Climateurope2

Inventory of data tools and knowledge for climate impacts, extremes and risks for the formulation of standards that can increase their quality and usefulness

Deliverable 2.5

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Climateurope2

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About Climateurope2

Timely delivery and effective use of climate information is fundamental for a green recovery and a resilient, climate neutral Europe, in response to climate change and variability. Climate services address this through the provision of climate information for use in decision-making to manage risks and realize opportunities.

The market and needs for climate information has seen impressive progress in recent years and is expected to grow in the foreseeable future. However, the communities involved in the development and provision of climate services are often unaware of each other and lack interdisciplinary and transdisciplinary knowledge. In addition, quality assurance, relevant standards, and other forms of assurance (such as guidelines, and good practices) for climate services are lagging behind. These are needed to ensure the saliency, credibility, legitimacy, and authoritativeness of climate services, and build two-way trust between supply and demand.

Climateurope2 aims to develop future equitable and quality-assured climate services to all sectors of society by:
- Developing standardization procedures for climate services
- Supporting an equitable European climate services community
- Enhancing the uptake of quality-assured climate services to support adaptation and mitigation to climate change and variability

The project will identify the support and standardization needs of climate services, including criteria for certification and labeling, as well as the user-driven criteria needed to support climate action. This information will be used to propose a taxonomy of climate services, suggest community-based good practices and guidelines, and propose standards where possible. A large variety of activities to support the communities involved in European climate services will also be organized.

Acronyms

C3S : Copernicus Climate Change Service
CE2: Climateurope2
CERFACS : Centre Européen de Recherche et de Formation Avancée en Calcul Scientifique
CFRF : Climate Financial Risk Forum
CSC: Climate Service Center
CSRD: Corporate Sustainability Reporting Directive
CRED Centre for Research on the Epidemiology of Disasters
DNSH: Do No Significant Harm
EEA: European Environment Agency
EFRAG: European Financial Reporting Advisory Group
ETH : Eidgenössische Technische Hochschule
ESRS : European sustainability reporting standards
EU: European Union
GIZ : Deutsche Gesellschaft für Internationale Zusammenarbeit
GP L & D: Global Programme on Risk Assessment and Management for Adaptation to Climate Change (Loss and Damage)
JRC: Joint Research Center
IEC: International Electrotechnical Commission

IFC:	International Finance Corporation
ISO:	International Organization for Standardization
KNMI:	Koninklijk Nederlands Meteorologisch Instituut
TCFD:	Task Force on Climate-Related Financial Disclosures
UK:	United Kingdom
UNDRR:	United Nations Office for Disaster Risk Reduction
UNEPFI:	United Nations Environment Programme Finance Initiative
SMHI:	Swedish Meteorological and Hydrographical Institute
WMO:	World Meteorological Organization
WP:	Work Package
WRI:	World Resources Institute,
XRB:	External Reporting Board

Executive Summary

The objective of this deliverable is to review international standards and guidelines for climate risk assessment and establish an inventory of data, tools and knowledge currently employed in the assessment of climate impacts, extremes and risks. Using an iterative literature review combined with a review of WP1 outputs, we identified publicly available international resources for climate risk assessment, identifying commonalities and discrepancies and highlighting areas where resource gaps exist. Section 1 introduces the scope of the report and sets out the process for selection. Section 2 provides a review of internationally relevant regulations, guidelines and standards to perform climate risks assessments, identifying 26 with international relevance. A detailed discussion is provided of three with broad cross-sectoral applicability, namely: ISO 14091, the EU Taxonomy and Recommendation for national risk assessment for disaster risk management in the EU. Comparative analysis of these guidelines and standards reveals broad consistency in terms of stressing a need to identify hazards that could impact on the focal activity or system prior to risk assessment; gathering the highest quality data available (e.g. current climate, futures projections, exposures, vulnerabilities); be transparent about uncertainties; and communicate the outputs of the assessment in a way appropriately tailored to the intended audience. It is found that while many standard and guidelines operationalise the concept of risk in line with the Intergovernmental Panel on Climate Change (IPCC) as a function of hazard, vulnerability and exposure this is not universal. It is also evident that the vast majority of existing standards and guidelines relate to physical risk, while comparatively little are addressing transition risks.

Section 3 collates an inventory of publicly available data resources and tools to support climate risk assessment. These are identified as services that provide climate data only; services providing climate indicators related to extremes and hazards; services providing data or information on climate impacts; services providing data for risk evaluation including exposure and vulnerability; services providing risk assessment outcomes; software tools for processing climate data; models and tools for evaluating climate impacts and/or risk; and stepwise methodologies or templates for risk evaluation. In reviewing data resources, we find that several services providing climate data and information on climate indicators and extremes exist, often intended for use by non-specialist users. However, training may be needed to utilise them. Gaps and challenges are identified with respect to resources on climate impacts, no publicly available resources on realised impacts of anthropogenic climate change, and vulnerabilities, which may be dynamic and difficult to capture. With respect to tools, we find that various open-access software resources are available, but quality assurance may be unclear. As with

standards and guidelines, tools overwhelmingly focus on supporting assessment of physical risk rather than transitional risk.

In Section 4 key conclusions regarding best practice and gaps are presented. For best practices core recommendations emerging from the standards and guidelines reviewed relate to appropriately defining the scope of the analysis, gathering the highest quality data available, screening hazards to identify those that pose the greatest risk in the focal context, identifying the most suitable methodology for the context and utilising multiple scenarios. Identified gaps relate to a lack of formal guidance and tools for assessing transition risks; guidance for developing suitable communication formats; tools and methodologies for conceptualising and assessing compound and cascading risk; guidance for assessing and addressing uncertainties; and considerations of 'response to adaptation' as a dimension of risk. Considerations for the development and utilisation of different services and tools are set out.

Keywords

Climate change risk, Physical risk, Transition risk, Climate impacts, Climate extremes, Standards, Guidelines.

1 Introduction

Climate change will affect our daily lives, making it essential to be prepared and to adapt to its consequences. It is important to acknowledge that the impacts of these changes are not spread evenly across the globe, depending on factors such as geography, economics, social conditions, and the environment. To ensure effective adaptation, there is an urgent need to accurately assess climate-related risks in the future.

Climateurope2 aims to develop future equitable and quality-assured climate services to all sectors of society by developing standardization procedures for climate services, supporting an equitable European climate services community and enhancing the uptake of quality-assured climate services to support adaptation and mitigation to climate change and variability. Climate services are particularly relevant in the management of climate risks and the impacts of climate extremes. A wide array of data, tools and knowledge is already being used by scientists and practitioners to evaluate the potential for climate impacts and risks, yet the harmonisation of approaches and the use of quality-assured data and tools have been lagging behind. For this reason, WP2 (Data and Processes) will develop guidelines to enhance the saliency and usefulness of data, tools and knowledge for the assessment of climate impacts, extremes and risks. The first step towards the formulation of these guidelines is an evaluation of existing literature as well as relevant projects and international initiatives in order to identify the current state-of-the-art and formulate a preliminary version of best practices. Further on in the project, these findings will be shared with the wider climate services community to collect feedback and further input. The community feedback will be integrated to produce a final version of the guidelines containing distilled recommendations for standardisation, supported by case studies.

1.1 Objectives

In response to the growing urgency of climate change adaptation and risk management, a multitude of regulations, standards, guidelines and tools have emerged to assist and enforce preparedness for future climate-related risk. This report aims to establish an inventory of data, tools and knowledge currently employed in the assessment of climate impacts, extremes and risks. Our objective is to identify the current state-of-the-art and, to the extent possible, best practices within these methodologies. This foundation will enable us to formulate guidelines and recommendations for standardizations (or standardised approaches). In doing so, we aim to enhance the quality, salience, and usefulness of these data, tools, and approaches to support effective climate adaptation and risk management strategies.

1.2 Scope of the report

This report aims to identify key knowledge and practices to assess climate impacts, climate extremes and climate risks and by compiling an inventory of international regulations, standards and guidelines related to climate risk assessment, to identify key elements to build a new standard for climate risk assessment based on best practices. Additionally, a list of open-access and free climate data tools and services to assess climate impacts, climate extreme and climate risks is presented to help identify best practices and access high quality data and tools available. This report has four sections following this introduction; Section 2 presents a review of standardization initiatives, guidelines, and requirements to assess climate risks. Section 3 focuses on an inventory of climate tools and climate services for climate projection and risk assessment. Finally, Section 4 provides a summary of the results and sets the requirements and good practices for the next step that will be to establish a guideline for climate risk assessment.

2 Review of international guidelines and standards to perform climate risks assessments

A quality-assured approach through the application of regulations, standards and guidelines is necessary to help stakeholders to properly assess risks from climate change and to mitigate these risks. However, these documents do not have the same hierarchical importance. WP1 from CE2 gathered some definitions to properly understand the differences between these documents.

Regulation

Regulations can be considered as a minimum quality standard that is compulsory to follow. A regulation is enforceable by law, so following regulations is mandatory[1]. WP1 defined a regulation as "Governmental standards, providing binding legislative rules, are usually called regulations". Regulations have a higher hierarchical importance than standards.

Standard

WP1 has defined a standard as "A document, established by consensus and approved by a recognized body, that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context. The broad participation of all stakeholders, a transparent development process and the consensus principle ensure the wide acceptance of community-accepted standards. To ensure they reflect the state of the art, standards are regularly reviewed by experts."[2]

In simple terms, a standard outlines minimum best practices as identified by industry representatives, practitioners and other stakeholders through a consensus process. In contrast to regulations, standards are not enforceable by law, only once it is incorporated by reference in legislation it becomes mandatory to follow. However, following standards assures the quality of a service as they provide a set of recognized guidelines and best practices.

Guideline

Guidelines can be defined "as a piece of information that suggests how something should be done". Guidelines could be associated with a standard or a regulation; setting out best practices, to guide the user step-by-step through the process of designing a climate risk assessment eligible to an associated standard[3].

2.1 Climate risk framework: IPCC - The concept of risk in the IPCC Sixth Assessment Report

Climate change risks assessments are pivotal for effective climate action and policy making. They serve as a foundation for global cooperation and ensure stakeholders are able to make well-informed decisions, allocate resources efficiently, and prioritize actions to mitigate and adapt to climate change. Over the years, the concept of climate risk has evolved significantly, reflecting a deepening understanding of the complex interplay between human activities and the Earth's climate system. The Intergovernmental Panel on Climate Change (IPCC) actively worked on the concept of climate risks to

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[1] Types of legislation [Types of legislation | European Union (europa.eu)]

[2] WP1 Task 1.2 Vocabulary [wiki:content:wp_1 [] (bsc.es)]

[3] European guidelines European guidelines | Safety and health at work EU-OSHA (europa.eu)

improve our understanding of the challenges posed by climate change and inform decision-making at all levels of society. While the definition of risk can vary across domains, with some sources characterizing it as consequence multiplied by probability, this deliverable adheres to the IPCC's Risk Framework. A more in-depth discussion of the definition of risk will follow later.

The IPCC framing of climate risk provides the foundation upon which numerous standards and guidelines for evaluating climate risk are built. The IPCC refers to climate risks as "the potential for adverse consequences for human or ecological systems, recognizing the diversity of values and objectives associated with such systems"[4]. Risks can arise from the potential impacts of climate change as well as the human responses to it. Risks result from the dynamic interaction between climate-related hazards with the exposure and vulnerability of the affected human or ecological system to the hazard (IPCC, 2022).

In the context of physical risk, the IPCC's risk framework acknowledges the dynamic nature of each of the three elements. Hazards, exposure, and vulnerability are not static but subject to change over time, influenced by short- and long-term climatic shifts and socio-economic transformation.

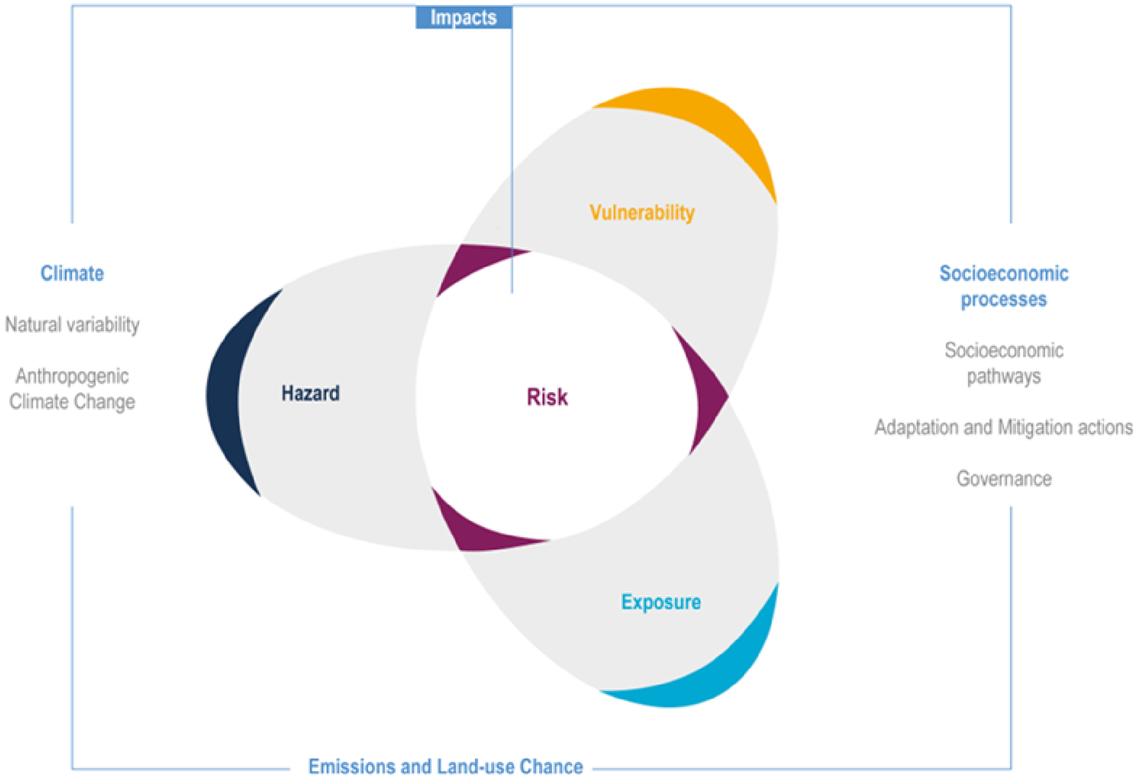

Figure 1: The IPCC conceptual framework with risk at the center[5].

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[4] IPCC, 2022: Annex II: Glossary [Möller, V., R. van Diemen, J.B.R. Matthews, C. Méndez, S. Semenov, J.S. Fuglestvedt, A. Reisinger (eds.)]. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 2897–2930, doi:10.1017/9781009325844.029.

[5] Figure 1.5 in Ara Begum, R., R. Lempert, E. Ali, T.A. Benjaminsen, T. Bernauer, W. Cramer, X. Cui, K. Mach, G. Nagy, N.C. Stenseth, R. Sukumar, and P. Wester, 2022: Point of Departure and Key Concepts. In: *Climate Change 2022: Impacts, Adaptation, and Vulnerability*. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 121-196, doi:10.1017/9781009325844.003.

The current assessment AR6 introduced a more sophisticated climate risk assessment, incorporating compound, cascading and aggregate risk, as well as introducing responses as a new dimension of risk.

This report follows the IPCC definition of hazard, exposure, vulnerability, climate impacts and climate extremes:

Hazard	The potential occurrence of a natural or human-induced physical event or trend that may cause loss of life, injury or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources.
Exposure	The presence of people; livelihoods; species or ecosystems; environmental functions, services, and resources; infrastructure; or economic, social, or cultural assets in places and settings that could be adversely affected.
Vulnerability	The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements, including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.
Impact	The effects on natural and human systems of extreme weather and climate events and of climate change, occurring within a specific time period and the vulnerability of an exposed society or system.
Climate Extreme	The occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variable. For simplicity, both extreme weather events and extreme climate events are referred to collectively as 'climate extremes'.

Transparent and detailed communication plays a pivotal role in characterizing risks. Decision-makers should evaluate and compare the potential adverse consequences and their magnitudes. It is through a diligent and holistic understanding of climate risks that society can navigate the challenges of climate change with greater resilience and adaptability.

Climate risk assessment is defined by the IPCC as "The qualitative and/or quantitative scientific estimation of risks"[6]. To provide a concise summary of climate risk assessment based on the risk outline from the guidance note[7] , we can express it as follows:

- **Temporal consideration**: The evolution of risks over time, from short-, medium-, long-term horizons need to be considered based on hazards, exposure and vulnerability changes from climatic and social-economics changes.
- **Transparency and communication**: Effective risk assessment demands transparency and proper communication in characterizing risks and addressing uncertainties, to support informed decision-making processes.

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[6] IPCC, 2022: Annex II: Glossary [Möller, V., R. van Diemen, J.B.R. Matthews, C. Méndez, S. Semenov, J.S. Fuglestvedt, A. Reisinger (eds.)]. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 2897–2930, doi:10.1017/9781009325844.029

[7] Reisinger, A., M. Garschagen, K.J. Mach, M. Pathak, E. Poloczanska, M. van Aalst, A.C. Ruane, M. Hoden, M. Hurlber, K. Mintenbeck, R. Pedace, M. Rojas Corradi, D. Viner, C. Vera, S. Kreibiehl, B O'Neill, H.-O. Pörtner, J. Sillmann, R. Jones, and R. Ranasinghe, 2020: The Concept of Risk in the IPCC Sixth Assessment Report: A Summary of Cross-Working Group Discussions: Guidance for IPCC Authors. Intergovernmental Panel on Climate Change.

2.2 Overview of existing standards and guidelines

The TCFD categorized climate risks into two main types: physical risks and transition risks. Physical risks involve risks from the impacts of climate change and emerge from the overlap of climate-related hazards, human systems and ecosystems exposure and vulnerability. Physical risk may be classified as acute (e.g. related to increases in the severity of specific types of weather event such as flooding or cyclones) or chronic (related to long term shifts in climate such as temperature increases and sea level rise). Transition risks refer to the financial and economic consequences that arise from the process of transitioning to a net zero carbon and sustainable economy. These transition risks include Policy; Legal; Technology; Market; Reputation[8]. Although the IPCC framework defines the broad concept of risk and its components, it does not provide guidelines on the evaluation of risks.

In recent years, various standards, guidelines, and regulations have proliferated that are relevant to the assessment of climate risks. This compilation aims to present an overview of these standards and guidelines for climate risk assessments. A list of regulations, standards and guidelines for climate risk assessment is compiled in Table 1 (for a more detailed list see in Appendix 1). These documents were identified through a search of the literature and by WP1, and were selected based on their provision of technical procedure or recommendation for assessing climate change risk. Guidelines may be associated with either a standard or a regulation. The specific document to which the guideline applies is presented in italics at the end of the guideline's title.

Table 1. Inventory of regulations, standards and guidelines, see Appendix 1

Organisation	Title
ISO	ISO 14090:2019 - Adaptation to climate change — Principles, requirements and guidelines
ISO	ISO 14091:2021 - Adaptation to climate change – Guidelines on vulnerability, impacts and risk assessment - *ISO 14090:2019*
ISO	ISO 14092:2020 - Adaptation to climate change – Requirements and guidance on adaptation planning for local governments and communities - *ISO 14090:2019*
ISO	ISO 31000:2018 - Risk management — Guidelines
IEC	IEC 31010:2019 - Risk management — Risk assessment techniques
IEC	IEC 63152 Smart Cities - City Service Continuity against disasters - the role of the electrical supply
ISO	ISO/CDTS 31050 - Guidance for managing emerging risks to enhance resilience
UK's Ministry of Defence	Climate Impacts Risk Assessment Methodology (CIRAM)
EU	Requirement of the Delegated Regulation 2021/2139 (Climate Delegated Act) supplementing the EU Taxonomy Regulation
GP L & D	Assessment of climate-related risks. A 6-step methodology
XRB	Aotearoa New Zealand Climate Standard 1 Climate-related Disclosures (NZ CS 1)

[8] TCFD. Final Report: Recommendations of the Task Force on Climate-related Financial Disclosures. June 29, 2017.

Organisation	Title
IFC	Performance Standard 1 Assessment and Management of Environmental and Social Risks and Impacts
IFC	Guidance notice Assessment and Management of Environmental and Social Risks and Impacts
EEA	Environmental Risk Assessment: Approaches, Experiences, and Information Sources. Copenhagen: EEA
EP4	The Equator Principle – Principle 2
EP4	Guidance note on climate change risk assessment - *The Equator Principle*
TCFD	Guidance on Risk Management Integration and Disclosure - *Recommendations of the Task Force on Climate-related Financial Disclosures*
EFRAG	ESRS E1 Climate Change (Draft) - *CSRD/ESRS*
EU	Reporting Guidelines on Disaster Risk Management
JRC	Recommendations for National Risk Assessment for Disaster Risk Management in EU - *ISO31010-2019*
UNDRR	Technical guidance on comprehensive risk assessment and planning in the context of climate change
UNEPFI	Climate Tango: Principles for integrating physical and transition climate risk assessment with sectoral examples
CFRF	Climate Disclosures Dashboard 2.0
ClimateWise	Transition risk framework: Managing the impacts of the low carbon transition on infrastructure investments
CSC	Adapting to Climate Change: Methods and Tools for Climate Risk Management
CLIMAAX	CLIMAAX Framework

The following section will highlight the recommendations, best practices and requirements extracted from these sources.

2.3 Key elements from selected standards and guidelines

The standards and guidelines discussed below were chosen for their relevance across different sectors at European and national level. The ISO14091:2021 stands out as one of the most frequently referenced documents by other standards and guidelines. Additionally, the EU taxonomy is a core part of the EU Sustainable Finance strategy in the financial and private sector. Lastly, the JRC guideline was selected to showcase certain national-level standards for risk assessment.

2.3.1 ISO 14091:2021 - Adaptation to climate change – Guidelines on vulnerability, impacts and risk assessments

The ISO guidelines on vulnerability, impacts and risk assessments provide recommendations on assessing the risks associated with climate change impacts. Their application aims to reduce vulnerability by addressing medium- and long-term adaptation demands and will help all businesses to improve their awareness of system vulnerabilities and the importance of these vulnerabilities to their operations.

One of the key aspects of ISO 14091 is to guide organizations in assessing their vulnerability to the impacts of climate change. This process involves identifying the organizations' sensitivities to climate-related issues, assessing their adaptive capacity, and gauging its exposure to climate-related hazards. These insights are crucial to create a comprehensive risk assessment framework.

The ISO 14091 guidelines provide a structured approach to assess the potential risks posed by climate change to various facets of an organization, including its operations, assets, supply chain, and stakeholders. This inclusive approach helps organizations to identify, prioritize, and evaluate physical risks.

a. Setting the scope for climate change risk assessment

According to the ISO 14091 guideline, assessing climate change risk demands proper preparation from the organization to determine the scope and methodology. This means that the context of the climate risk assessment should include the system at risk and associated activities and supply chains, the population groups and stakeholders involved, a range of potential hazards, the area under review, setting the time horizon and the regulations in order.

b. Initial screening of potential climate change impacts

A preliminary output should be derived from an initial screening of the impacts of climate change within the context of the assessment at the present time. This screening process involves identifying hazards and sensitive elements of the system to establish a list of potential impacts of climate change. This list should be accompanied by comprehensive notes elucidating the rationale behind each potential impact, each hazard, and the elements of the system at risk.

Climate change impacts that emerge as particularly relevant during this initial screening should be considered in subsequent stages of the assessment. However, if the primary objective is to identify and prioritize the potential consequences of climate change impacts as a basis for adaptation planning, no further assessment is needed.

c. Selecting indicators and gathering data for each component of risk

For a more in-depth assessment, a set of specific indicators must be chosen for each relevant potential risk, to provide insights into various states or conditions. This requires the collection of data and knowledge to estimate each component of the risk: hazards, exposure, sensitivity, and adaptive capacity. Climate projections and sensitivity scenarios serve as valuable sources for future data.

d. Addressing and mitigating uncertainties

The magnitude of climate change is unknown and future impacts and vulnerabilities are uncertain. Addressing these uncertainties is essential in the risk assessment process. One approach to managing uncertainties is to use different climate scenarios as the basis for the assessment and to ensure the high quality of data. Moreover, involving experts in consultations with feedback loops can further mitigate uncertainties. Uncertainties will never be eliminated from climate change risk assessments; it is imperative to state explicitly where these uncertainties lie.

e. Evaluating climate change risks

One approach suggested in the guideline for evaluating climate change risk from selected indicators is to use a rating scale, ranging from one to three or one to five. This scale may be derived from expert judgement and best available knowledge (qualitative method), from collected data combined with threshold values for risk (quantitative method), or from a mixed method involving both collected data and expert judgement (semi-quantitative method). The selection of the method should be based on the quality of the data gathered for each risk component. If high-quality data is available for all components, the quantitative method is preferable; otherwise, if components have poor-quality data or lack thereof, the semi-quantitative or qualitative methods should be chosen.

f. Communication of results

The results of climate change risk assessments, in accordance with the ISO 14091 guideline, should be communicated by providing a comprehensive description of the context, scope, and objective of the climate change risk, along with details on data sources and methods applied. A summary of both quantitative and qualitative information obtained should be included, accompanied by illustrative results, and associated uncertainties. Finally, the risks should be prioritized based on the objective of the assessment and accompanied by suggestions for adaptation planning and monitoring. If these essential elements are included, there is no preferred format of communication.

g. Recommendations of adaptation strategies

ISO 14091 provides guidance on developing effective adaptation strategies and plans to address the identified risks and vulnerabilities. These strategies can significantly improve an organization's resilience to the challenges of climate change. Importantly, the standard recommends continuous monitoring and regular reviews of climate change risks and adaptation measures to ensure their ongoing effectiveness and relevance.

In summary, ISO 14091 serves as a comprehensive framework for organizations to navigate the complex landscape of climate change risks and vulnerabilities, which can be expressed as follows:

- **Scope of the system:** Comprehensive risk assessment demands a structured assessment of the context, lifetime, geography, environment, and assets of the system.
- **Risk components:** Climate risk emerges from climate hazards, exposure, sensitivity, and adaption capacity.
- **Temporal consideration:** The evolution of risks over the lifetime of the system, from short-, medium-, long-term horizons compared to a reference period needs to be considered based on hazards, exposure, and vulnerability changes from climatic and social-economics changes.
- **Communication:** Effective risk assessment demands proper communication suited to the targeted audience with tangibility, conclusions, and recommendations.

2.3.2 Climate risk assessment in the EU Taxonomy

The EU Taxonomy functions as a categorization system, providing a list of economic activities deemed environmentally sustainable. The regulation establishes the first uniform and credible standard, offering a common language for economic parties to align their operations with the transition to low-carbon, resilient, and sustainable pathways. Its primary purpose is to guide private investments to achieve the goals of the EU Green deal, by providing market participants with a reliable means of identifying and investing in assets with a higher level of sustainability assurance. The EU Taxonomy establishes two entry points for assessing physical climate risks:

- Technical screening criteria to assess the substantial contribution of an activity to the adaptation objective.

- "Do No Significant Harm" criteria for adaptation objective while assessing the substantial contribution to one of the other 5 objectives.

a. Preparation of the scope for climate change risk assessment and initial screening

The scope of the assessment can be established with an initial screening of the activity to identify which physical climate hazard from the list in Table 2 may affect the performance of the economic activity during its expected lifetime. It is imperative to include all locations of the activity in the screening, and in the case of supply dependencies, suppliers should also be considered[9].

Table 2. Classification of climate-related Hazards[10]

	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, fluvial, pluvial, ground water)	Subsidence
			Glacial lake outburst	

The identified climate-related hazards which will negatively affect the economic activity should be considered for the next step: a climate risk and vulnerability assessment to assess the materiality of the physical climate risks on the economic activity.

[9] "How to perform a robust climate risk and vulnerability assessment for EU taxonomy reporting?",2022, German Environment Agency

[10] The list of climate-related hazards in Appendix A to the Annex of Commission Delegated Regulation 2021/2139 (EU)

An assessment should be prepared where the activity is assessed to be at risk from one or more of the physical climate risks. The depth of the assessment is based upon the lifespan of the activity. For economic activities with a lifespan of less than 10 years, gathering information and data on current climate-related hazards is deemed sufficient for climate risk assessment. In contrast, for all other economic activities, state-of-the-art climate projections at the highest available resolution across the existing range of future scenarios should be incorporated.

b. Evaluating climate change risk

The methodology and climate projections applied for the risk assessment should align with the most recent IPCC reports, scientific peer-reviewed publications, and open source or paid models, as no preferred methodology is suggested in the EU taxonomy.

c. Assessment of adaptation strategies

To make a significant contribution to climate change adaptation, it is imperative to draw up a plan implementing adaptation solutions to mitigate the most critical climate change risks. On the other hand, DNSH requirements in terms of adaptation objectives require the development of a five-year plan aimed at reducing the most significant climate risks that have been identified. The adaptation solutions should favour to the extent possible nature-based solutions or rely on blue or green infrastructure, ensuring they do not negatively impact the adaptation efforts or resilience of other people, nature, assets, and economic activities.

In summary, the EU taxonomy involves a climate change risk assessment to significantly contribute to climate change adaptation or for DNSH requirement, that systematically screens, identifies, and assesses climate risks, utilizing high-quality data and expert knowledge to categorize economic activities. It can be expressed as follows:

- **Climate Risk Assessment Process:** The text outlines a systematic process for assessing physical climate risks in economic activities. This includes screening, evaluating materiality, and identifying adaptation solutions.
- **Temporal consideration:** The scope of the assessment is determined by the expected lifespan of the activity, with more extensive assessments for longer-term projects.
- **Communication and Planning:** Effective communication and the development of an adaptation plan are integral components of the process. It highlights the implementation of physical and non-physical solutions to reduce significant climate risks over a period of up to five years.

2.3.3 Recommendation for National Risk Assessment for Disaster risk Management in EU – JRC

The “Recommendation for national risk assessment for disaster risk management in the EU”, gives recommendations to identify key risks. Its purpose is to provide an opportunity to better understand the underlying disaster risk drivers and inform disaster risk management measures, including but not limited to risk caused by climate change.

A national risk assessment necessitates robust governance supported by a framework and a standardized approach to risk assessment. This is essential to establish a consistent working environment based on a shared set of evidence, yielding harmonized results, across the multidisciplinary nature of risk and facilitating communication with stakeholders, authorities, and the public to enhance community awareness.

a. Setting the scope for national risk assessment and identifying potential hazards

The process of the National Risk Assessment, outlined in the "Recommendation for National Risk Assessment for Disaster Risk Management in the EU," begins with proper preparation, supported by all relevant stakeholders, to establish the context of the risk assessment. This encompasses assets and associated activities, infrastructure, population groups, the environment, and others at risk, a range of potential hazards to which the country is exposed, and the setting of the temporal horizon for the assessment.

b. Analyzing and evaluating the risk

The risk should be identified, by collecting relevant and up-to-date information on each component of the risk: hazard, exposure, vulnerability, risk drivers and capacities. For future disaster events, it is recommended to use multiple futures scenarios with various likelihoods of occurrence. Each component of the risk is then combined to ascertain the level of risk associated with each identified risk. The most suitable methodology depends on the analysis's context and objective, as well as the available data. Options include a qualitative method based on expert judgement, a quantitative method, or a semi-quantitative method when data are available but limited.

c. Communication of results

The experts engaged in the risk assessment process are responsible for the results. Consequently, the presentation of results should be suited to an audience without a technical background. Clear and accessible communication is crucial to ensure that the findings are comprehensible and actionable for the decision-makers.

National risk assessment plays a pivotal role in the continuous review of existing risk management plans, facilitating regular updates to incorporate new adaptation, mitigation, and preventive options over time. In this way, it forms a continuous and indispensable building block for the coherent development of a robust risk management policy.

In summary, national risk assessment establishes a policy cycle, requiring robust governance and collaboration, to provide a comprehensive understanding of risks, mobilize national expertise, address knowledge gaps, and advocate for improved risk management strategies and mechanisms. We can express it as follows:

- **Comprehensive Risk Assessment**: provides guidance on a wide range of risk assessment techniques, emphasizing a systematic and structured approach to identify, assess, and manage risks across diverse organizational contexts.
- **Tailored Techniques and Methodologies**: The standard offers flexibility in selecting risk assessment techniques, acknowledging that different methods may be suitable for different situations, encouraging organizations to tailor their approach based on specific needs.
- **Effective Communication**: Emphasizing the importance of clear and transparent communication, guides organizations in effectively conveying risk assessment findings to stakeholders, ensuring informed decision-making in the context of uncertainty.

2.3.4 Synthesis of a comparative analysis

Guidelines and standards on climate risk assessment primarily focus on physical risk, with very few guidelines and standards in the public domain incorporating both physical and transition risks. The Equator Principles' guidance note, ESRS E1 and 'Principles for Integrating Physical and Transitional Climate Risk Assessment' are among the few guidelines and standards presenting a methodology for both physical climate risk and transition climate risk. Physical risk would be linked to indicators of climate-related hazards, exposure and vulnerability whereas transition risk would be related to drivers of low carbon transition (e.g. carbon prices, energy mandates, consumers preferences and other drivers that could pose a risk or present and opportunity[11]). Future transition risk can be assessed by using transition scenarios, including a 2°Celsius scenario or lower which are more closely linked to economic changes rather than climate change. The comparative analysis will primarily focus on climate change risk assessment for physical risk.

a. Definition of climate change risk

In the context of climate risk assessment, risk is commonly defined as the combined result of hazard, exposure, vulnerability and as "the potential for adverse consequences for human or ecological systems"[12]. This definition emphasizes that risk arises from the dynamic interplay of climate-related hazards, vulnerability of the affected system, and its exposure to the hazard over time. While the IPCC's definition of risk is widely accepted, certain standards, for example in the financial sector, diverge by defining risk as a combination of the likelihood or frequency of a defined climate-related hazard or the potential consequences. This definition introduces a more neutral perspective where potential consequences could be either adverse or beneficial for financial activities. There are also older definitions of risk for example ISO 31000 standard on Risk management defined risk as "the effect of uncertainty on objectives". Despite these variations, recent guidelines and standards, including ISO 14091and ESRS E1, agree on the IPCC framework, suggesting that best practices involve adopting the IPCC's definitions in the context of climate risk assessment.

b. Setting the scope for climate change risk assessment

Risk assessment, whether related to climate or other types of risk, involves a series of key steps to assess, evaluate and communicate risk. It starts with an initial phase that is found in all standards and guidelines, which is defining the scope and lifespan of the activity or system and establishing the objective of the climate risk assessment. This phase involves gathering comprehensive knowledge and information about the activity or system, including its location, lifespan, identifying stakeholders and experts, and preparing an optimal methodology tailored to address climate risk assessment.

Most standards and guidelines propose to identify hazards which could have an impact on the activity or system prior to the risk assessment. Yet methodologies for identifying these hazards vary among sector-specific and general standards. Some regulations, like the TCFD or the EU taxonomy, suggest a predefined list of climate-related hazards and recommend a screening process to identify those relevant for risk assessment. The screening involves gathering and synthesising information on the current climate, system's vulnerabilities and potential climate impacts. This involves reviewing relevant data, historical records, and expert knowledge. An alternative approach suggested by a couple of

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[11] Guidance note on climate change risk assessment, Equator Principle, 2023

[12] IPCC, 2022: Annex II: Glossary [Möller, V., R. van Diemen, J.B.R. Matthews, C. Méndez, S. Semenov, J.S. Fuglestvedt, A. Reisinger (eds.)]. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 2897–2930, doi:10.1017/9781009325844.029

standards and guidelines is to organize workshops involving stakeholders and experts to identify the relevant hazards.

c. Assessing and evaluating climate risk

An essential part of the assessment is to gather climate data and knowledge about hazards, exposures and vulnerabilities for both the current and future climate. The timing of this data gathering can be done before or after hazard identification, depending on the specific standards or guidelines being followed. Best practice would be to gather the highest quality data available, of current climate, state of the art futures projections, exposures and vulnerabilities. Obtaining high-quality climate data for climate change assessments can be a significant challenge. Data availability varies widely across regions, and even in regions where data exists, it may not be readily accessible or freely available. In the worst case, global data with lower resolution may be used as a fallback when finer-resolution data is not available. Additionally, data on future climate exposures and vulnerabilities can be challenging to obtain, so current and future climate data are the minimum requirements for comprehensive risk assessments.

Once data has been gathered, the next step, in most standards and guidelines, is to analyse the risk. Standards and guidelines do not specify one methodology for risk assessment. A screening, a qualitative method based on expert judgement, a quantitative method, or a semi-quantitative method when data are available but limited are all possible methods for a climate risk assessment. The choice of methodology should be selected based on the objective, scope and available data for the activity or system. However, determining the likelihood or frequency and assessing the magnitude of hazards for the current and future climate emerges as a fundamental requirement across most standards and guidelines for climate risk assessment. These standards generally suggest evaluating current climatic conditions and, at the very least, over the lifetime of the activity or system. Some standards require a scenario analysis, such as a high-level emissions scenario to estimate physical risk, while more rigorous frameworks require a scenario analysis incorporating at least three climate scenarios. Additionally, a comprehensive climate risk assessment involves assessing the vulnerability of the activity or system and evaluating the consequences or opportunities associated with all climate-related hazards, providing the foundation to evaluate and prioritize risk. Furthermore, some standards or guidelines highlight the importance of considering uncertainties, establishing thresholds, and defining risk tolerance as indispensable components to make well-informed decisions.

Best practices in climate risk assessment involve utilizing the most recent scientific knowledge to ensure the rigor and accuracy of evaluation. Emerging standards are beginning to address the interconnected nature of climate risks. This includes incorporating a new component of climate risk, such as the response to mitigate risk. To address these advances, One Earth published an article, proposing a comprehensive framework to introduce complex climate risk assessments[13]. These complex climate risk assessments integrate new elements like the risk caused by a response to adaptation, the increasing risk of multiple climate hazards drivers and cascading risk. However, the standardization of complex climate risk assessments remains in an early developing stage within standards.

[13] Simpson, N.P., Mach, K.J., Constable, A., Hess, J., Hogarth, R., Howden, M., Lawrence, J., Lempert, R.J., Muccione, V., Mackey, B., New, M.G., O'Neill, B., Otto, F., Pörtner, Hans-O., Reisinger, A., Roberts, D., Schmidt, D.N., Seneviratne, S., Strongin, S. and van Aalst, M. (2021). A framework for complex climate change risk assessment. One Earth, 4(4), pp.489–501. doi:https://doi.org/10.1016/j.oneear.2021.03.005.

d. Addressing and mitigating uncertainties

Uncertainties are an inherent part of risk assessment, but very few standards or guidelines address uncertainties. Understanding and mitigating uncertainties is vital for making informed decisions and developing effective strategies to manage risks. One approach to addressing uncertainties is the use of multiple model ensembles. Another way suggested would be considering multiple scenarios to account for a range of possible futures. Expert reviews also play a role in mitigating uncertainties. However no single approach is able to eliminate uncertainties The main output to address uncertainty is making the source of uncertainty transparent so that stakeholders can understand the level of confidence associated with the assessment findings.

e. Communication of results

Effective communication is a cornerstone of any successful risk assessment, ensuring that findings and implications are conveyed to the relevant stakeholders. Transparent and timely communication is crucial to make informed decisions and raise public awareness about risks and opportunities. Involving stakeholders throughout the process fosters an understanding and ownership of climate risk. However, all standards lack specific guidance on how to effectively communicate the results of the risk assessment. This gap in best-practices will be addressed by another CE2 WP2 deliverable focusing on the communication of uncertainty.

3 Inventory of tools and data to support climate risk assessments

3.1 The role of climate services in risk assessments

A climate service can be defined as the generation, translation, transfer and use of climate information and knowledge (Vaughan and Dessai, 2014). In Climateurope2, four main components of a climate service have been identified (Baldissera Pacchetti & St. Clair, 2023):

1. The decision context, referring to the decisions the climate services aim to support, as well as their geographical and political context.
2. Data of different types (quantitative, qualitative, mixed) and related selection, evaluation, and translation processes. This component relates not only to climate data, but also to social, economic and technical data necessary to develop and implement local adaptation and mitigation strategies, as well as all selection, evaluation and translation processes related to this data. Data accessibility, storage and stewardship also fall under this component.
3. The delivery mode of the climate service, and evaluation of the delivery mode at various steps.
4. The ecosystem of actors and co-creation processes. This component identifies the different actors involved in (co)producing, evaluating, and taking up climate services, including those actors that might become relevant because of a particular decision context. It also addresses the co-production processes that are relevant for different actors and different stages of the climate service development process.

As we have seen in Chapter 2, the provision of information on climate hazards and current and/or future climate conditions more generally is a key element in the climate risk assessment process, especially in the case of physical risk assessments. Climate services therefore have a key role to play in supporting climate risk assessments. However, the **decision context** is often not the risk assessment per se, but policies or actions to manage or mitigate climate-related risks.

In a simple case, information about the hazard can be derived directly from climate data (observations or climate model projections), typically by calculating an indicator relating to a particular extreme such as a particular temperature threshold or a maximum daily rainfall amount (Figure 2).

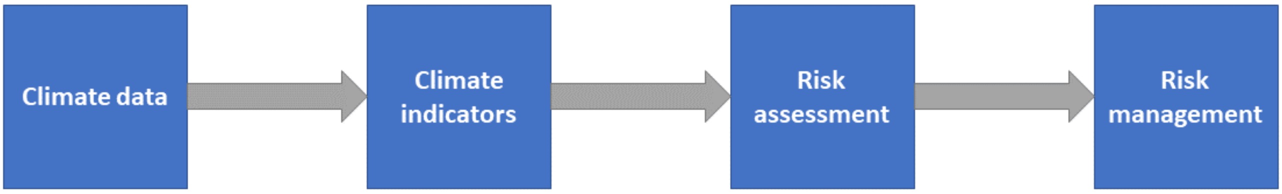

Figure 2: Schematic visualisation of the role of climate services in climate risk assessment.

However, since risk is defined as the potential for adverse consequences, in most cases evaluating risks involves evaluating the potential impacts, for example by applying an impact model (Figure 3). In many applications it will not be the weather or climate (e.g., a certain amount of rainfall) that constitutes the risk, but its consequences on a system (e.g., crop losses due to too little or too much water). Impact models translate, as it were, the climate data into information about impacts, and come in different types ranging from simple empirical relationships to complex, process-based models to - since recently – machine-learning models. Depending on the scope of the risk assessment and the eventual impact of interest, this step may in fact need to be repeated multiple times: for example, a crop model may be able to simulate a decline in crop yield due to climate conditions, but not the financial losses that may ultimately be of interest to a farmer, a commodity trader, or an investor.

Figure 3: Climate information feeding into one or more impact models before a climate risk assessment can be made.

We have also seen that risks arise from the interaction between climate-related hazards with the exposure and vulnerability of the affected human or ecological system of interest (Figure 4). Typically, a climate risk assessment therefore requires not only information about the climate, but also non-climate information relating to both components, which could involve many different types of data including ecological, social, economic and technical data. If impact models are applied, information on the exposure and vulnerability of the system of interest may be captured there, but it may - additionally or exclusively - also feed directly into the risk evaluation process.

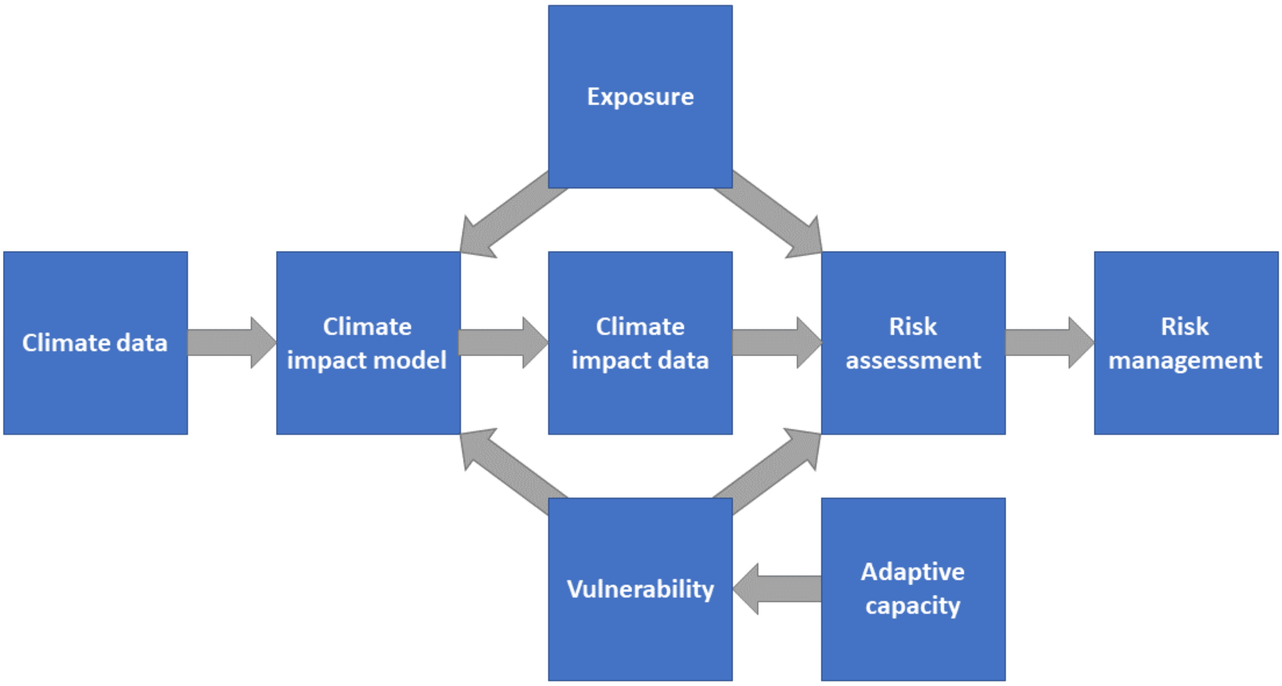

Figure 4: Information on exposure and vulnerability feeding into the risk assessment process.

Climate data will then be, almost by definition, only one of multiple sources of information feeding into a comprehensive climate risk assessment in which vulnerability and exposure are considered. To what extent the provisioning of non-climatic information should still be considered part of a climate service is up for debate. In many cases it will depend on the context of the analysis, including roles and responsibilities of the different actors involved in the risk assessment process, and the need for domain-specific knowledge. Yet, the need for quality-assured information and harmonisation of procedures in climate services that Climateurope2 is addressing clearly extends to the use of non-climatic data as well, and to the whole process of risk evaluation.

3.2 Overview of data, tools and services for climate risk assessment

With the impacts of climate change becoming more and more manifest, the management of climate-related risks has become increasingly important. This has led to the proliferation of services and tools aiming at supporting the climate risk assessment process. This section provides an overview of the most important services and tools currently available. Such an overview is merely a snapshot at this time, as new services are constantly being developed while others may become outdated, for example when funding runs out. Nor is it complete, as not all information is available in the public domain. Sometimes services are developed for one particular country, region and/or sector only, or even to address the needs of a single organisation and contain commercially sensitive information. A selection of (European) climate services delivering information through web portals can be found in Bessembinder et al. (2018). In addition, national meteorological services often develop national or regional climate scenarios although these are often shaped by their own specific context, including social and scientific values (Skelton et al., 2017).

Although the words "service" and "tool" are often used interchangeably, we have attempted to distinguish between ***services*** that provide data and information, and ***tools*** that can be used by a stakeholder to support their own climate risk assessment, but which require them to provide their own input data. A typical example of a service would be a web platform where a user can access, visualise, and download climate data or hazard indicators for their own area of interest. A typical example of a tool could be a software that allows users to calculate hazard indicators or risk scores based on local data.

Given the role of climate services in the risk assessment process, a distinction may be made between different types of ***services*** with respect to the data or information provided:

1) Climate data or information only (not including data repositories);
2) Climate indicators on extremes relevant to climate hazards;
3) Data and information on impacts;
4) Data for risk evaluation, including exposure and vulnerability;
5) The outcomes of a risk evaluation, such as a risk index.

In addition to data and information, tools may be provided to support any of the steps in the risk assessment process (or even the entire process itself); examples range from software to calculate climate indicators, to impact and risk models, to overall frameworks for climate risk assessment. We can therefore distinguish three different types of tool:

6) Software tools to process climate data (not including general software libraries);
7) Models or software tools to evaluate impacts and/or risk;
8) Stepwise methodologies or templates for the risk evaluation process.

These categories represent only a first attempt to categorise the various services, tools and products relating to climate risk that are currently on offer, and indeed not all services neatly fall into one of these categories. Different categorisations may also be conceivable, for example according to the target audience or user; however the target audience for a service or tool is not always clear from its description.

In the following sections we will discuss examples of tools and services from each of these categories, what role they could play in the risk assessment process, and what the limitations are (if any). The examples of the services and tools are given in Table 3. A more elaborate overview is given in Appendix 2. The discussion will focus on physical climate risk assessment tools and services, as very little information could be found on transition risk assessment tools.

Table 2. List of selected climate services and tools for climate risk assessment. For further details and references, see Appendix 2.

ORGANISATION	NAME	LINK
C3S	Climate Data Store	https://cds.climate.copernicus.eu/
CERFACS (lead developer)	icclim	https://github.com/cerfacs-globc/icclim
Climate Analytics	Climate Impact Explorer	https://climate-impact-explorer.climateanalytics.org/
CRED	EM-DAT	https://www.emdat.be/

ORGANISATION	NAME	LINK
EC-JRC	Risk Data Hub	https://drmkc.jrc.ec.europa.eu/risk-data-hub/
EC-JRC	Clisagri	https://github.com/ec-jrc/Clisagri
Eurac Research	climdex-kit	https://pypi.org/project/climdex-kit/
ETH Zurich	CLIMADA	https://wcr.ethz.ch/research/climada.html
Germanwatch	Global Climate Risk Index	https://www.germanwatch.org/en/cri
GIZ	Climate Expert	https://www.climate-expert.org/en/home
IPCC	Working Group 1 Interactive Atlas	https://interactive-atlas.ipcc.ch/
(Joint development)	Climate4impact	https://www.climate4impact.eu/c4i-frontend/
KNMI	Climate Explorer	https://climexp.knmi.nl/start.cgi
OS-Climate	OS-C Physical Risk & Resilience Tool	https://os-climate.org/physical-risk-resilience/
SMHI	Climate Information Portal	https://climateinformation.org/
Univ. de Cantabria	climate4R	https://github.com/SantanderMetGroup/climate4R
University of Notre Dame	ND-GAIN Country Index	https://gain.nd.edu/our-work/country-index/
WMO	Climpact	https://climpact-sci.org/
World Bank	Climate Change Knowledge Portal	https://climateknowledgeportal.worldbank.org/
World Bank	Climate and Disaster Risk Screening Tool	https://climatescreeningtools.worldbank.org/
WRI	Aqueduct	https://www.wri.org/aqueduct
WRI	Climate Watch	https://www.climatewatchdata.org/

ORGANISATION	NAME	LINK
IMPACT2	IMPACT2 web-atlas	https://www.atlas.impact2c.eu/en/

3.2.1 Services providing climate data or information only

Providing information about climate and climate change is a key characteristic of a climate service, and an important element in many climate risk assessments. Apart from general repositories of climate data (such as the Earth System Grid Federation (ESGF), https://esgf.llnl.gov/mission.html), an increasing number of services aims to provide easier access to the data to users who are not climate scientists or technical experts. Examples include the IPCC Working Group 1 Interactive Atlas; the World Bank's Climate Change Knowledge Portal; and the Climate Information Portal developed by the Swedish Meteorological and Hydrological Institute (SMHI) on behalf of the World Meteorological Organization (WMO), World Climate Research Programme (WCRP) and the Green Climate Fund (GCF). Many of these services provide similar functionalities by allowing users to create maps and plots for pre-defined regions of observed and projected climate change for time periods, emissions scenarios or global warming levels of interest. Users can select data from global, quality-controlled datasets such as global and regional observations and the three most recent coordinated global and regional climate projection experiments (CMIP5, CORDEX and CMIP6). In many cases users are provided with access to the underlying data in an easy-to-use format, including for individual climate models and/or the ensemble mean, often aggregated at national, sub-national, and watershed levels.

A slightly different approach is taken by the Climate4impact portal that aims to support climate impact modellers, impact and adaptation consultants, by providing them with a flexible way to access and manipulate ESGF datasets and guiding them through the selection process.

Although the aim of many of these services is to provide non-specialists, including policy makers, development practitioners and interested parties with a way to explore, analyse and visualise climate-related information, some background knowledge will typically be required, for example to understand the meaning of different scenarios, the differences between individual models and the ensemble mean, or between interannual variability and trends. In many cases the climate variables provided (such as temperature and precipitation) are not directly related to the hazards that may be relevant to a climate risk assessment, so further processing will be required. In practice, many services also provide data on indicators that are relevant to climate extremes. Information on quality assurance, including to what extent the data provided adhere to the FAIR principles (Findability, Accessibility, Interoperability, and Reusability; Wilkinson et al., 2016) is not always provided or easily accessible.

3.2.2 Services providing climate indicators on extremes or hazards

Many services provide information about hazard indicators, sometimes as a graphical summary (e.g., Climate Information Portal) or sometimes as a dataset that can be downloaded for further processing or analysis (e.g., Climate Data Store). Many of these indicators are based on, or sometimes variants of, those of the Expert Team on Climate Change Detection and Indices (ETCCDI) which has proposed a set of core climate indices, used to monitor the occurrence of temperature and precipitation extremes (Klein Tank et al., 2009). An additional set of 50 indices highlighting characteristics of climate change in Europe (including snow depth, sunshine duration, etc.) has been proposed by the European Climate Assessment & Dataset project and are also available from the ECA&D website.

The generic nature of these indicators means they can easily be compared across regions and timescales. However, it also means they may not always be appropriate as a hazard indicator, as they are not tailored to local conditions and may not always represent extremes. For example, one of the ETCCDI indicators is the number of tropical nights, defined as the annual count of days when the daily minimum temperature is higher than 20°C. However, in many tropical areas this threshold will be exceeded throughout the year, and while high nighttime temperatures are known to have a detrimental health impact, in reality some acclimatisation and adaptation will have taken place in those areas. Even for indicators with relative thresholds, such as a particular percentile of the rainfall distribution, it is hard to assess whether exceedance of the threshold will automatically result in impacts. These indicators may, however, provide useful guidance on how the more extreme ends of a variable distribution may change under climate change.

3.2.3 Services providing data and information on climate impacts

Several services provide data on (mostly physical) climate impacts, often based on the results of impact models. Examples include the Climate Impact Explorer, the IMPACT2C web-atlas and the Aqueduct portal. Some of these provide very specific information: Aqueduct, for example, provides global maps of inundation depth of floods with different magnitudes (return periods), for different climate scenarios, time periods and driving global climate models. However, as the inundation depths are based on a global modelling approach, local adaptation and flood defence measures may not have been considered, which may limit their applicability in local risk assessments. More generally, information on the quality of the climate impact simulations - for example from model validation studies - is not provided or easily accessible. Other portals provide information about climate impact drivers (e.g., the IPCC WGI Interactive Atlas) or indicators relevant to impacts in a particular sector (such as certain datasets in the Climate Data Store).

Only a few portals provide data on the actual impacts of historical events. Most of these focus on human impacts (number of people affected, casualties) or economic damage. Examples include the EM-DAT that provides data on the occurrence and impacts of large-scale disasters worldwide, and the Risk Data Hub that allows users to explore data on disaster losses for European countries from a variety of sources. However, to our knowledge, no current database comprehensively collects data on the (actual) impacts of human-induced climate change, which has been highlighted as a knowledge gap (Otto et al., 2020).

3.2.4 Services providing data for risk evaluation, including on exposure and vulnerability

A number of services provide information on vulnerability and exposure. The Climate Impact Explorer provides data on several indicators in which hazard information has been combined with exposure and vulnerability (such as Annual Expected Damage from River Floods and Fraction of Population annually exposed to Crop Failures) at country or regional level. In other portals, the exposure and vulnerability information can be evaluated separately. The Risk Data Hub allows users to combine data on hazards with (types of) assets at different levels of spatial aggregation. Based on data on hazards and assets, the platform is able to compute risk components: hazards footprints, exposure of assets and ultimately a risk indicator. Vulnerability is represented for each spatial unit through a composite indicator based on four main pillars: social, political, economic, and environmental. And despite its name, the Global Climate Risk Index is actually a country-level index ranking the impacts (losses) of historical weather and climate events, with the aim of highlighting existing vulnerabilities to future climate change; it could therefore also be seen as a country vulnerability index.

Vulnerability is hard to characterise and even harder to quantify, as it depends on many technical, social, economic, and institutional factors. Furthermore, vulnerability is not static: it evolves over time. When using some of these generic vulnerability indicators, care should be taken to ensure that the information used accurately captures the factors that contribute to the system being assessed.

3.2.5 Services providing the outcomes of a risk evaluation

Information about climate risks is usually provided either as a risk score or risk index, or as a description of current and/or future risks faced by a country, region or sector (sometimes referred to as “risk profiles”). Sometimes the risk is provided for only a single type of hazard or sector, other times it combines information about multiple hazards and/or across different sectors. An example of the single hazard-sector approach is the Climate Change Knowledge Portal that provides a risk score of extreme heat based on data on extreme heat conditions in combination with projections on population and poverty dynamics.

An example of a multiple hazard-sector indicator is the Aqueduct Water Risk Atlas that provides an overall water risk index measuring all water-related risks, by aggregating selected risk indicators related to physical quantity, quality and regulatory & reputational risk. Aqueduct also provides country rankings for a number of risk indicators such as water stress, drought risk and riverine flood risk, allowing users to understand and compare national and sub-national water risks. Similarly, the Notre Dame Global Adaptation Initiative’s (ND-GAIN) Country Index shows current vulnerability to climate disruptions based on more than 40 core indicators; although it is called a vulnerability score, it combines data on exposure, sensitivity and adaptive capacity and therefore can be seen as a risk index. The ND-GAIN index is also used in a more descriptive way in the Climate Watch portal to provide information on climate risks and vulnerabilities in country and sectoral profile pages.

In many cases the risk scores or indicators are provided in discrete classes (e.g., from low to high) or normalised from 0 to 1 or 0 to 10 (as is done in, e.g., the Risk Data Hub). While this makes comparisons between countries or regions easier, it may limit its application in decision-making, as many of the assumptions being made in calculating the index (e.g., assigning weights to diverse and often subjective risk factors) may not be optimal for the decision at hand.

3.2.6 Software tools for processing climate data

Apart from the generic programming languages and software libraries that are used for climate data processing, there are a number of specific packages that can be used to calculate climate indices and assist in characterising the hazard component of climate risk. Examples include the python packages icclim and clmdex-kit, and the R packages Climpact, Clisagri and climate4R. Most of these allow users to compute standard climate indices such as those defined by the European Climate Assessment & Dataset or the Expert Team on Sector-Specific Climate Indices (ET-SCI). The standardisation of these indices allows researchers to compare results across time periods, regions and source datasets.

The R package Clisagri includes a dynamic phenological model, enabling users to quantify the occurrence of different climatic extremes such as drought, excessive wetness, heat stress and cold stress during sensitive crop growth stages, making the indicators more relevant to impacts.

While a large number of open-source packages is available, the level of quality assurance is not always clear. The R-based framework for climate data access and processing climate4R includes a provenance metadata model for traceability and reproducibility of results. As a result, climate4R allows end-to-end experimental reproducibility and facilitates the description (metadata) and documentation of the whole data flow. While transparency and reproducibility are obviously key concerns when the outputs of a data processing chain are supposed to support decision-making by stakeholders, a survey by the journal Nature in 2016 showed that the majority of research works could not be reproduced, including in the Earth and Environment Sciences. More than half of the researchers taking part in the survey even failed to reproduce their own experiments (Baker, 2016).

3.2.7 Models or tools for evaluating impacts and/or risk

A wide array of impact models has been used by researchers to study the effects of climate change, ranging from simple empirical relationships to machine-learning models to complex, process-based models describing environmental and ecological processes in the landscape. A good overview can be obtained from the models that have participated in the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP) available at https://www.isimip.org/impactmodels/. Many impact models that have been applied focus on one particular field or sector (for example water resources or forest ecology) although a few take a more multidisciplinary approach. Many impact models (such as those used in ISIMIP) aim to simulate the effects of climate variability and change and do not follow a strict risk framework; of course, the estimation of potential impacts can be an important step in a risk assessment process.

A number of tools have, however, been developed that focus specifically on the evaluation of risk. Examples include the physrisk library that is part of the OS-C Physical Risk & Resilience Tool. Physrisk was designed to run 'bottom-up' calculations that model the impact of climate hazards on large numbers of individual assets (including natural) and operations. These calculations can be used to assess financial risks or socio-economic impacts. To do this, physrisk collects hazard indicators and combines these with models of vulnerability of the assets or operations to these hazards.

Another example is CLIMADA, a Python library that allows users to estimate the expected economic damage as a measure of risk. CLIMADA is a fully probabilistic climate risk assessment tool providing a framework for users to combine exposure, hazard and vulnerability or impact data to calculate risk. Users can create probabilistic impact data from event sets, look at how climate change affects these impacts, and see how effectively adaptation measures can change them. CLIMADA also allows for studies of individual events, historical event sets and forecasts. According to its creators, the model is well-suited to provide an open and independent view on physical risk, in line with e.g., the Task Force for Climate-related Financial Disclosure (TCFD) and underpins the Economics of Climate Adaptation (ECA) approach.

Adopting an approach that requires less programming knowledge, users of the Climate Explorer platform can upload assets via the intuitive dashboard and generate insights for properties, land parcels, and portfolios in the form of clear financial loss modelling, value-at-risk projections, and business interruption insight. Hazard data are provided covering wildfire, floods, cyclones, water stress, drought and sea-level rise across multiple global warming scenarios on an annual basis to 2100.

3.2.8 Stepwise methodologies or templates for risk evaluation

The process of risk evaluation typically involves more than just the simulation of potential impacts and the calculation of a risk score. A number of organisations provide guidance and materials covering the entire process.

The Climate and Disaster Risk Screening Tool of the World Bank provides high-level screening to help consider short- and long-term climate and disaster risks at an early stage of project design. The tool applies an Exposure–Impact–Adaptive capacity framework to characterise risks. The tool does not provide a detailed risk analysis. Instead, it is intended to help determine whether further consultations, dialogue with local and other experts and analytical work at the project location are needed to strengthen resilience measures during project design. Users are guided step-by-step through the screening process; templates are provided.

Similarly, the Climate Expert website provides working materials, tools and guidance that help companies analyse climate change risks and opportunities and generate strong adaptation strategies. The tool is aimed at small and medium-sized enterprises (SMEs), industrial zones and multiplier organisations and entails a practical 4-step approach that includes a cost-benefit analysis of potential adaptation measures.

4 Conclusion and perspective

In the face of an uncertain future climate, it is essential to prepare for the potential impacts that climate change will have on different regions and populations. To ensure effective adaptation, there is an urgent need to accurately assess climate risks. With the goal of developing equitable and quality-assured climate services for all sectors of society, Climateurope2 is developing a comprehensive approach to climate services standardisation and community engagement, supporting the FAIR principles.

Climate services are crucial in managing climate risks and the impacts of climate extremes. In recent years, a multitude of regulations, standards, guidelines, data services and tools have emerged to assist and support adaptation to climate risk. However, the current landscape of climate risk assessment procedures is scattered and fragmented due to a lack of standardized reference points. This report aims to address this gap by reviewing existing standards and guidelines, services, and tools for climate risk assessments, climate impacts, and extremes. This review will help to identify current best practices, recommendations, and requirements from these standards, contributing to the development of more standardized and effective climate risk assessment procedures.

A list of 26 regulations, standards, and guidelines addressing climate change risks and impacts was identified as relevant for this report in Section 2. The identification process was based on references from literature and web searches using the keyword "climate risk". The selected documents were those that specifically addressed climate risk. These documents exhibited a consistent structure, and we identified several points that could be considered gaps or best practices:

<u>Best practices:</u>

- **Setting the scope of the assessment**: All standards and guidelines emphasize the need for a properly defined climate risk assessment. A climate change risk assessment is always relevant to its subject, whether it is an asset, a system, an organisation or a community. Climate change is a complex issue, and the preparation should correctly consider the location of the site, the objectives of the assessment (screening, risk assessment, adaptation measure, etc), the lifespan of the system or activity, and whether to consider chain values. Additionally, data and expertise on exposure and vulnerabilities should be gathered, and experts and stakeholders should be identified.

- **Gathering climate data (current and future climate):** All standards agree on gathering the highest-quality data available as a best practice. Standards acknowledge the disparity in the quality of climate data and other data between regions and countries around the world. As such, if no high-quality data is available, current and future climate data at the finest resolution available are the minimum requirements for a climate risk assessment. Many services and data portals provide access to quality-controlled climate data and hazard indicators, often at a global resolution.

- **Screening before assessment:** Some standards or guidelines propose an initial step to identify hazards that could pose the greatest risk. This can be done through a stakeholder and expert roundtable on sensitivity of the system to climate-related hazards, or by reviewing available climate data at a regional level. This screening serves two key purposes: first, it provides an overview of all potential climate risks, and second, it validates focusing the risk assessment on the most critical threats.

- **Climate risk assessment methodology**: The most appropriate methodology for a climate risk assessment, whether it is a screening, qualitative, quantitative, or semi-quantitative method, should be selected based on the scope of the assessment and the quantity and quality of data available for the assessment.

- **Scenario analysis**: Most standards agree that a scenario analysis of the likelihood and magnitude of hazards, at least based on the current and future climate projections over the lifespan of the system, is a fundamental requirement. It would be preferable to have multiple scenarios to evaluate the uncertainties associated with climate projections, but many standards do not require this. However, a high-level emission scenario is often required by standards and guidelines for such analysis. The time horizon (short-, medium-, long-term) should be adapted to the lifespan of the system or activity, generally over a period of 20 or 30 years.

Gaps:

- **Physical risk and transition risk**: Most standards or guidelines focus exclusively on physical risk, with a few considering both risks. To our knowledge, none of them address transition risk independently. The standards and guidelines that do consider transition risk provide less detailed procedures compared to those focused on physical risk. Standards and guidelines from economic and financial sectors are more likely to address transition risk, whereas those from other sectors often do not.

- **Definition of risk**: While most current standards or guidelines agree with the IPCC's definition of risk, they do not always use the same definition. The definition of risk in standards can be found to be "uncertainty in the outcome" or "the likelihood or potential outcome of climate-related hazards." The IPCC's definition of risk is based on exposure, hazards, and vulnerability. As the IPCC is the leading authority on climate change and most recent standards refer to IPCC reports, it makes sense to adopt the IPCC's definition of risk for climate risk assessments. A similar inconsistent use of vocabulary is also found for the components of risk, especially with regards to the concept of vulnerability.

- **Addressing and mitigating uncertainties**: A few standards address the issue of uncertainties. The suggestion for addressing uncertainties is to be transparent about the confidence level and to use multiple model ensembles and multiple scenarios to consider a range of possible futures. This gap is further explored in another deliverable of Climateurope2, specifically “D2.3: Preliminary Best Practices in Climate Uncertainty Quantification and Communication”.

- **Communication:** While some of the standards and guidelines identified in this deliverable emphasise the importance of effective and appropriately formatted communication for the target audience, the question of how this should be done and the processes that can be used to develop effective communication arises. Although there is a vast academic and practical literature on risk communication, with a growing body of work focused on communicating risk and uncertainty in the context of climate services, this has yet to be integrated into formal standards and guidelines for climate risk assessment. The development of guidelines for the communication of uncertainty was the focus of a Climateurope2 workshop in November 2023 and is further explored in another deliverable of Climateurope2, specifically “D2.3: Preliminary Best Practices in Climate Uncertainty Quantification and Communication”.

- **Response to adaptation:** The current assessment AR6 introduces "responses to adaptation" as a new dimension of risk. However, existing standards and guidelines have yet to incorporate this new element. A holistic approach encompassing both mitigation and adaptation strategies would significantly benefit decision-makers by helping them validate whether their chosen adaptation measures effectively mitigate climate risks while avoiding unintended consequences. Scenario-neutral approaches to climate impact and risk assessment have been proposed in the literature (e.g., Prudhomme et al., 2010), but have yet to find their way in guidelines and standards.

- **Compound and cascading risks:** The compound and cascading nature of physical climate risks and their interplay with transition risks as well as those related to economy and biodiversity, is increasingly recognised as a critical consideration for climate risk management. Indeed, a recent report by the Network for Greening Financial Systems (NGFS) has highlighted the need to take this into account in climate scenario planning within the financial sector, citing examples of institutions that are already integrating this into planning. However, there are currently no publicly available tools and guidelines for assessing compound and cascading risks, with the NGFS highlighting the need to develop methodologies and toolkits.

The increasing need for climate risk assessments has led to the proliferation of services and tools to support the process. Section 3 provided an overview of the different types of services and tools currently available. While "service" and "tool" are often used interchangeably, we distinguish between data and information providers (services) and tools requiring user input for personalised risk assessments. These diverse services and tools may be categorised into eight distinct categories based on their functionality:

1. **Climate data or information only:** Climate services make it easier for non-specialists to access quality-controlled climate data, enabling them to map and visualise observed and future climate changes, but some background knowledge is still needed to interpret the data and understand the limits of climate risk assessments.
2. **Climate indicators on extremes relevant to climate hazards:** Many services offer information about hazard indicators (typically in the form of maps or graphs or as downloadable data). Many of the standard indicators (such as those proposed by the ETCCDI) may be useful for comparisons or provide an indication of changes in extremes but could potentially be inadequate in a formal risk assessment as they may not represent the relevant hazards at the local scale of interest.
3. **Data and information on impacts:** There are a smaller number of portals providing data on (mainly physical) climate impacts, often based on the results of global impact models. Few services provide quality information or real-world impact data, highlighting the current lack of comprehensive databases on actual human-driven climate change impacts. Information about the quality of the climate impact projections is often not provided nor easily accessible.
4. **Data for risk evaluation, including on exposure and vulnerability:** Vulnerability is one of the main components of risk, but characterizing and quantifying vulnerability remains a challenge due to its complex mix of social, economic, and dynamic factors. A number of services provide information on vulnerability, mostly in the form of a generic or composite indicator. Caution should be exercised when using generic indicators in specific contexts.
5. **The outcomes of a risk evaluation, such as a risk index:** Readily available climate risk reports and scores simplify comparisons across regions; however, their calculations and limited scope may not be optimal for broader decision-making contexts.
6. **Software tools for processing climate data:** While a large number of programming libraries are available to support the calculation of climate indices and assist in characterizing the hazard

component of climate risk, the level of quality assurance is not always clear. Transparency and reproducibility are key concerns when the outputs are meant to support decision-making. Examples of good practice in quality assurance and provenance metadata exist but are not universally adopted.

7. **Models or software tools for evaluating impacts and/or risk:** Many of the impact models that have been used by researchers do not follow a strict risk framework but could still support the risk evaluation process by providing an assessment of the potential impacts of climate change. In recent years a number of tools have been developed that focus specifically on the evaluation of risk, but it is not clear how widely they are being used.
8. **Stepwise methodologies or templates for the risk evaluation process:** Risk evaluation typically involves more than just the simulation of potential impacts and the calculation of a risk score. A number of organisations provide guidance and materials to navigate this complex process. More research may be necessary to evaluate the usefulness, user-friendliness, and saliency of such approaches.

In summary, many services and tools are available to support one or more steps in a typical physical risk assessment process, but few of them take a comprehensive approach. And while access to quality-controlled data on climate change and climate indicators has greatly improved in recent years, some background knowledge on climate science will still be required to properly evaluate and use these data. In many cases further data processing may still be necessary to ensure the saliency of the climate data in a specific risk assessment. Furthermore, several knowledge gaps have been identified:

- **Quality assurance**: Few climate services provide readily accessible information on data quality, such as validation details for impact simulations. To what extent the data provided to the FAIR principles (Findability, Accessibility, Interoperability, and Reusability; Wilkinson et al., 2016) is often not obvious to a user. Many of the available tools do not explicitly provide provenance metadata or information on quality assurance, which creates challenges for transparency and quality assessment.

- **Addressing and mitigating uncertainties:** While most climate data-oriented portals provide information from one or more ensembles of climate models, it is sometimes left to the user to ensure that this uncertainty information is taken into account. The same rigour in providing uncertainty information is often not found in services and tools supporting other parts of the risk assessment process, such as the provision of data on impacts, exposure and vulnerability.

- **Vulnerability indicators:** More research may be necessary to guide vulnerability analyses. A number of services provide vulnerability information but often in the form of generic or composite indicators that may or may not be relevant to a particular risk context. Often it is not clear how sensitive the results are to some of the assumptions that were made in producing the indicators.

This deliverable lays the foundation for WP2's next deliverable, "Guidelines on Enhancing Data Tools and Knowledge for Climate Impacts, Extremes, and Risks through Standardized Climate Services". The best practices and gaps identified through the review of regulation, standards, guidelines, services and tools will enable us to formulate guidelines and recommendations for a standardization of tools and services for risk assessment, following the FAIR principle. This standardization aims to enhance the quality, salience, and usefulness of these data, tools, and approaches to support effective climate adaptation and risk management strategies.

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Appendix 1

The detailed compilation of regulations, standards and guideline are presented in a PDF file linked below:

https://earth.bsc.es/climateurope2/lib/exe/fetch.php?media=wiki:content:appendix_1_d25_inventory_regulations_standards_guidelines.pdf

This document provides a brief overview of all documents reviewed for this report, the types of documents, and the risk assessment methodology employed. It also outlines the types of risks (physical, transition, or disaster risks) and the definition of risk used. If the document recommends a specific timeframe, uncertainty mitigation strategies, and communication suggestions are also provided.

Climateurope2

Deliverable 2.5 : Inventory of data tools and knowledge for climate impacts, extremes and risks for the formulation of standards that can increase their quality and usefulness

Appendix 1

Missing Information

Title	Summary	Organisation	Access	Type of document	Definition of risk	Type of risk	Temporal consideration	Uncertainties management	Communication	Overview
ISO 14090:2019 - Adaptation to climate change — Principles, requirements and guidelines	International standard that offers organizations a structured framework to build resilience against the impacts of climate change. It provides guidelines for understanding climate risks, integrating adaptation into decision-making, and developing effective adaptation plans with stakeholder involvement.	ISO	ISO 14090:2019(en), Adaptation to climate change — Principles, requirements and guidelines	Standard	Risk is the effect of uncertainty on objectives as the composent of likelihood and potential consequences	Climate change physical risk and transition risk	No temporal suggestion	Establish and apply quality management procedures to manage data and information, including the assessment of uncertainty, relevant to the data collection and scenarios selected in adaptation planning.	Climate change adaptation communication must be accurate, transparent, and adaptable, avoiding misleading information, false endorsements, and overstated claims.	• Define the scope, objectives, and boundaries of the climate risk assessment and identify the relevant stakeholders. • Determine the range of climate hazards that could impact the organization. • Evaluate the susceptibility of systems, assets, and populations to climate change effects. • Determine the potential consequences of climate change on the assessed systems, assets, and populations. • Evaluate the likelihood and severity of climate change impacts, combining vulnerability and impact information. • Interpret and prioritize climate change risks, considering uncertainties, thresholds, and risk tolerance. • Develop and implement strategies to reduce or manage climate change risks, ensuring sustainable and resilient outcomes. • Continuously monitor and review the effectiveness of adaptation measures and update assessments as necessary to respond to changing climate conditions.
ISO 14091:2021 - Adaptation to climate change – Guidelines on vulnerability, impacts and risk assessment	Significant standard that provides a structured and comprehensive framework for assessing climate change vulnerabilities, impacts, and risks, offering valuable guidance to organizations and governments in understanding and proactively addressing the challenges posed by climate change, enhancing resilience, and promoting sustainable adaptation strategies.	ISO	ISO 14091:2021(en), Adaptation to climate change — Guidelines on vulnerability, impacts and risk assessment	Guideline of standard Adaptation to climate change	Risk is the effect of uncertainty on objectives as the composent of likelihood and potential consequences	Climate change physical risk	Risks over the lifetime of the system, from short-, medium-, long-term horizons compared to a reference period	Uncertainties addressed by using multiple scenarios (climatic and others) and by experts reviews	Suit the target audiences, with tangibility and conclusions and recommendations	• Define the scope, objectives, and boundaries of the climate risk assessment and identify the relevant stakeholders. • Gather and analyze historical, current, and future climate data to understand climate change impacts. • Evaluate the susceptibility of systems, assets, and populations to climate change effects. • Determine the potential consequences of climate change on the assessed systems, assets, and populations. • Evaluate the likelihood and severity of climate change impacts, combining vulnerability and impact information. • Interpret and prioritize climate change risks, considering uncertainties, thresholds, and risk tolerance. • Develop and implement strategies to reduce or manage climate change risks, ensuring sustainable and resilient outcomes. • Continuously monitor and review the effectiveness of adaptation measures and update assessments as necessary to respond to changing climate conditions.

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Title	Summary	Organisation	Access	Type of document	Definition of risk	Type of risk	Temporal consideration	Uncertainties management	Communication	Overview
ISO 14092:2020 - Adaptation to climate change – Requirements and guidance on adaptation planning for local governments and communities - ISO 14090:2019	Framework for local governments and communities to develop plans that address climate change impacts, reduce risks, and build resilience.	ISO	ISO/TS 14092:2020(en), Adaptation to climate change — Requirements and guidance on adaptation planning for local governments and communities	Guideline of standard Adaptation to climate change	Risk is the effect of uncertainty on objectives as the composent of likelihood and potential consequences	Climate change physical risk	Risks over the lifetime of the system, from short-, medium-, long-term horizons compared to a reference period	Uncertainties should be analysed and documented to the needs and the situation of the local government and community.	Communication shall: — be accurate, verifiable, relevant and not misleading; — be unlikely to result in misinterpretation; — clearly state the scope of the reasons for concern and the related climate change adaptation. Climate change adaptation communications should: — be reassessed and updated as necessary to reflect changes in climate change risks and adaptation opportunities, or the results of monitoring and evaluation; — include qualitative or quantitative information about uncertainties; — explain the monitoring and evaluation plan as well as any relevant monitoring and evaluation results	• Determine what local climate change effects are likely. • Assess how people, infrastructure, ecosystems, and economic activities are susceptible to those hazards. • Evaluate the potential consequences if these vulnerabilities are exposed to the hazards. • Assess the likelihood of the impacts occurring and their severity, leading to a risk rating. • Focus attention and resources on addressing the most significant climate change risks facing the community. • Recognize that risk assessments should be updated regularly as new climate data emerges or as community circumstances change.
ISO 31000:2018 - Risk management — Guidelines	International standard for risk management that provides a comprehensive framework for organizations to systematically identify, assess, and manage risks, with an emphasis on effective communication, transparency, and adaptability throughout the risk management process.	ISO	ISO 31000:2018(en), Risk management — Guidelines	Guideline	Risk is the effect of uncertainty on objectives as the composent of likelihood and potential consequences	Disaster risk	No temporal suggestion	Uncertainties are an inherent part of the risk	emphasizes the importance of transparent and tiemly communication throughout the risk management process	• Define the scope, objectives, and internal/external factors impacting risk assessments. • Identify and compile a comprehensive list of potential risks. • Assess and analyze the likelihood and consequences of identified risks. • Compare assessed risks to established criteria to determine their significance. • Select and implement strategies to manage or mitigate identified risks. • Continuously monitor, review, and update risk assessments and treatments. • Engage stakeholders and ensure transparent and timely risk communication. • Maintain comprehensive records of the entire risk assessment process.
IEC 31010:2019 - Risk management — Risk assessment techniques	International standard that offers guidance on selecting and applying risk assessment techniques to help organizations systematically evaluate risks and uncertainties in a structured and effective manner.	IEC	https://www.iso.org/obp/ui/en/#iso:std:iec:31010:ed-2:v1:en,fr	Standard	Risk is the composent of likelihood and potential consequences	Disaster risk	No temporal suggestion	Selection of risk assessment techniques to help to quantify and manage uncertainties by using probalilistic modeling and sentivity analysis	emphasizes the importance of clear and transparent communication with stakeholders throughout the risk assessment process.	• Establish a risk management framework and context for the assessment. • Define the objectives and constraints of the risk assessment. • Identify potential risks relevant to the objectives. • Evaluate the identified risks, considering their likelihood and potential consequences. • Use appropriate techniques to estimate and quantify the assessed risks. • Interpret the results to determine the significance and potential impact of the risks on the objectives. • Communicate the results and findings of the risk assessment effectively. • Continuously review and update the risk assessment in response to changing circumstances or new information.
ISO/CDTS 31050 - Guidance for managing emerging risks to enhance resilience	**Under development**									

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Deliverable 2.5 : Inventory of data tools and knowledge for climate impacts, extremes and risks for the formulation of standards that can increase their quality and usefulness

Appendix 1

Missing Information

Title	Summary	Organisation	Access	Type of document	Definition of risk	Type of risk	Temporal consideration	Uncertainties management	Communication	Overview
Recommendations of the Task Force on Climate-related Financial Disclosure	An international initiative that provides a standardized framework for organizations to transparently report climate-related financial risks and opportunities in their financial disclosures, facilitating better understanding and management of the financial implications of climate change.	TCFD	https://assets.bbhub.io/company/sites/60/2021/10/FINAL-2017-TCFD-Report.pdf https://www.fsb.org/wp-content/uploads/P291020-2.pdf	Standard	Risk as the potential financial impacts and liabilities that organizations may face due to climate-related factors	Climate change physical and transition risk	No temporal suggestion	No mention of uncertainties	encourages companies to transparently report on these risks, their potential financial impact, and their management strategies, facilitating informed decision-making by investors and stakeholders.	• Establish governance structures to oversee climate-related risks and opportunities. • Develop a strategy to address climate-related risks and opportunities. • Implement processes for identifying, assessing, and managing climate risks. • Define and disclose metrics and targets for assessing climate-related performance and progress.
Requirement of the Delegated Regulation 2021/2139 (Climate Delegated Act) supplementing the EU Taxonomy Regulation	Framework designed to help assess and classify economic activities based on their environmental sustainability and climate impact.	EU	https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32021R2139 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32022R1214 How to perform a robust climate risk and vulnerability assessment for EU taxonomy reporting?	Regulation	Risk following the IPCC definition as "potential for adverse consequences for human or ecological systems"	Climate change physical risk	Risk for a economic activity with a lifespan inferior to 10 years can be considered based on the current time Risk for a economic activity with a lifespan superior to 10 years should be considered based on future projection	No mention of uncertainties	No framework for communication	• Define taxonomy-eligibility economic activities and expected lifespan • Screen and identify climate-related hazards that may affect performance • Identify vulnerability affected by impacts of climate-related hazards • Gather relevant climate data and future projections. • Evaluate the severity of climate change impacts to which the elements of activity is affected • Assess nature-based solutions and adaptations solutions to mitigate identified climate risk
ESRS E1 (Draft)	Set of environmental and social guidelines adopted by financial institutions to assess and manage risks associated with major projects, emphasizing transparency, stakeholder engagement, and responsible project development, particularly in emerging markets.	EFRAG	Download (efrag.org)	Standard associated with the CSRD	Risk as the potential financial impacts and liabilities that organizations may face due to climate-related factors	Climate change physical and transition risk	Risk over short, medium and long term	No mention of uncertainties	No framework for communication	Transition Risk: • Identify climate-related risk that pose a potential threat to assets and business operations. • Identify transition events linked to climate change, including scenarios aligned with limiting global warming to 1.5°C, in accordance with climate goals. • Document the climate-related scenario analysis process. • Identify assets and business activities that are incompatible with, or require substantial efforts to align with, a climate-neutral economy. Physical Risk: • Identify climate-related hazards, considering at least high emission climate scenarios that pose a potential threat to assets and business operations. • Evaluate the level of asset exposure by considering the likelihood, severity, and duration of climate hazards. • Conduct a comprehensive analysis of climate-related impacts, risks, and opportunities. • Evaluate potential financial effects from material physical risks. • Include the impact and risk caused of climate-related policies and actions.
Assessment of climate-related risks. A 6-step methodology	Guideline designed help decision makers to identify response, based on the best-practices of CRA	Global Programme on Risk Assessment and Management for Adaptation to Climate Change (Loss and Damage)	GIZ_CRA-6-step-methodology.pdf (adaptationcommunity.net)	Guideline	Risk as the results from the interaction of vulnerability (of the affected system), its exposure over time (to the hazard), as well as the (climate-related) hazard and the likelihood of its occurrence	Climate change physical risk	No temporal suggestion	No mention of uncertainties	emphasize stakeholder-based elicitation of options	• Analyse the current knowledge of climate change impacts and climate data availability • Identify highly vulnerable sector and region • Develop with stake holders a context-specific climate change risk assessment • Evaluate the current and projected climate change impacts • Evaluate is the risk can be acceptable, tolerable or intolerable • Identifie with stake holders feasible option to address identified risk
Aotearoa New Zealand Climate Standard 1 Climate-related Disclosures (NZ CS 1)	Framework for entities to identify risk and oppertunities that climate change presents	XRB	https://www.xrb.govt.nz/dmsdocument/4770	Regulation	Risk as the potential negative impacts of climate change on an entity	Climate change physical risk	Risk over short, medium and long term	No mention of uncertainties	presents amount of business activities vulnerable to risk or aligned to climate oppertunities	• Analyse the current financial impact of physical and transition risk • Undertake at least three climate-related scenarios analysis • Identify climate-related risks and opportunities over the short, medium and long term • Document the anticipated financial impact of the climate-related risks and opportunities • Propose a transition plan, including how the business might transitions toward a low-emission state

Deliverable 2.5 : Inventory of data tools and knowledge for climate impacts, extremes and risks for the formulation of standards that can increase their quality and usefulness

Appendix 1

Missing Information

Title	Summary	Organisation	Access	Type of document	Definition of risk	Type of risk	Temporal consideration	Uncertainties management	Communication	Overview
TECHNICAL GUIDANCE ON COMPREHENSIVE RISK ASSESSMENT AND PLANNING IN THE CONTEXT OF CLIMATE CHANGE	Provides orientation on how risks in the context of climate change can be comprehensively and systemically addressed through risk assessment.	UNDRR	https://www.undrr.org/media/79566/download?startDownload=true	Guideline	Risk as potential for adverse consequence for human or ecological systems	Climate change physical and Disaster risk	30 year period over short, medium and long term	Address uncertainty as confidence and making the source of uncertainty transparent	results should include impact chains showing the interdependencies for particular risks or sectors, as well as maps representing where in the region assessed.	• Define scope and objectives of the risk assessment • Identify current and future potential climate-related hazards or risks that could impact the subject of assessment • Analyse exposition, vulnerability and impact of hazards • Evaluate the risks • Adress and minimize risks through Nature based solutions
Guidance notice Assessment and Management of Environmental and Social Risks and Impacts	Framework for systematically identifying, assessing, and managing risks and impacts related to environmental and social factors in projects	IFC	https://www.ifc.org/content/dam/ifc/doc/2021/20210614-ifc-ps-guidance-note-1-en.pdf	Guideline of Environmental and Social Risks and Impacts	Risk as the potential for adverse environmental or social consequences that may arise from a project or business activity	Disaster risk, climate change physical risk and transition risk	No temporal suggestion	No mention of uncertainties	emphasize clear and transparent communication of environmental and social risks and impacts to stakeholders	• Define the scope and purpose of the assessment to establish clear objectives. • Identify potential hazards or risks that could impact the subject of assessment. • Analyze risks by identifying potential events and assessing their likelihood and impact. • Assess and prioritize risks by assigning ratings based on their significance. • Develop and implement risk control and mitigation strategies. • Continuously monitor and review the effectiveness of control measures and evolving risks. • Communicate risk information to relevant stakeholders. • Document the entire assessment process, including findings and actions taken. • Use feedback to improve and refine risk assessment procedures. • Prepare and distribute risk assessment reports summarizing findings and recommendations.
Environmental Risk Assessment: Approaches, Experiences, and Information Sources. Copenhagen: EEA	Guideline presenting environment risk assessment	EEA	https://www.eea.europa.eu/publications/GH-07-97-595-EN-C2/chapter4h.html	Guideline	Risk combination of the probability, or frequency, of occurrence of a defined hazard and the magnitude of the consequences of the occurrence	ecological risk	No temporal suggestion	No mention of uncertainties	No framework for communication	• Define the scope of the problem • Identify Hazard • Assess Release • Assess Exposure • Assess Consequence • Estimate Risk
The Equator Principle	Set of environmental and social guidelines adopted by financial institutions to assess and manage risks associated with major projects, emphasizing transparency, stakeholder engagement, and responsible project development, particularly in emerging markets.	EP4	The Equator Principles_EP4_July2020 (equator-principles.com)	Standard	Risk as the potential adverse financial impacts and liabilities that organizations may face due to climate change.	Climate change physical and transition risk	No temporal suggestion	No mention of uncertainties	promote transparent communication of environmental and social risks associated with large projects.	• Define the boundaries and objectives of the risk assessment. • Identify potential risks associated with environmental and social factors. • Analyze risks by assessing their likelihood and potential consequences. • Assign risk ratings and develop strategies to control or mitigate risks. • Engage with relevant stakeholders, including local communities. • Continuously monitor project progress and risks to adapt as necessary. • Transparently communicate environmental and social risks to stakeholders. • Maintain records of risk assessment and management activities. • Prepare and distribute reports summarizing risk assessment findings.
Guidance note on climate change risk assessment	Support the implementation of the requirements contained in the Equator Principles on climate change risk assessment	EP4	https://equator-principles.com/app/uploads/Guidance-CCRA_May-2023.pdf	Guideline of the equator principle	Risk as the potential adverse financial impacts and liabilities that organizations may face due to climate change.	Climate change physical and transition risk	Temporal consideration should be site specific	No mention of uncertainties	No framework for communication	• Define the location and resources of the project, • Analyze current and long-term climate condition to identify potential physical risk • Identify the consequence of these risk to assets. • Identify current and anticipated policy risk, technology and market risk, legal risk and reputation risk • Document plan to mitigate the identified climate-related risk

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Reporting Guidelines on Disaster Risk Management	Set of instructions developed by the European Commission to streamline reporting by member states on their disaster risk management efforts	EU	https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52019XC1220(01)	Guideline		Disaster risk	Future Risk and emerging should be considered with analysis scenario	No mention of uncertainties	results should be properly communicated to all expert and people facing threats to their health and/or their economic or social well-being	• Describe the scope and context of the national risk assessment • Consult relevant stakeholders • Identify key risk and high-light key risk linked to climate change • Analyze and map risk by assessing the levels of probability and impacts • Monitor and review that the risk remains valid • Communicate the results of risk assessments to used in decision-making
Performance Standard 1 Assessment and Management of Environmental and Social Risks and Impacts	Ensures businesses consider the environmental and social impact of their projects. It requires them to proactively assess risks, involve communities, and develop a plan to manage these issues throughout the project's life cycle.	IFC	2012-ifc-performance-standard-1-en.pdf	Standard	Risk is a combination of the probability of certain hazard occurrences and the severity of impacts resulting from such an occurrence	Disaster risk, climate change physical risk and transition risk	No temporal suggestion	No mention of uncertainties	encouraged to make publicly available periodic reports on their environmental and social sustainability	• Define the environmental and social policy and principle • Define the scope of the assessment • Determine the appropriate method to identify risk • Identify potential risk in the scope of assessment • Establish mitigation and performance improvement measures • Monitor and review the risk
Recommendations for National Risk Assessment for Disaster Risk Management in EU	Provide a structured framework for conducting comprehensive risk assessments to enhance disaster preparedness and resilience, emphasizing clarity in communication and the management of uncertainties to foster informed decision-making and public awareness.	JRC	Recommendations for national risk assessment for disaster risk management in EU - Publications Office of the EU (europa.eu)	Guideline of Reporting Guidelines on Disaster Risk Management	Risk as the potential for loss and composed of hazard, exposure and vulnerability	Disaster risk	Risk over short, medium and long term	No mention of uncertainties	ensures that the findings and implications of risk assessments are clearly and transparently conveyed to relevant stakeholders, fostering informed decision-making and public awareness	• Define the purpose and boundaries of the risk assessment. • Identify potential natural and man-made hazards. • Assess the vulnerability of assets and populations. • Analyze and quantify risks associated with each hazard. • Create scenarios outlining various disaster situations. • Gather relevant data to support the risk assessment. • Assess the potential impacts of disasters. • Calculate overall risk by combining hazard probability, vulnerability, and exposure. • Create visual representations of assessed risks. • Develop a clear communication strategy for risk findings. • Develop strategies to manage and mitigate risks. • Continuously monitor and review risk management measures and the assessment.
Principles for Integrating Physical and Transitional Climate Risk Assessment	Framework to conduct a combined assessment of physical and transition risks (integrated climate-risk assessment), to help financial institutions implement this approach and build understanding amongst staff	UNEPFI	https://www.unepfi.org/wordpress/wp-content/uploads/2022/01/Climate-tango_Principles-for-integrating-physical-and-transition-climate-risk-assessment_Report.pdf	Guideline	No stated definition of risk	Climate change physical and transition risk	No temporal suggestion	No mention of uncertainties	No framework for communication	• Choose the scope of risks and sector to be assessed • Capture the interplay between transition and physical risks • Quantify the risk transmission channels
Climate Impacts Risk Assessment Methodology (CIRAM)	Systematic approach designed to assess climate-related risks, emphasizing the impact of climate change on organizations, assets, and objectives.	MOD (UK GOV)	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/842735/20191003-Section_7-CIRAM-O.pdf	Guideline	Risk is an uncertain future event that could affect the ability to achieve its objective	Climate change physical risk	A 2050 timescale averaged over 30years relative to the 1961-1990 baseline or different timescale based on a identified business benefit	No mention of uncertainties	emphasizes transparent and effective communication of climate-related risks to stakeholders, ensuring that information on identified risks and adaptation strategies is clearly and timely conveyed to support informed decision-making	• Define the assessment scope and objectives, outlining what is to be achieved. • Gather relevant climate data and future projections. • Identify vulnerabilities within the context of climate impacts. • Identify and list potential climate-related risks and their sources. • Evaluate the likelihood and impact of identified risks. • Prioritize assessed risks based on their significance. • Develop strategies to address identified risks. • Put strategies into action and continuously monitor their effectiveness. • Effectively communicate risk assessment results to stakeholders. • Maintain comprehensive records of the risk assessment process. • Periodically review and update the assessment to account for changing circumstances.

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Climate Disclosures Dashboard 2.0	Incorporates both recent regulatory developments and progress made by industry in preparing climate-related disclosures whilst retaining the userfriendly structure of the original.	CFRF	https://www.fca.org.uk/publication/corporate/cfrf-guide-2023-climate-disclosures-dashboard.pdf	Guideline	Based on the TCFD definiotion of risk as the potential financial impacts and liabilities that organizations may face due to climate-related factors	Climate change physical risk and transition risk	A present day, 2030 and 2050 timescale	No mention of uncertainties	No framework for communication	Transition Risk: • Carbon-related assets should be defined as those tied to the four groups identified by TCFD i.e. Energy; Transportation; Materials and Buildings; and Agriculture, Food and Forest Products. • Map carbon-related assets by sector and risk level, and identify investees with climate transition resilience plans. • Disclose outputs and methods of scenario analysis for both physical and transition risks, potentially using tools like CFRF and aggregating results into a climate CVaR metric. Consider opportunities emerging from the climate transition. Physical Risk: • Analyzing asset location and types alongside predicted climate changes reveals portfolio areas most vulnerable to physical climate risks. • For finer detail, assess individual property exposure, sectors, and geographies across various scenarios and risk types. Consider AR6's list of physical climate hazards for impact assessment. • Conduct scenario analysis with multiple scenarios (e.g., NGFS), utilizing past and recent impacts as a baseline for projected financial impacts. Use available data (e.g., Moody's PD model, MSCI VaR) and facilitate comparisons between transition and physical risks, ideally using the same metric for financial impact disclosure.
CSC Report 17- Adapting to Climate Change: Methods and Tools for Climate Risk Management	Provide organisations with the information they need in order to understand the range of issues involved in adaptation, and to help them make informed decisions about how they may make progress with adaptation planning in practice.	CSC	csc_report17.pdf (climate-service-center.de)	Guideline	Risk is the effect of uncertainty on objectives as the composent of likelihood and potential consequences	Climate change physical risk	No temporal suggestion	Uncertainties addressed by using multiple models ensemble	No framework for communication	• Establish the organization's objectives, risk tolerance, and the geographical scope of the assessment. • Determine the potential climate change threats relevant to the organization's context. • Use reliable sources of climate data and information on the organization's vulnerabilities to ensure the accuracy of the assessment. • Estimate the potential consequences if vulnerabilities are exposed to the hazards. • Combine the likelihood and severity of potential impacts to assign a risk rating to each identified risk.
Transition risk framework: Managing the impacts of the low carbon transition on infrastructure investments	Manage the impacts of the low carbon transition on infrastructure investments offers a step-by-step guide for investors to navigate the shift to a low-carbon economy.	ClimateWise	https://www.cisl.cam.ac.uk/system/files/documents/cisl-climate-wise-transition-risk-framework-report.pdf	Guideline	Based on the TCFD definition of risk as the potential financial impacts and liabilities that organizations may face due to climate-related factors	Climate change transition risk	No temporal suggestion	No mention of uncertainties	No framework for communication	• Identify the material financial impacts from transition risks across a large portfolio, by applying the Infrastructure Risk Exposure Matrix. • Assess the financial impact from the low carbon transition at an asset-by-asset level, which provides insights on ways to improve asset resilience. • Incorporate the potential impacts of transition risk directly into their own financial models • Inform investment strategy and risk management
CLIMAAX Framework	Provide a reference for defining CRA workflows and their implementation that are consistent with the highest standards and best practices as well as state-of the art scientific findings	CLIMAAX	Framework description — crabook (climaax.eu)	Guideline	Under development possibly similar to the IPCC definition of risk	Climate change physical risk	No temporal suggestion	No mention of uncertainties	No framework for communication	• Define context, objectives, and criteria for the assessment. • Identify risks by scoping the background, analyzing data records, and incorporating stakeholder knowledge and expertise. • Analyze risks by using a quantitative method using future scenarios for hazards, exposure, and vulnerability. • Prioritize risks to inform climate risk management strategies. • Monitor and evaluate the implementation of risk management strategies and consider the need for a new climate risk assessment as climate risk may change.

Deliverable 2.5 : Inventory of data tools and knowledge for climate impacts, extremes and risks for the formulation of standards that can increase their quality and usefulness

Appendix 1

Missing Information

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IEC 63152 Smart Cities - City Service Continuity against disasters - the role of the electrical supply	Provide guidance on how to ensure the continuity of city services in the event of a disaster. The standard focuses specifically on the role of the electrical supply in maintaining essential services such as water, sanitation, healthcare, and transportation.	IEC	IEC 63152:2020 | IEC Webstore	Standard	Risk define as potential events or situations that can cause harm to city services and their continuity.	Disaster risk	No temporal suggestion	No mention of uncertainties	No framework for communication	• Identify the potential hazards that could disrupt the electrical supply. • Assess the vulnerability of the electrical system to the identified hazards. This includes considering the age and condition of the infrastructure, the level of redundancy, and the availability of backup power. • Identifying the critical services that rely on the electrical supply. • Assess the potential consequences of disruptions to the electrical supply for critical services. • Developing strategies to mitigate the risks to the electrical supply, such as investing in redundancy, backup power, and emergency response planning.

Appendix 2

The overview of the services and tools are given in a PDF file linked below:

https://earth.bsc.es/climateurope2/lib/exe/fetch.php?media=wiki:content:appendix_2_d25_climate_tools_service.pdf

This appendix provides an overview and brief descriptions of all the assessed services and tools. Each of these tools and services addresses one or more of the following eight categories:

1) Climate data or information only (not including data repositories);
2) Climate indicators on extremes relevant to climate hazards;
3) Data and information on impacts;
4) Data for risk evaluation, including on exposure and vulnerability;
5) The outcomes of a risk evaluation, such as a risk index;
6) Software tools for processing climate data (not including general software libraries);
7) Models or software tools for evaluating impacts and/or risk;
8) Stepwise methodologies or templates for the risk evaluation process.

For each category, the appendix provides a brief description of the types of services and tools that fall into that category.

Name	Organisation	Link	Climate Tool or Service	Documentation	Comments	1. Climate data/ Information only	2. Climate indicators	3. Data/ Information on impacts	4. Data on hazard, exposure, vulnerability	5. Outcomes of risk evaluation	6. Software tools for processing climate data	7. Models/software tools for evaluating impacts and/or risk	8. Stepwise methodologies/ templates for the risk evaluation process
Climate and Disaster Risk Screening Tools	World Bank	https://climatescreeningtools.worldbank.org/	Tool	See documentation on web portal, in particular https://climatescreeningtools.worldbank.org/background-screening-methodology	The Climate and Disaster Risk Screening Tool provides high-level screening to help consider short- and long-term climate and disaster risks at an early stage of project design. The tool applies an Exposure–Impact–Adaptive capacity framework to characterize risks. Potential risks are identified by connecting information on climate and geophysical hazards with users' subject matter expertise of project components (both physical and non-physical) and understanding of the broader sector and development context. The tool does not provide a detailed risk analysis. Rather, it is intended to help inform the need for further consultations, dialogue with local and other experts and analytical work at the project location to strengthen resilience measures in the course of project design. **Users are guided step-by-step through the screening process; templates are provided.** Screening should be based on knowledge of the project location and components, sector expertise, as well as climate and disaster risk information from global or national, quality-controlled sources.								The Climate and Disaster Risk Screening Tool provides high-level screening to help consider short- and long-term climate and disaster risks at an early stage of project design. The tool applies an Exposure–Impact–Adaptive capacity framework to characterize risks. Potential risks are identified by connecting information on climate and geophysical hazards with users' subject matter expertise of project components (both physical and non-physical) and understanding of the broader sector and development context. The tool does not provide a detailed risk analysis. Rather, it is intended to help inform the need for further consultations, dialogue with local and other experts and analytical work at the project location to strengthen resilience measures in the course of project design. **Users are guided step-by-step through the screening process; templates are provided.**
Climate Change Knowledge Portal	World Bank	https://climateknowledgeportal.worldbank.org/	Service	See documentation on web portal, in particular https://climateknowledgeportal.worldbank.org/media/document/metatag.pdf	The Climate Change Knowledge Portal (CCKP) provides historical and future climate and climate-related datasets. The CCKP data draw on global, quality-controlled data sets and are continually updated as new data becomes available. In some cases, the CCKP is supplemented with other sources of information. The aim of the CCKP is to help provide policy makers, development practitioners and interested parties with a resource to explore and analyze climate and climate-related data to assess future scenarios, projected physical climate risks and vulnerabilities for national and sub-national contexts and across key sectors. Data are aggregated at national, sub-national, and watershed levels. CCKP data is presented across multiple scales demonstrating historical contexts, climatological means, anomalies, trends, as well as inter-annual and inter-seasonal variability, which can be understood through a variety of interactive visualizations.	Historical; CMIP5; CMIP6	ECVs; ETCCDI + bespoke indicators	Agriculture; Water; Sea level;	Data on hazards and historical disasters	Heat risk			
IPCC WGI Interactive Atlas	IPCC	https://interactive-atlas.ipcc.ch/	Service	See documentation on web portal, in particular https://interactive-atlas.ipcc.ch/documentation plus links	The IPCC WGI AR6 Interactive Atlas allows flexible spatial and temporal analyses of much of the observed and projected climate change information underpinning the WGI assessment. The Interactive Atlas has two components. The first (regional information) includes the ability to generate global maps and a number of regionally aggregated products (time series, scatter plots, tables, climate stripes, etc.) for observed and projected climate change for time periods, emissions scenarios or global warming levels of interest. It integrates a range of different datasets, including global and regional observations and the three most recent coordinated global and regional climate projection experiments: CMIP5, CORDEX and CMIP6, for different key variables, extreme indices and climatic impact-drivers (CIDs). The second component (regional synthesis) provides qualitative information about changes in climatic impact-drivers (CIDs) in several categories such as heat and cold, wet and dry, or coastal and oceanic. Users can select one or several impact-drivers and visualize the regional historical trends and projected changes over the sub-continental reference regions.	Historical observations; CMIP5; CORDEX; CMIP6	Atmospheric and ocieanic essentival variables; exteme indices; climate impact drivers	Qualitative information about changes in climatic impact-drivers (CIDs)					
Climate Expert tool	Deutsche Gesellscha	https://www.climate-expert.org/en/home	Tool	See documentation on web portal.	The Climate Expert entails a practical 4-step approach and working materials that help companies analyse climate change risks and opportunities and generate strong adaptation strategies. It was developed by the Deutsche Gesellschaft fuer Internationale Zusammenarbeit (GIZ) GmbH. There are four steps: 1) Identify and analyze climate change impacts; 2) Assess climate risks and opportunities; 3) Identify and evaluate adaptation measures, including cost-benefit analysis; 4) Develop adaptation strategy. The Climate Expert approach was developed for small and medium-sized enterprises (SMEs) and industrial zones that are or will be affected by climate change. It also addresses consultants, experts and multipliers who want to support the private sector in adapting to climate change. The Climate Expert website provides materials, tools and guidance for SMEs and multiplier organisations, aimed at raising awareness and building practical skills of SMEs to prepare for the impacts of climate change. For this purpose the website contains the **online learning programme** "Becoming a Climate Expert" for companies as well as a **Toolbox with materials and further information** on a related training programme.								The Climate Expert entails a practical 4-step approach and working materials that help companies analyse climate change risks and opportunities and generate strong adaptation strategies. There are four steps: 1) Identify and analyze climate change impacts; 2) Assess climate risks and opportunities; 3) Identify and evaluate adaptation measures, including cost-benefit analysis; 4) Develop adaptation strategy. The Climate Expert website provides materials, tools and guidance for SMEs and multiplier organisations, aimed at raising awareness and building practical skills.
Think Hazard		https://www.thinkhazard.org/	Service	Documentation on https://gfdrr.github.io/thinkhazardmethods/	ThinkHazard! is a web-based tool enabling non-specialists to consider the impacts of disasters on new development projects. Users can quickly and robustly assess the level of river flood, earthquake, drought, cyclone, coastal flood, tsunami, volcano, and landslide hazard within their project area to assist with project planning and design. ThinkHazard! is a simple flagging system to highlight the hazards present in a project area. As such, a user is only required to enter their project location – national, provincial or district name. The results interface shows a user whether they require high, medium or low awareness of each hazard when planning their project. ThinkHazard! also provides recommendations and guidance on how to reduce the risk from each hazard within the project area, and provides links to additional resources such as country risk assessments, best practice guidance, additional websites. ThinkHazard! also highlights how each hazard may change in the future as a result of climate change.				Data on hydraulic and meteo-climatological hazards at country or regional level classified according to intensity and/or frequency				
Climate Data Store	Copernicus Climate Change Service (C3S)	https://cds.climate.copernicus.eu/#!/home	Service	Documentation per dataset/application on web portal; general CDS documentation on https://confluence.ecmwf.int/display/CKB/Climate+Data+Store+%28CDS%29+documentation	The Climate Data Store (CDS) enables the provision of Essential Climate Variables (ECVs), climate analyses, reanalyses, projections and indicators at temporal and spatial scales relevant to adaptation and mitigation strategies for various sectoral and societal benefit areas.	Historical observations; climate reanalyses; CMIP5; CORDEX; CMIP6	Essential Climate Variables and bespoke indicators for different sectors	Sectoral indicators based on impact models					
CatNet	Swiss Re Group	https://www.swissre.com/reinsurance/property-and-casualty/solutions/property-specialty-solutions/catnet.html	Service	Restricted access; limited information available on website	The CatNet Suite provides globally consistent, high-resolution hazard data and data on risk exposures, catastrophic events and losses that can be combined with customer data to support risk assessment.				Global, high-resolution data on natural hazards (frequency and/or intensity) and near real-time catastrophic event data				
Notre Dame Global Adaptation Initiative's (ND-GAIN) Country Index	University of Notre D	https://gain.nd.edu/our-work/country-index/	Service	Technical document linked on web page: https://gain.nd.edu/assets/522870/nd_gain_countryindex techreport_2023_01.pdf	The Notre Dame Global Adaptation Initiative's (ND-GAIN) Country Index shows a country's current vulnerability to climate disruptions. It also assesses a country's readiness to leverage private and public sector investment for adaptive actions. The ND-GAIN Country Index brings together more than 40 core indicators to measure vulnerability and readiness of 182 UN countries from 1995 to the present (10 countries only have readiness scores). Although it is called a vulnerability score, it combines data on exposure, sensitivity and adaptive capacity and therefore can be seen as a risk index.					Country-level index showing current vulnerability to climate disruptions based on more than 40 core indicators.			
Global Climate Risk Index	Germanwatch	https://www.germanwatch.org/en/cri	Service		The annually published Global Climate Risk Index analyses to what extent countries have been affected by the impacts of weather-related loss events. (storms, floods, heat waves etc.). Human impacts (fatalities) and direct economic losses were analysed. Although it is named a "risk index", it is actually a ranking of the impacts (losses) of historical weather and climate events, however it is framed as highlighting existing vulnerabilities to future climate change.				Country-level index of the impacts of historical weather-related loss events (storms, floods, heat waves etc.), based on fatalities and direct economic losses.				
EM-DAT	Centre for Research on the Epidemiology of Disasters (CRED)	https://www.emdat.be/	Service	Various publications linked at https://www.emdat.be/publications/	EM-DAT contains data on the occurrence and impacts of over 26,000 mass disasters worldwide from 1900 to the present day. The database is compiled from various sources, including UN agencies, non-governmental organizations, reinsurance companies, research institutes, and press agencies.			Database of the impacts of historical disasters (loss events)					
European Climate Data Explorer (ECDE)	European Environme	https://climate-adapt.eea.europa.eu/en/knowledge/european-climate-data-explorer/	Service	See documenation on web portal and in Climate Data Store (CDS) for underlying datasets	The European Climate Data Explorer (ECDE) provides interactive access to a growing selection of climate indices reflecting the priorities of the European Environment Agency (EEA). The underlying data is from the Climate Data store (CDS) of the Copernicus climate change service (C3S). The indices relate to six themes and sectors: health, agriculture, forestry, energy, tourism, water and coastal.		Climate indicators related to six themes and sectors: health, agriculture, forestry, energy, tourism, water and coastal. The indicators are generally provided at national and sub-national level.						
Adaptation Support Tool (AST)	European Environme	https://climate-adapt.eea.europa.eu/en/knowledge/tools/adaptation-support-tool	Tool	See documenation on web portal	The aim of the Adaptation Support Tool (AST) is to assist policy makers and coordinators on the national level in developing, implementing, monitoring and evaluating climate change adaptation strategies and plans. The AST was developed as a practical guidance tool for national level actors for all steps needed to develop, implement, monitor and evaluate a national adaptation strategy. The Adaptation Support Tool (AST) consists of six steps including **assessing climate change risks** and vulnerabilities.								
OS-C Physical Risk & Resilience Tool	OS-Climate	https://os-climate.org/physical-risk-resilience/ and https://physrisk-ui-sandbox.apps.odh-cl1.apps.os-climate.org/ (sandbox environment)	Both	Documentation and code on https://github.com/os-climate/physrisk In particular https://github.com/os-climate/physrisk/blob/main/methodology/PhysicalRiskMethodology.pdf For the hazard indicators: https://github.com/os-climate/hazard	An open-source library for assessing the physical effects of climate change and thereby the potential benefit of measures to improve resilience. Physrisk is primarily designed to run 'bottom-up' calculations that model the impact of climate hazards on large numbers of individual assets (including natural) and operations. These calculations can be used to assess financial risks or socio-economic impacts. To do this physrisk collects (a) hazard indicators and (b) models of vulnerability of assets/operations to hazards. Hazard indicators are on-boarded from public resources or inferred from climate projections, e.g. from CMIP or CORDEX data sets. Indicators are created from code in the hazard repo to make calculations as transparent as possible.		Hazard indicators are on-boarded from public resources or inferred from climate projections, e.g. from CMIP or CORDEX data sets. Based on the sandbox environment, indicators include riverine inundation; coastal inundation; chronic heat; fire; drought; precipitation; hail; wind; combined inundation.				Apart from providing access to hazard indicators, the Physrisk library also provides access to the underlying code library that may be used to calculate these indicators from different data sources.	The Physrisk library provides tools for assessing the physical effects of climate change, including models of vulnerability of assets/operations to hazards.	

Name	Organisation	Link	Climate Tool or Service	Documentation	Comments	1. Climate data/ Information only	2. Climate indicators	3. Data/ Information on impacts	4. Data on hazard, exposure, vulnerability	5. Outcomes of risk evaluation	6. Software tools for processing climate data	7. Models/software tools for evaluating impacts and/or risk	8. Stepwise methodologies/ templates for the risk evaluation process
Climate Explorer	Sust Global	https://www.sustglobal.com/	Both	Not freely accessible	web-based climate risk analytics platform. Users can upload assets via the intuitive dashboard and generate insights for properties, land parcels, and portfolios. Hazard data are provided covering wildfire, floods, cyclones, water stress, drought and sea level rise across multiple global warming scenarios on an annual basis to 2100.		Hazard data are provided covering wildfire, floods, cyclones, water stress, drought and sea level rise across multiple global warming scenarios on an annual basis to 2100.					Users can upload assets via the intuitive dashboard and generate insights for properties, land parcels, and portfolios in the form of clear financial loss modeling, value-at-risk projections, and business interruption insights.	
Climate Watch	World Resources Institute (WRI)	https://www.climatewatchdata.org/	Service	Training and tutorials on website	Climate Watch, hosted by the World Resources Institute (WRI), is a leading climate data repository, with information on greenhouse gas (GHG) emissions, country policies, and mitigation and adaptation commitments. The platform also hosts national and sectoral profile pages that offer a snapshot of climate progress, risks and vulnerabilities.	Data and visualizations on all countries' greenhouse gas emissions; a comprehensive, user-friendly database of all countries' Nationally Determined Contributions (NDCs); and more.				National and sectoral profile pages that offer a snapshot of climate progress, risks and vulnerabilities.			
Aqueduct	World Resources Institute (WRI)	https://www.wri.org/aqueduct	Service	Documentation linked from website	WRI's Aqueduct informs companies, governments, and non-governmental organizations (NGOs) about water-related risks such as floods, droughts and stress through the following products: (1) Aqueduct Water Risk Atlas, which maps and analyzes current and future water risks across locations; (2) Aqueduct Food, which identifies current and future water risks to agriculture and food security; (3) Aqueduct Floods, which identifies coastal and riverine flood risks, and analyzes the costs and benefits of investing in flood protection; and (4) Aqueduct Country Rankings, which allows decision-makers to understand and compare national and subnational water risks. Aqueduct provides access to the information through interactive web platforms ("tools") as well as the underlying datasets.			Aqueduct Floods provides data on coastal and fluvial flood hazard for a range of flood magnitudes (probabilities), time periods, climate scenarios and climate models.		Aqueduct provides ionformation about current and future water risks related to coastal and riverine flooding; agriculture and food security. It also maps and analyzes current and future water risks across locations and provides country rankings, which allows decision-makers to understand and compare national and subnational water risks.			
Climate Impact Explorer	Climate Analytics	https://climate-impact-explorer.climateanalytics.org/	Service	See https://climate-impact-explorer.climateanalytics.org/methodology/ and linked documentation.	A web-based tool, covering information on a broad range of climate impacts in all continents and countries down to the province level. The Climate Impact Explorer shows how the severity of climate change impacts will increase over time in continents, countries and provinces at different levels of warming, starting with 1.5°C, the limit in the Paris Agreement. It also allows access to the underlying data.	The Climate Impact Explorer provides data on a number of climate change indicators (such as change in mean annual temperature or the relative change in precipitation) on a country or regional level.	The Climate Impact Explorer provides data on a broad range of hazard indicators (such as change in soil moisture or change in daily maximum air temperature) on a country or regional level.	The Climate Impact Explorer provides data on a broad range of climate impact indicators (such as change in annual mean maize yield) on a country or regional level.	The Climate Impact Explorer provides data on a broad range of indicators in which hazard information has been combined with exposure and vulnerability (such as Annual Expected Damage from River Floods and Fraction of Population annually exposed to Crop Failures) on a country or regional level.				
Risk Data Hub	European Commissi	https://drmkc.jrc.ec.europa.eu/risk-data-hub/	Service	Documentation on the web platform, in particular https://drmkc.jrc.ec.europa.eu/risk-data-hub/#/learningspace	The Risk Data Hub is expected to be the point of reference for curated Europe wide risk data, either through hosting relevant datasets or through linking to national datasets. Collecting and producing an inventory of relevant methodologies and datasets will set the bases for qualitative evaluation of science-based approaches on risk assessment and will locate and propose alternative sources. Risk Data Hub offers an open-source methodology for risk assessment as well as an authoritative loss and damage database that can provide indication of what has been lost at European level as a result of disaster events. The Risk Data Hub is a GIS web platform of European wide risk data and methodologies for Disaster Risk Assessment. Currently it contains: (a) Curated European-wide risk data; (b) Composite vulnerability index; (c) Historical loss and damage data from open sources; (d) Data from other sources: Outcomes from EU funded DRM projects; (e) Knowledge library: A learning and training space. Climate-related hazards currently included in the Risk Data Hub include coastal and river flooding.			Risk Data Hub contains data on disaster losses from a variety of sources	Users can combine data on hazard and (types of) assets at four levels of spatial aggregation, ranging from NUTS1 (Country) to Local Administrative Units. Based on data on hazards and assets the platform is able to compute risk components: hazards footprints, exposure of assets and ultimately a risk indicator. Vulnerability is represented for each spatial level through a composite indicator based on four main pillars: social, political, economic and environmental.	Based on data on hazards and assets the platform is able to compute risk components: hazards footprints, exposure of assets and ultimately a risk indicator. The risk indicator is further weighted through a composite vulnerability indicator at each spatial level. All metrics of risk components are conveniently shown as normalized indicators ranging from 0 (the minimum level) and 10 (the maximum level).			
Climate Information Portal	Developed by the Sw	https://climateinformation.org/	Service	Documentation, tutorials etc. on the web platform, in particular https://climateinformation.org/knowledge-base/	The Climate Information Portal provides: (a) Instant summary reports of the climate change for any site on the globe; (b) Easy access to many pre-calculated climate indicators (both weather and water variables), based on state-of-the-art in climate science, of the past, present and future; (c) Climate information guidance.	The platform provides summaries, graphs and tables for a number of climate variables including temperature and precipitation, and derived indicators such as heating degree days, wetness potential and soil moisture. Data are provided for a number of CMIP experiments, individual models as well as the ensemble mean, and a number of different 30-year time periods.	In addition to summaries of climate variables, the platform provides a number of derived indicators relevant to hazards, including minimum and maximum temperature, number of tropical nights, aridity, longest dry spell, annual maximum discharge at different return periods.						
icclim	CERFACS (lead deve	https://github.com/cerfacs-globc/icclim	Tool	https://icclim.readthedocs.io/en/stable/	icclim (Index Calculation for CLIMate) is a Python library to compute climate indices.						Python library to compute climate indices, as defined by European Climate Assessment & Dataset.		
Climate4impact	European project IS-	https://www.climate4impact.eu/c4i-frontend/	Service	Help pages available on the portal	The aim of Climate4impact portal is to enhance the use of climate research data. It is currently under development in the European project IS-ENES3. Climate4impact is connected to theEarth System Grid Federation (ESGF) infrastructureusing ESGF search and thredds catalogs. The portal aims to support climate change impact modellers, impact and adaptation consultants, as well anyone else wanting to use climate change data.	The Climate4impact portal provides a more flexible way to access and manipulate the data provided by the Earth System Grid Federation (ESGF).							
Climpact	World Meteorologica	https://climpact-sci.org/ https://github.com/ARCCSS-extremes/climpact	Tool	https://github.com/ARCCSS-extremes/climpact/blob/master/www/user_guide/Climpact_user_guide.md	R package that calculates indices of daily climate extremes. It can read data for a single site (e.g. a weather station) or for gridded data (e.g. from a climate model). Climpact offers indices derived from daily temperature and precipitation data. These indices are a standardised set originally recommended by the Expert Team on Sector-Specific Climate Indices (ET-SCI) and now under the oversight of the Expert Team on Climate Information for Decision-making. The standardisation of these indices allows researchers to compare results across time periods, regions and source datasets.						Climpact allows users to calculate a large number of indices derived from daily temperature and precipitation data.		
Clisagri	European Commissi	https://github.com/ec-jrc/Clisagri	Tool	https://www.sciencedirect.com/science/article/pii/S2405880720300492	Clisagri is a R package that can be used to calculate a set of dynamic agro-climatic indicators that bring key information to crop producers during different stages of the crop growth. Clisagri quantifies the occurrence of different climatic extremes such as drought, excessive wetness, heat stress and cold stress during sensitive crop growth stages. Input climate data consists of minimum and maximum daily air temperature and daily precipitation cumulates. All the functions can run with observational as well as with predictions and projections.						Clisagri is a R package that can be used to calculate a set of dynamic agro-climatic indicators to quantify the occurrence of different climatic extremes such as drought, excessive wetness, heat stress and cold stress during sensitive crop growth stages. Input climate data consists of minimum and maximum daily air temperature and daily precipitation cumulates.	By combining agro-climate indicators characterizing weather conditions with a dynamic phenological model, Clisagri can highlight the potential for impacts such as losses of crop yield quality and quantity.	
climdex-kit	Eurac Research	https://pypi.org/project/climdex-kit/	Tool	https://www.preprints.org/manuscript/202301.0228/v1	Python package for multi-scenario calculation, publishing, and analysis of indices from 3D time-series of climate projections.						Python package for the parallelized local computation of scenario-aware climate indices starting from input time-series of climate projections. The package comes with an initial set of more than 30 temperature and precipitation-related indices referring to both mean and extreme climate conditions. Climdex-kit also offers functionalities to analyze the data, perform spatial and temporal aggregations and derive maps and graphs.		
climate4R	Univ. de Cantabria	https://github.com/SantanderMetGroup/climate4R	Tool	https://www.sciencedirect.com/science/article/pii/S1364815218303049?via%3Dihub	climate4R is a bundle of R packages for transparent climate data access, post-processing (including data collocation and bias correction / downscaling) and visualization, including a package to compute several climate indices.						climate4R is a bundle of R packages for transparent climate data access, post-processing (including data collocation and bias correction / downscaling) and visualization, including a package to compute several climate indices.		
CLIMADA	ETH Zurich	https://wcr.ethz.ch/research/climada.html	Both	https://climada-python.readthedocs.io/en/stable/	CLIMADA is a Python library that allows to estimate the expected economic damage as a measure of risk today, the incremental increase from economic growth and the further incremental increase due to climate change. The economics of climate adaptation methodology as implemented in CLIMADA provides decision makers with a fact base to understand the impact of weather and climate on their economies, including cost/benefit perspectives on specific risk reduction measures. The model is well suited to provide an open and independent view on physical risk, in line with e.g. the TCFD (Task Force for Climate-related Financial Disclosure), and underpins the Economics of Climate Adaptation (ECA) approach. In addition to the python library, CLIMADA provides global data of major climate-related extreme-weather hazards at high resolution via a data API, namely (i) tropical cyclones, (ii) river flood, (iii) agro drought and (iv) European winter storms, all at 4km spatial resolution. For all hazards, historic and probabilistic event sets exist, for some also under select climate forcing scenarios (RCPs) at distinct time horizons (e.g. 2040).		CLIMADA provides global data of major climate-related extreme-weather hazards at high resolution via a data API, namely (i) tropical cyclones, (ii) river flood, (iii) agro drought and (iv) European winter storms, all at 4km spatial resolution.					CLIMADA is a fully probabilistic climate risk assessment tool. It provides a framework for users to combine exposure, hazard and vulnerability or impact data to calculate risk. Users can create probabilistic impact data from event sets, look at how climate change affects these impacts, and see how effectively adaptation measures can change them. CLIMADA also allows for studies of individual events, historical event sets and forecasts.	
European Climate Assessment & Dataset	European Climate As	https://www.ecad.eu/	Service	Documentation available from the website: https://www.ecad.eu/publications/index.php	The ECA&D project provides information on changes in weather and climate extremes. Apart from access to the underlying data, the website also provides the functionality to plot the results for meteorological stations throughout Europe and the Mediterranean.		Apart from access to the underlying data, the ECA&D website also provides the functionality to plot the results for meteorological stations throughout Europe and the Mediterranean for a range of indicators, including the ETCCDI indicators as well as 50 additional indicators tailored to Europe						
Climate Explorer	KNMI	https://climexp.knmi.nl/start.cgi	Service	Help topics and examples available on the website	The KNMI Climate Explorer is a tool that allows users to explore a large number of climate datasets, including observations, reanalysis and climate projections. Apart from access to the data, users can also create plots and/or maps.	The KNMI explorer provides access to a large number of climate datasets, including observations, reanalysis and climate projections.							

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IMPACT2C web-atlas	European project MI	https://www.atlas.impact2c.eu/en/	Service	Tutorials, storylines and explanation provided on platform	The IMPACT2C web-atlas summarises in maps and texts the impact of global 2°C warming for a number of key sectors: energy, water, tourism, health, agriculture, ecosystems and forestry, as well as coastal and low-lying areas, at both the pan-European level, and for some of the most vulnerable regions of the world. By using a multi-model ensemble of both climate and impact projections ranges of impacts and therefore some of the uncertainty around future climate and climate impact projections have been quantified. For each of the sectors and regions, the IMPACT2C web-atlas tells visual stories of potential impacts for different topics related to a specific sector or region. Results are based on CMIP5 climate model simulations with dynamical downscaling by different regional climate models.		The IMPACT2C web-atlas provides maps and explanatory texts for a number of climate indicators, such as the 95th percentile of precipitation. The data shown are generally based on an ensemble of 5 regional climate simulations for 2ºC (and sometimes 3ºC) global warming.	The IMPACT2C web-atlas also provides maps and storylines on the impacts in a number of sectors, based on impact model simulations. The type and number of models used differs per sector. Results are generally presented as an ensemble mean of the impact models and the driving climate models.	For some sectors (such as forestry), the IMPACT2C web-atlas also provides an assessment of the vulnerability and adaptive capacity for different regions.				