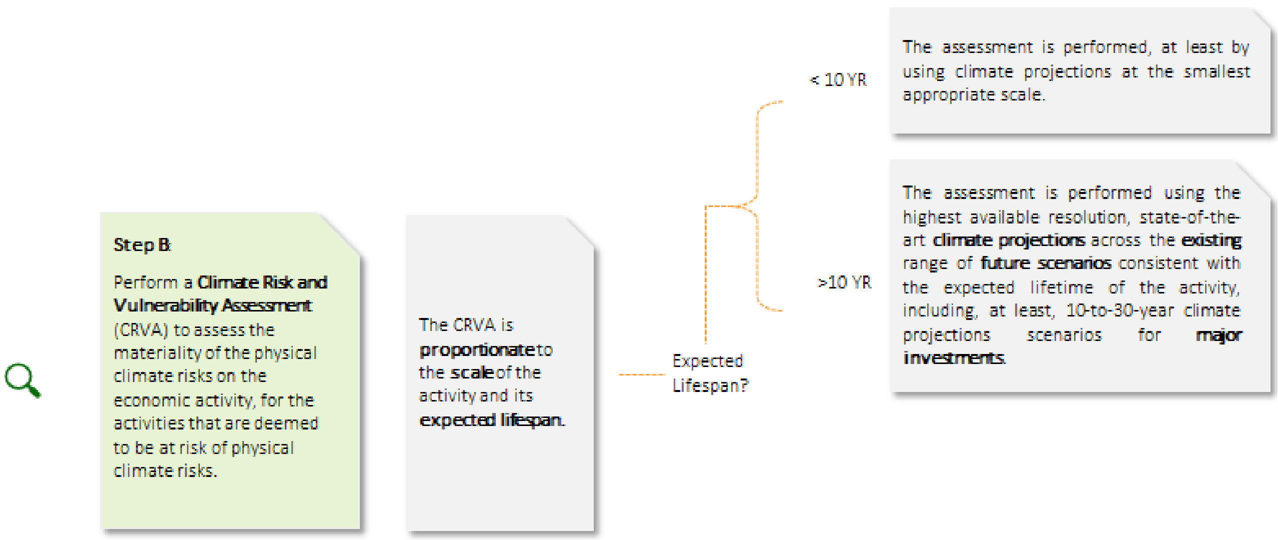
<u>Concluding remarks on Step A</u>:

- As described in the introduction of this section: in step A: we have to not only look into the hazards that are relevant but also somewhat assess if these *may affect the performance* of buildings.
- Therefore, we propose that step 4 is carried out in step A with a pragmatic approach and not by considering all potentially relevant climate projections (across multiple scenarios) at this stage.
- We currently do not have guidance on the assessment inference: (very) low to (very) high.
- It is a recommended best practice to detail (document) the rationale for relevant physical hazards.
- It is a recommended best practice to detail (document) the rationale for irrelevant physical hazards.
- The vulnerability assessment including the incorporation of building components and adaptive capacity is at the moment of writing, challenging to perform, in practice based on readily available data. In appendix (Section 10) we illustrate and explain this.

Step B: Climate Risk and Vulnerability Assessment

Once we have identified that an economic activity is at risk from one or more physical climate risks and hazards, we have to perform a Climate Risk and Vulnerability Assessment (CRVA). We assume the expected lifetime is > 10 years and we therefore have to look into branch B of the decision tree as depicted in Figure 19.

Figure 19: Step B of the DNSH analysis.



Wording	Footnote
The climate risk and vulnerability assessment is proportionate to the scale of the activity and its expected lifespan, such that: a) for activities with an expected lifespan of less than 10 years, the assessment is performed, at least by using climate projections at the smallest appropriate scale; b) for all other activities, the assessment is performed using the highest available resolution, state-of-the-art climate projections across the existing range of future scenarios [320] consistent with the expected lifetime of the activity, including, at least, 10 to 30 year climate projections scenarios for major investments. The climate projections and assessment of impacts are based on best practice and available guidance and take into account the state-of-the-art science for vulnerability and risk analysis and related methodologies in line with the most recent Intergovernmental Panel on Climate Change reports [321], scientific peer-reviewed publications and open source [322] or paying models.	[320] Future scenarios include Intergovernmental Panel on Climate Change representative concentration pathways RCP2.6, RCP4.5, RCP6.0 and RCP8.5. [321] Assessments Reports on Climate Change: Impacts, Adaptation and Vulnerability, published periodically by the Intergovernmental Panel on Climate Change (IPCC), the United Nations body for assessing the science related to climate change produces, https://www.ipcc.ch/reports/. [322] Such as Copernicus services managed by the European Commission.

Assumptions:

- In the previous step (A) we have identified the physical climate-related hazards and risks from this list that "may affect the performance" of the economic activity (7.7) during its expected lifetime".
- We assume at least one hazard has been found to be relevant for the Netherlands in stap A and thus step B a Climate Risk and Vulnerability analysis is needed[77].
- We have to assess the materiality of these identified climate hazards.

In this step we will build upon the previous step where we identified risks that may affect the performance of the activity. The goal of the CRVA is to estimate for each building (location) the risk that arises from each climate-related hazard found in the previous step (A). Following the EU Taxonomy wording: the assessment must be conducted for the current situation and for different future scenarios. The Climate Delegated Act distinguishes between two time periods: an expected lifetime <10 years and > 10 years. For buildings we will specifically be looking at the latter timeframe, as described in Section 6.

Practically, detailed climate projections are often available that detail the projections in the year 2050. This year is a milestone for the Paris Agreement and the EU Green Deal[78] ambitions. Therefore, we assume that where 30 years projections are not available the projections for the year 2050 are suitable.

In the CRVA one can assess the overall materiality of the physical climate risks to the economic activity by:

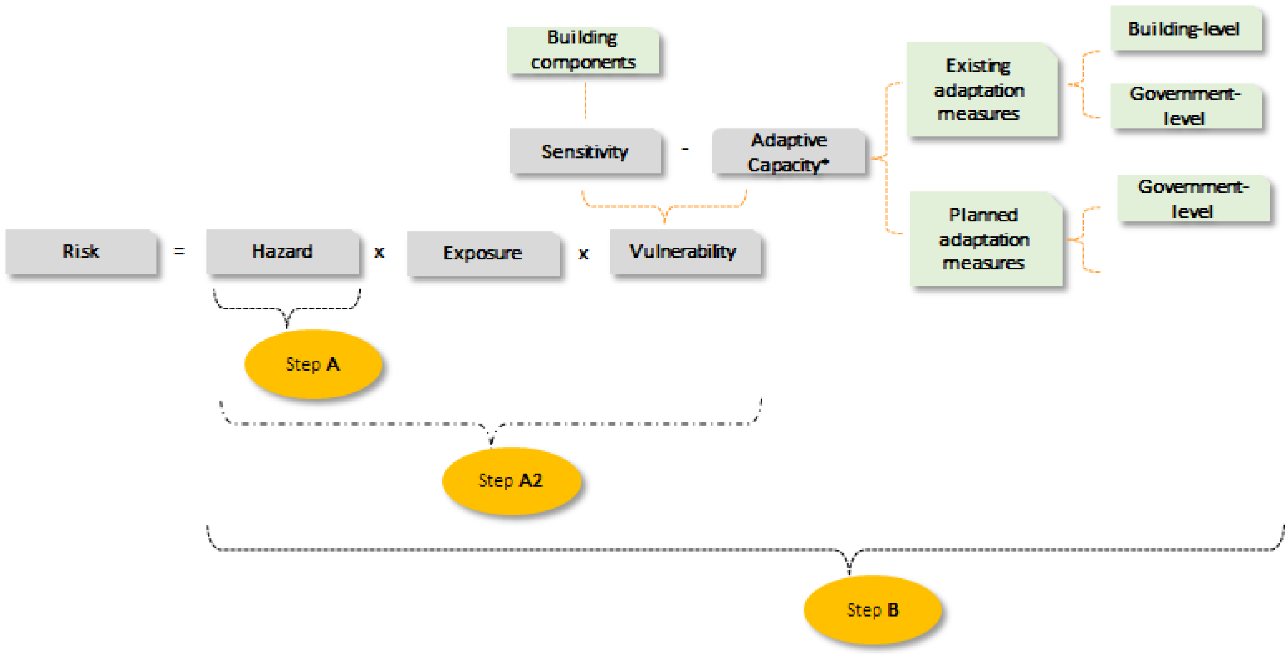
- Understanding potential (impact) relationships between the climate-related hazards and buildings.
- Gather information on current and future climate-related hazards. This can be done by employing data on climate projections.

[77] This step of the assessment, in theory, might not be needed if the building is not deemed to be vulnerable to a climate hazard.
[78] And thus the EU Taxonomy.

- Gather information on the sensitivity, impact and adaptive capacity of the possibly affected building.

In this step we will build not only on the outcome of Step A, but we will also re-use most of the tools and concepts. The (most) important difference being that we will 'deepen' our analysis. Specifically in the vulnerability assessment where we will investigate the exposure and sensitivity to explore the potential impact. We will also take into consideration (existing and planned) adaptation measures that (could) severely lower the impact and thus the vulnerability and the overall risk. In Section 4.6 we detail the importance of including adaptive capacity into risk assessment. Figure 20 illustrates the emphasis on vulnerability. Note that in Figure *20*, other than in Figure *16*, we therefore fully coloured the Exposure and Vulnerability elements of the analysis.

Figure 20: Risk representation for DNSH analysis step B.



We will have to assess the likelihood of climate hazards and their potential impacts on the building. Thereby we have to conduct an assessment of magnitude of an impact based on a combination of probability and consequence.

<u>Steps:</u>

1. Impact & consequence analysis:

   We will build on the insights of the vulnerability assessment for the identified hazards in the previous step. We will begin with an analysis of potential adverse physical impact to the building (damage).

   Building characteristics can form an important role in vulnerability assessments. As one can imagine apartments in 15-level building built below sea level near a river delta faces different risk than a relatively new residential property that is not below sea level. In addition, construction year can be a relevant factor. Some examples of building characteristics that can be important in this context are given in Box 5.

   As described in section the vulnerability impact can depend on building characteristics such as building age or building type. In this step we advocate to (re)-use the available information on the collateral (the building characteristics, including energy performance metrics) from the mortgage servicing system and (open) sources such as: 1) the national energy performance database ("*EP-Online*") and 2) the land registry ("*Kadaster*")[79].

Analysing current sensitivity and impact

We must understand and analyse the climate impact relationship ('*klimaateffect*') that have been found relevant. Some useful analytical questions that are to be considered here are:

- *'Has the building or building location been adversely affected or nearly affected by impacts of climate-related hazards in the last one or two decades?'*
- *'How did these adverse effects arise? (directly/through successive impacts/through combined hazards[80])'*
- '*What could have happened if the climate-related hazards had been stronger or had occurred simultaneously*?'
- *'What has been the trend for the climate-related hazard over the past one or two decades in the region of the building and in the wider surrounding area/across regions?'*

In Table *7* we have given an overview of physical climate hazards and (potential) impact on residential real estate, in the Netherlands. The German Environment Agency notes on the sensitivity analysis:' *If there are reasonable indications that the sensitivity of your system elements will also change in the future (e.g. due to demographic developments), it makes sense to consider these changes as well'*. Table *12* and Table 13 list various steps and methods to gauge vulnerability and sensitivity respectively.

The assessment of impact should be carried out for each applicable hazard identified. It is suggested that impacts are assessed from 'very low' to 'very high', see Figure 21, taken from the DG Climate report. Notice the difference between Figure 18 and Figure 21 as the later also looks into the future climate. In this document we do not provide (deterministic) guiding principles for assessing (very) low, medium or (very) high risks.

Figure 21: Hazard exposure assessment example, taken from DG Climate.

Table 3.4 Example of a table to assess overall exposure of the building to each applicable hazard[59]

	Climate variables and hazards					
	Flooding	Storms	Heat wave	Heavy precipitation	Subsidence	Drought
Current climate	Medium	Low	Medium	Low	Very low	Very low
Future climate	High	Medium	High	Medium	Very low	Low
Highest score (current + future)	High	Medium	High	Medium	Very low	Low

2. Likelihood analysis:

In this step one should consider how likely it is that the impacts identified in the previous step (impact & consequence analysis) will occur over the lifespan of the building. The assessment of the future can be based on climate scenarios.

The assessment of future climate hazards requires information about possible future climate change – based on the information about the current state of these hazards. The main components of the assessment of future climate risks are the expected changes in climate-related hazards and the range of these changes[81]. For each case or climate scenario, the

[79] For instance by using https://3dbag.nl/en/viewer to investigate 3D geometrical features of a building.
[80] As described in Section 3.5.
[81] German Environment Agency.

analytical question can be formulated as: *How material is the future potential for adverse consequences from each climate-related hazard for each system element of your investigation object (~30 years from now)* taking into account adaptive capacity*?* (low/medium/high). There are some useful analytical sub-questions to consider here[82]:

- *How can the frequency and the intensity of each climate-related hazard change in the future in the region of the investigation object and in the surrounding region/across regions?*
- *How wide are the ranges of future scenarios? What could be a worst and best case?*

The combination of local and regional climate risk assessments can provide a good basis of information for the assessment of long-term hazards. The CDA specifies that the climate risk assessment for activities with a lifetime of at least 10 years is to be based on *state-of-the-art climate projections* with the *highest available resolution*.

As noted in our analysis on the wording and he Q&A we do not assume that we have to consider, per se, all the (IPCC) scenarios. The proportionality principle applies as does answer 168 of the Q&A: that at least RCP 8.5 should be employed. Some of the recently published papers propose to look at an optimistic (such as RCP 2.6) and a pessimistic scenario (such as RCP 8.5). As DNB points out it is a best practice to look at least 2 climate scenarios', see Section 5.8.

For the assessment of 1) impact & consequence relationship and likelihood analysis we advise to use the data of the *klimaateffectatlas* for the Netherlands. This resource provides a visual representation of climate scenarios based on KNMI (which in its turn are based on IPCC scenarios)[83]. In addition, it provides a helpful resource for identification of map narratives ("*klimaatverhalen*") a useful instrument in impact analyses. Using the map narratives is also in line with the DNB advice on best practices. At this stage we recommend to take into account the guidance and recommendations for conducting climate risk analysis that have been published by the DNB, see Table 16 and Box 15.

Local and regional climate risk assessments can provide a good basis of information for the assessment of long-term hazards, provided that they are based on highest-resolution data for the above-mentioned range of future scenarios. Note that these (climate-scenario) maps and map narratives can provided detailed information on a detailed level and include the hazard or map-narratives pre-made based on scenario projections. This should give an indication of how probable (likelihood) it is that a climate hazard (e.g. flooding) will occur at a given location within the appropriate time frame.

We have to "*consider any steps that have been taken to avoid the impact!"*[84]. This last part points towards the inclusion of adaptive capacity in the assessment of the potential impact and vulnerability. It is important to consider the adaptive capacity in the vulnerability or impact analysis, as this can (significantly) influence if the economic activity is at low, medium or high risk. As mentioned in Section 4.6 adaptive capacity affects not only the vulnerability component but can also affect hazard and exposure beneficially. Therefore we propose to include adaptation measures. Table 14 list some examples. Some maps or map narratives take into account adaptive capacity (such as raised dykes). Therefore it is important to ascertain if the data (such as vulnerability or sensitivity scores or maps or estimates), takes into account adaptive capacity and to which extend.

[82] Idem.
[83] see Sections 5.3 and 7.4
[84] EU-level technical guidance on adapting buildings to climate change notes: *"For a building's CVRA, this step should consider how likely it is that the impacts identified in (e.g. damage to the roof) will occur over the lifespan of the building, considering any steps that have been taken to avoid the impact. This method would allow for assessment of both existing and planned buildings and provide a more realistic assessment of risk. Any existing or planned climate adaptation measures would reduce the likelihood of impact. For example, it could be highly likely that there will be a heavy rainfall event during the lifetime of the building, but it could be unlikely the building will flood during a heavy rainfall event due to flood mitigation measures."*

3. Risk assessment

The risk assessment is a combination of the likelihood and impact analyses. A level of risk tolerance may be assigned to each physical risk, so that risks that are outside of tolerance can be identified. The level of risk tolerance can differ per use case or institution. According to the ECB guidance it is a best practice to explain these risk tolerances.

Both a quantitative and qualitative assessment can be applied. However given the uncertainty in the assessment of likelihood, a (qualitative) scale of low-to-high is recommended. The level of risk assigned to each hazard can be calculated using a matrix. This analysis should be completed for each applicable hazard, as with the impact analysis. In Figure 22 we depict a risk assessment example proposed by the EC. If risks are deemed to be significant (i.e. medium-high risks), further assessment and consideration of relevant adaptation measures must be identified in step C of the DNSH Analysis. Given the uncertainty in the assessment of likelihood, a scale of low-to-high is recommended for risks. If no medium or high climate risks have been identified the CRVA is finished.

Figure 22: Risk assessment based on likelihood analysis and impact analysis[85].

LIKELIHOOD ANALYSIS

Indicative scale for assessing the likelihood of a climate hazard (example):

Term	Qualitative	Quantitative (*)
Rare	Highly unlikely to occur	5 %
Unlikely	Unlikely to occur	20 %
Moderate	As likely to occur as not	50 %
Likely	Likely to occur	80 %
Almost certain	Very likely to occur	95 %

The output of the likelihood analysis may be summarised in a qualitative or quantitative estimation of the likelihood for each of the essential climate variables and hazards. (*) Defining the scales requires careful analysis for various reasons including e.g. that the likelihood and impacts of the essential climate hazards may change significantly during the lifespan of the infrastructure project among other due to climate change. Various scales are referred to in the literature.

IMPACT ANALYSIS

Indicative scale for assessing the potential impact of a climate hazard (example) — *Risk areas:* / *Impacts:*	Insignificant	Minor	Moderate	Major	Catastrophic
Asset damage, engineering, operational					
Safety and health					
Environment, cultural heritage					
Social					
Financial					
Reputation					
Any other relevant risk area(s)					
Overall for the above-listed risk areas					

The impact analysis provides an expert assessment of the potential impact for each of the essential climate variables and hazards.

RISK ASSESSMENT

Indicative risk table: *(example)*

Overall impact of the essential climate variables and hazards (example)

Likelihood	Insignificant	Minor	Moderate	Major	Catastrophic
Rare					
Unlikely		Drought			
Moderate		Heat	Flood		
Likely					
Almost certain					

Legend: Risk level

- Low
- Medium
- High
- Extreme

The output of the risk analysis may be summarised in a table combining likelihood and impact of the essential climate variables and hazards. Detailed explanations are required to qualify and substantiate the assessment conclusions. The risk levels should be explained and justified.

<u>Concluding remarks on Step B</u>:

- Contrary to step A, we have to look 'deeper' at the elements of the risk representation.
- We should take into account adaptive capacity where possible, as advised by the IPCC, to obtain a true value of hazards, exposure and vulnerability.
- It is key to identify adaptive capacity in it's various forms: governmental – to building (unit) scale.
- Ascertain if data and intermediate inference is net or gross of adaptive capacity.
- It is a recommended best practice to detail (document) risk tolerance.

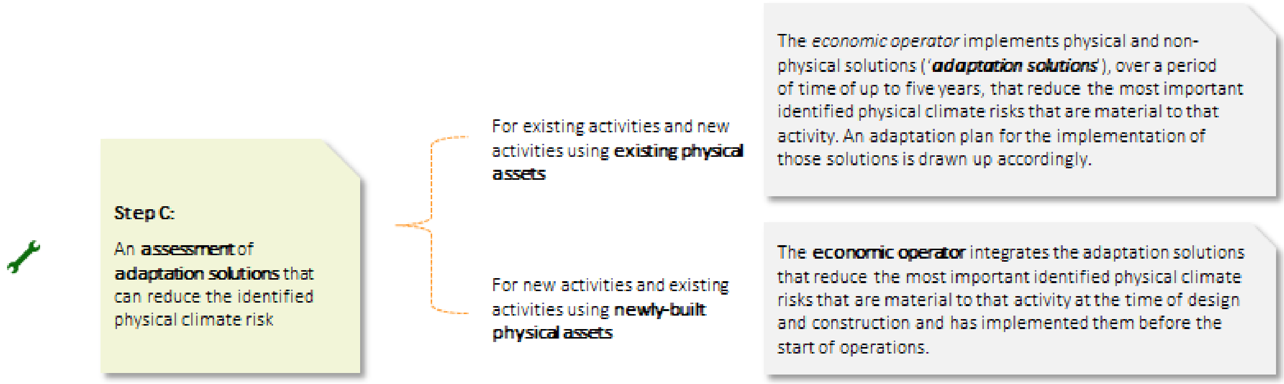
[85] *Adapted from page 35 of Technical* guidance on the climate proofing of infrastructure in the period 2021-2027 (European Commission).

- If no medium or high climate risks have been identified the CRVA is finished. - Risk tolerance might differ per case and institution. - We currently do not have a guidance on the assessment (very) low to (very) high. - The vulnerability assessment (including the incorporation of building components and adaptive capacity is at the moment of writing, challenging to perform, in practice based on readily available data. In appendix (Section 10) we illustrate and explain this.

8.3 Step C: Assessment of adaptation solutions

To meet the requirements for EU Taxonomy alignment, it is necessary to assess adaptation solutions "*that can reduce the identified physical climate risks*". We assume to do this for economic activities that have been assessed to be of high risk. In Figure *23* we illustrate this.

Figure 23: Step C of Appendix A.



Section	Wording	Footnote
DNSH Appendix A Climate risk and vulnerability assessment	For **existing activities** and **new activities** using **existing physical assets**, the **economic operator implements physical and non-physical solutions ('adaptation solutions'), over a period of time of up to five years,** that reduce the most important identified physical climate risks that are material to that activity. An **adaptation plan** for the implementation of those solutions is drawn up accordingly. For new activities and existing activities using **newly-built physical assets**, the economic operator **integrates** the **adaptation solutions** that reduce the most important identified physical climate risks that are material to that activity **at the time of design and construction and has implemented them before the start of operations.**	[323] **Nature-based solutions** are defined as 'solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions'. Therefore, nature-based solutions benefit biodiversity and support the delivery of a range of ecosystem services. (version of [adoption date]:

	The adaptation solutions **implemented** do not adversely affect the adaptation efforts or the level of resilience to physical climate risks of other people, of nature, of cultural heritage, of assets and of other economic activities; are consistent with local, sectoral, regional or national adaptation strategies and plans; and consider the use of nature-based solutions[323] or rely on blue or green infrastructure[324] to the extent possible.	https://ec.europa.eu/research/environment/index.cfm?pg=nbs). [324] See Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Green Infrastructure (GI) — Enhancing Europe's Natural Capital (COM/2013/0249 final).

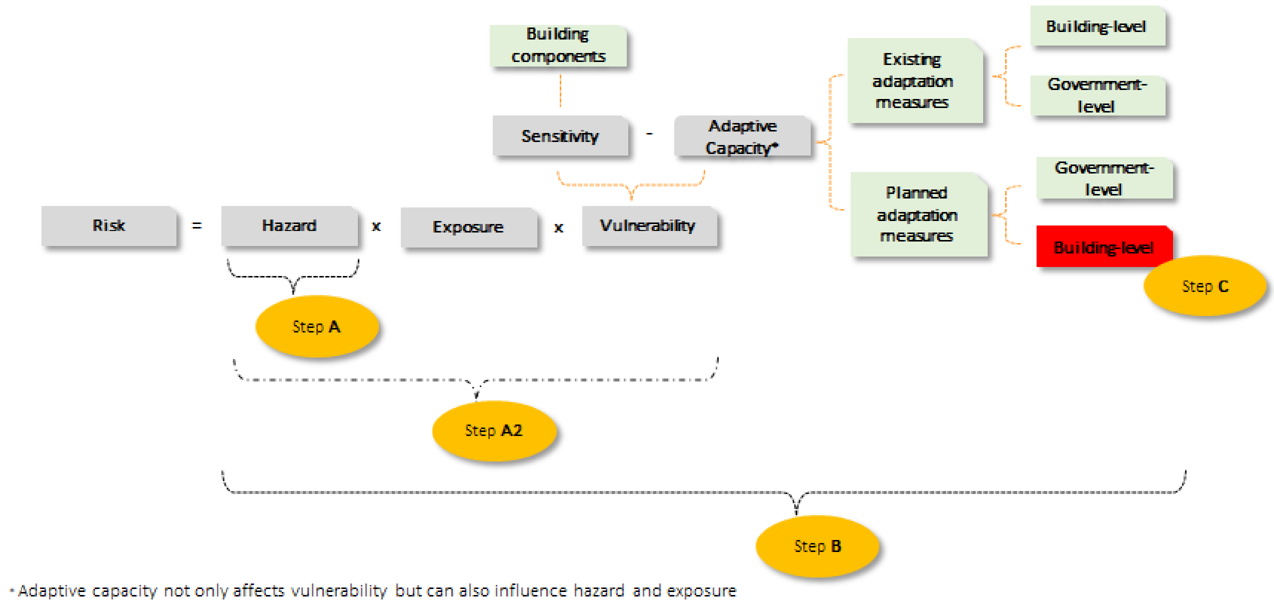
Ideally, the goal of vulnerability assessment should be to inform the development of adaptation solutions. This is because adaptation solutions are designed to increase the capacity of the system to withstand and recover from potential changes and threats. In the real estate sector, these solutions could take various forms:

1. **Building-level adaptations:** This could involve the implementation of resilient design principles and construction methods that improve the building's ability to withstand climate-related hazards. For example, in flood-prone areas, properties could be designed with elevated structures or waterproofing measures to minimize flood damage.
2. **Infrastructure-level adaptations:** This could involve the development of resilient infrastructure that supports the stability and safety of real estate assets. For instance, the creation of efficient drainage systems in urban areas can help manage stormwater and reduce the risk of flooding.
3. **Policy-level adaptations:** This could involve the establishment of regulations and standards that mandate the incorporation of climate resilience measures in the design and construction of buildings. For instance, updating building codes to require the use of heat-resistant materials in construction can reduce the vulnerability of properties to heatwaves.

Figure 24 depicts step C as via the risk representation including adaptation solutions.

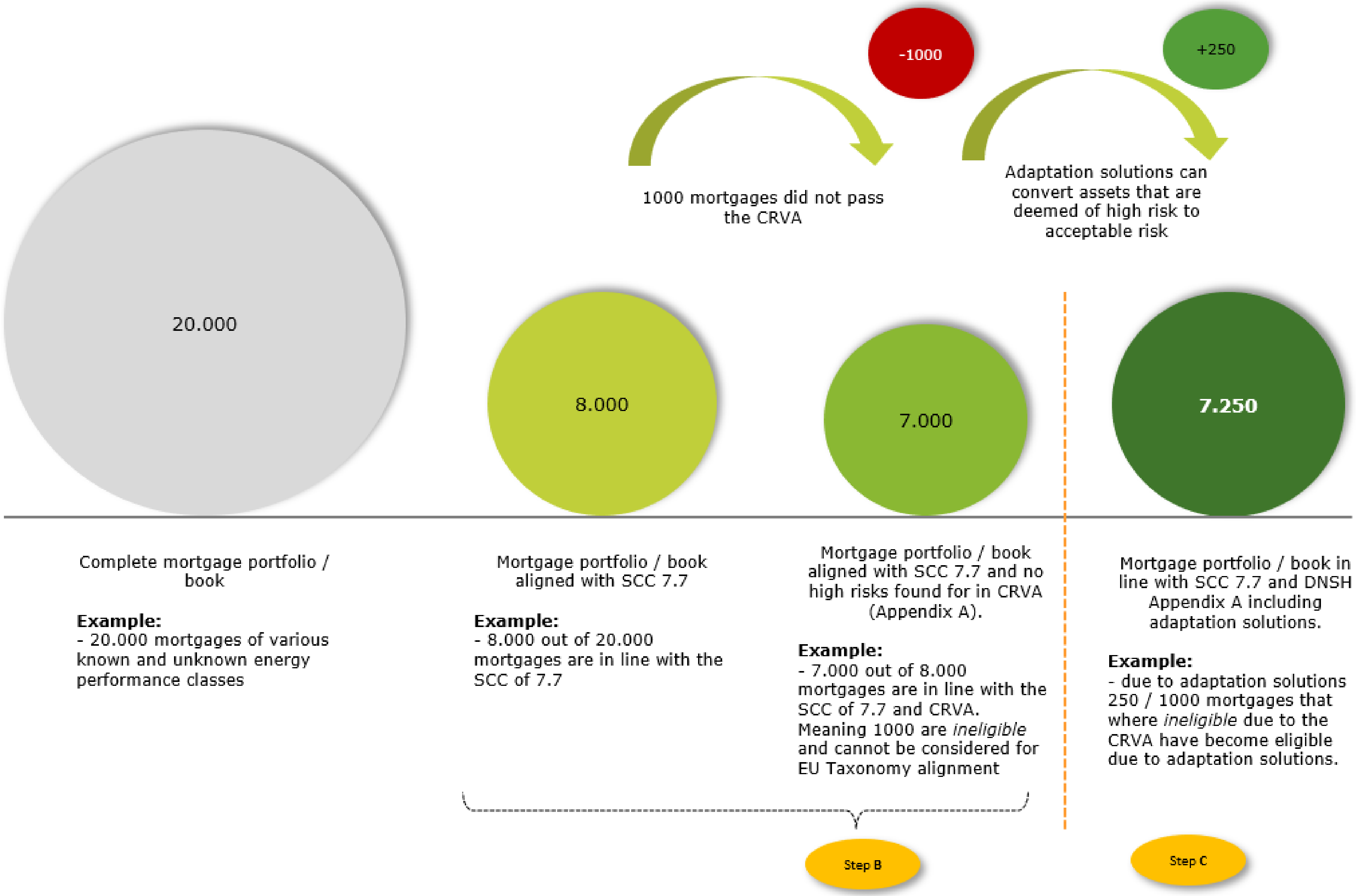
Important note: The (practical) analysis of Step C, adaptation solutions, have not been analysed and discussed yet within the EEM NL Hub WG. Therefore, in this version of DEEMF we have no exploration and guidance on this step.

Figure 24: Risk representation including adaptation solutions.



Adaptation solutions can have the ability *convert* assets (building units) that did not pass the Climate Risk and Vulnerability Assessment (CRVA) into acceptable risks – passing the CRVA, this is illustrated in Figure 25 , with an example.

Figure 25: Example of the influence of adaptation solutions when performing a CRVA (step B) and consequentially analysing Adaptation Solutions (Step C).



9 Conclusion and considerations

9.1 Considerations for future updates

Below we highlight considerations and suggestions for future analysis:

- Explore finding (and maintaining) common ground on a standard set of applicable climate hazards.
- Establish best practice around the use of data resources.
- An analysis of data quality, availability and completeness.
- Establish best practices in the practical application of exposure & vulnerability assessment.
- Establish best practices around scenario use and inference.
- Establish best practices around qualitative risk assessment.
- Best practices around documentation and the use and disclosure of adaptation solutions.
- Incorporation of KNMI AR6 update (to be published in Q4 2023).

9.2 Conclusion

In this report we describe the analysis of the Do No Significant Harm (DNSH) criteria of Appendix A of the Climate Delegated Act for the EU Taxonomy environmental objective: Climate Change Mitigation. Thereby we have made an initial exploration in the world of climate risk analysis. A topic of growing urgency that is and will become increasingly relevant for the financial sector – including and specifically for mortgage loans. Buildings serve as the fundament of the mortgage product, and they are highly affected by climate change but at the same time play a pivotal and critical role in climate change mitigation and Net-zero ambitions.

As written in the introduction, the goal of the document is to make the reader familiar with:

1. The conduct of climate risk analysis.
2. The Do No Significant Harm (DNSH) wording of the EU Taxonomy.
3. Best practices and (regulatory and supervisory) guidance upon this topic.
4. The (linguistic) interpretation and analysis of the DNSH wording in the context of residential mortgages.
5. The potential (data) (re)sources to apply to the Netherland.
6. Different methods and best practices to perform a CRVA.

The EEM NL Hub WG has examined how the DNSH wording applies in the context of residential mortgage lending. Though it might initially appear abstract, we have hopefully shown how it ties to climate risks such as flooding or heat stress which could significantly affect the value of residential properties and the related financing.

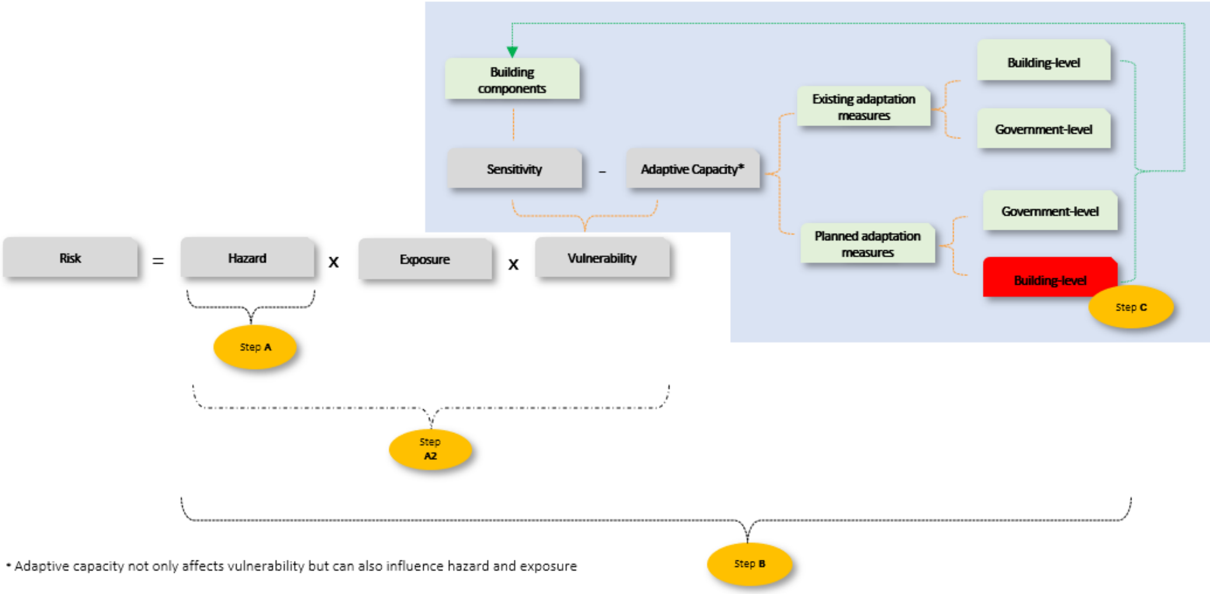
Through the careful interpretation of the DNSH wording, mortgage lenders and borrowers alike can better identify and mitigate these climate-related financial risks, turning the abstract into actionable steps towards EU Taxonomy alignment. We have explored potential data resources available for the Netherlands, highlighting how unique geographic, demographic and climate factors can influence the CRVA process. By using the right data and understanding its implications, stakeholders can make better-informed decisions, more accurate predictions, and prepare effective risk mitigation strategies. A subsequent report will delve into the analyses of the DNSH criteria from a (pragmatic) data and inference perspective, building and extending upon the theory and resources in this document. Section 9.1 highlights several suggestions and considerations for the forthcoming update of DEEMF. We kindly request all readers to share any thoughts, questions and ideas that can help us in our joint mission to make and maintain a general methodology for DNSH analysis for mortgage loans.

10 Appendix

10.1 Working Group commentary and observations on the (use of the) conceptual risk model

Below we have included some observations on the use of the conceptual model introduced in Figure 24.

Figure 26: Risk representation including (positive) feedback loop stemming from adaptive capacity. In blue we have illustrated areas where data considerations are relevant.



Box 19: From conceptual framework to practical application

From Conceptual Framework to possible (future) practical application in light of potential lack of data availability

The conceptual framework as depicted in the figure [] above lays out all relevant elements to consider in the CRVA at asset – building (unit) level. It consists of elements put forward by the IPCC, ISO and DG Climate, for conducting (physical) climate risk assessment.

We have identified several applications for the use of this conceptual model:

- It depicts the (traditional) climate risk representation including (potential) interactions with adaptive capacity and the importance of building characteristics, as advised by the IPCC and DG Climate.
- It could help identify and assess the certain elements and dynamics influencing the risk assessment.
- It could help us identify and map the CRVA steps towards elements of physical risk assessment.
- It could serve as a classification system for conducting CRVA.
- It might help in identifying & distinguishing short-term dynamics from long-term dynamics.
- It can uncover data availability considerations.
- It could guide inspiration for future potential risk 'dampening' measures (i.e., adaptive capacity / adaptation solutions) – i.e. a *wish list*.

In Figure 26 we have made a variant of Figure 24 illustrating the (theoretical) presence of a (positive) feedback loop between the adaptive capacity of adaptation measures on building level (existing and planned) and building components sensitivity. This green line depicts those measures taken o (such as for instance installing passive ventilation) can influence the building components sensitivity.

In the current assessment *landscape* data availability, granularity, quality and governance considerations play a key role in determining the practical application.

For instance, the data availability on the building characteristics component is limited in practice. This affects the potential for the use of adaptive capacity and thus (potentially) impacts **Sensitivity** and **Vulnerability** (see the blue plane in the figure).

There is a lack of readily-available data sources on building(unit) level that provides insight in components that may have a reducing effect on the relevant **Hazards**. An example of this lack of information could be the heights of the doorstep of the respective building in case of flooding. Or available information on ventilation to mitigate heat stress. Although there are developments in this field[86], many of these developments are not yet concretely openly available and in a centralised, accessible, and useable data format or resource.

Exemplary for this issue is the information published in the EC report on (potential) adaptation solutions on building (unit) level, which we have referred to in this document (in Section 7)[87]. These adaptation solutions seem interesting and promising. However, readily-available data on measures taken or incorporated is not readily available in a central data resource.

It therefore also uncovers the need for a comprehensive and centralised data overview of **existing adaptation measures** and **planned adaptation measures** on **Government Level** both on central government as on (local) municipality level. An example could be the impact of a *WADI system (Water Afvoer Drainage en Infiltratie, ENG: Water Drainage and Infiltration)* or the number of trees in the surroundings of the respective building when intensive rainfall or flooding occurs[88]. Another example of this is a having a central overview of planned measures to implement district heating in a postal-code level ("aardgasvrije wijken"). However, many of these developments are not yet concrete and do not provide for centralised and comprehensive data resource (or readily available in the short term).

The fact that data availability is limited to establish **Vulnerability** does not prevent the functioning of this conceptual model for the coming years. Namely if no elements are available for **Building Components** or **Adaptive Capacity** there is no mitigating or reducing effect on **Sensitivity** and thus **Vulnerability.** The result is that the CRVA outcomes may be more conservative since these elements are not considered and main focus lays on **Hazard** x **Exposure** (step A2).

Practically this may mean that the performing party of the CRVA leverages its data sources for the relevant **Hazards** (such as *Klimaateffectatlas)* and applies this to the relevant exposure. In the future, if data for reducing elements are available (see blue plane) are more readily available, this may influence the **Vulnerability** outcome and have a reducing effect on the **Risk** outcome.

For completeness's sake, it should be noted that some elements such as **Existing Adaptation Measures** for example on **Government Level** may already be taken into account in the data source of the respective **Hazard**. An example is the Deltawerken from the Dutch Government which are already taken into account in the *Klimaateffectatlas* for some Flooding maps (e.g. *Plaatsgebonden overstromings kans - 2050).*

[86] Such as the DGBC adaptive capacity of buildings which envision to provide a score to the adaptive capacity of buildings taking all building elements and components into account.
[87] EU-level technical guidance on adapting buildings to climate change - Best practice guidance.
[88] Also, in this respect there are developments, again from for example the DGBC which envisions to establish a score ("*omgevingsscore*") centralising and taking all relevant elements of the surroundings into account which have may an adaptive capacity.

11 Disclaimer

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