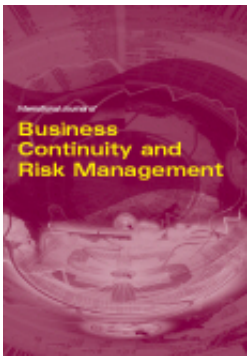

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Principles and guidance on climate risk disclosure for businesses

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Abstract: The present paper discusses how businesses should conduct climate risk disclosures. The work builds on guidance provided by the Task Force on Climate-related Financial Disclosures (TCFD) and related work. Using current risk science knowledge, we question what should be the fundamental principles for defining and using such disclosures when the scope is all types of risks, not only financial. From these principles, we present and discuss some specific guidance on how to formulate the disclosures. Examples are used to illustrate the principles and guidance. Businesses are encouraged to use the figure and guidance provided in the current work when planning and presenting climate change disclosures.

Keywords: climate risk disclosures; climate change risk; risk science; risk management principles.

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1 Introduction

In 2017, the Task Force on Climate-related Financial Disclosures (TCFD) presented a document (TCFD, 2017) to guide organisations and investors in how to report and take into account in their strategy climate-related risks, as well as how these risks should be identified, assessed, and managed. In more detail, the document makes recommendations for how businesses should communicate to the public climate-related risks. The document has been extensively referred to in the literature and has strongly influenced the way organisations and investors conduct climate-related financial disclosures. It is considered to be the 'first step towards an internationally accepted standard in climate-related financial disclosure' (see e.g., CDSB, 2022; SASB, 2016; B20 Financing Growth & Infrastructure Taskforce, 2017).

The TCFD document includes supporting information on climate-related risks and opportunities, scenario analysis, and industry feedback that the Task Force used to develop and then finalise its recommendations. The recommendations provide disclosure recommendations for four thematic areas: governance, strategy, risk management, and metrics and targets. Risk management is to be interpreted as operational risk management. The guidance mainly concerns the processes that should be carried out; for example, it states under governance: "describe the board's overview of climate related risks and opportunities" and under risk management: 'describe the organisation's processes for identifying and assessing climate related risks'. How one should actually assess risk, the TCFD document does not explain, beyond reference to the use of scenario analysis.

The TCFD approach is discussed in NOU (2018). Some foundational risk science issues are looked into and suggestions for modifications of the TCFD framework suggested. The NOU (2018) report also has a financial focus, but the suggested extension is general and relevant for all types of risks that a company faces as a result of climate change. The TCFD work explains the rationale for key features of the guidance recommendations but is not very detailed and does not use generic and current risk science knowledge.

The present paper takes one step back and asks what the fundamental principles should be for supporting such disclosures when the scope is all types of risks of relevance for an enterprise, not only financial. Our sources are TCFD (2017) and related literature, NOU (2018), as well as generic risk science knowledge which provides concepts, principles, approaches, and methods for understanding, assessing, characterising, communicating, and handling risk (SRA 2015, 2017; Aven and Thekdi, 2022). When using risk science knowledge, there is potential for businesses to improve the understanding and communication of climate risk. A main aim of the paper is to present and discuss some specific guidance to businesses on how to formulate disclosures and deliver relevant information, to enable relevant stakeholders to better understand the climate-related risks and their impacts.

The paper is organised as follows. Firstly, in Section 2 we provide a brief review of current work on climate-related risk disclosures. In Section 3, we present the announced fundamental principles that we consider should define and support such climate-related disclosures. From these principles, in Section 4 we give some specific guidance to businesses on how to formulate climate-related disclosures to deliver relevant

information to stakeholders. Section 5 discusses the principles and guidance of the previous sections. Finally, Section 6 provides some conclusions.

2 Review of current work on climate-related risks' disclosures

First, in this section we discuss the TCFD report in more detail, following up the presentation in Section 1. Then we look at related work, including NOU (2018).

2.1 TCFD report

The TCFD work revealed a growing demand for decision-useful, climate-related financial information among investors, creditors, lenders, and other stakeholders. While several climate-related disclosure approaches had emerged to meet the growing demand for such information, the TCFD concluded that there was a need for a standardised framework to promote alignment across existing regimes and different jurisdictions. The framework should provide the interested stakeholders with the metrics and information they need to conduct robust and consistent analyses of the potential financial impacts of climate change.

The TCFD identified four key features for climate-related financial disclosures:

- adoptable by all organisations
- included in financial filings
- designed to solicit decision-useful, forward-looking information on financial impacts
- strong focus on risks and opportunities related to transition to lower-carbon economy.

As mentioned in the introduction section, the TCFD organised its recommendations around four thematic areas: governance, strategy, risk management, and metrics and targets. The recommendations for these four areas are summarised in Table 1.

Under governance, the TCFD recommends organisations to report on the board and management's roles in dealing with climate-related risks and opportunities. According to the TCFD, this information will make it easier for investors and other stakeholders to assess whether the board and management are adequately addressing climate-related issues. Under strategy, the TCFD's recommendation is to report actual and potential effects of climate-related risks and opportunities for business, strategy, and financial planning, where such information is critical. In addition, businesses should include in their reporting a description of how resilient their strategy is under various climate-related scenarios. Furthermore, under risk management, organisations should report how climate-related risk is identified, assessed, and managed. Stakeholders will benefit from this information to shape their understanding of the organisation's climate risk profile and risk management. Finally, under the thematic area of metrics and targets, the TCFD recommends that businesses provide information on the goals, parameters, and methods they use to assess and manage relevant climate-related risks and opportunities, as well as their main climate-related objectives, such as targets for greenhouse gas emissions, water, and energy consumption. Reporting of businesses' goals and methods will make it easier for investors and other stakeholders to compare companies in the same industry.

Table 1 TCFD recommendations and supporting recommended disclosures

Governance	*Strategy*	*Risk management*	*Metrics and targets*
Disclose the organisation's governance around climate-related risks and opportunities	Disclose the actual and potential impacts of climate-related risks and opportunities on the organisation's businesses, strategy, and financial planning where such information is material.	Disclose how the organisation identifies, assesses, and manages climate-related risks	Disclose the metrics and targets used to assess and manage relevant climate-related risks and opportunities where such information is material.
Recommended disclosures	Recommended disclosures	Recommended disclosures	Recommended disclosures
Describe the board's oversight of climate-related risks and opportunities	Describe the climate-related risks and opportunities the organisation has identified over the short, medium, and long-term.	Describe the organisation's processes for identifying and assessing climate-related risks.	Disclose the metrics used by the organisation to assess climate-related risks and opportunities in line with its strategy and risk management process.
Describe management's role in assessing and managing climate-related risks and opportunities	Describe the impact of climate-related risks and opportunities on the organisation's businesses, strategy, and financial planning.	Describe the organisation's processes for managing climate-related risks.	Disclose scope 1, scope 2, and, if appropriate, scope 3 greenhouse gas (GHG) emissions, and the related risks.
	Describe the resilience of the organisation's strategy, taking into consideration different climate-related scenarios including a 2°C or lower scenario.	Describe how processes for identifying, assessing, and managing climate-related risks are integrated into the organisation's overall risk management.	Describe the targets used by the organisation to manage climate-related risks and opportunities and performance against targets.

Source: TCFD (2017)

Table 2 TCFD principles for effective disclosures

	Principles for effective disclosures
1	Disclosures should represent relevant information
2	Disclosures should be specific and complete
3	Disclosures should be clear, balanced, and understandable
4	Disclosures should be consistent over time
5	Disclosures should be comparable among companies within a sector, industry, or portfolio
6	Disclosures should be reliable, verifiable, and objective
7	Disclosures should be provided on a timely basis

Source: TCFD (2017)

In addition, the TCFD developed seven principles for effective disclosures, to help guide current and future developments in climate-related financial reporting; see Table 2. The TCFD encourages organisations to keep these principles in mind as they create their climate-related financial disclosures. The principles are intended to help organisations understand the connections between climate-related concerns and their governance, strategy, risk management, metrics and targets. The seven principles are shown in Table 2.

Furthermore, according to the TCFD, all organisations exposed to climate-related risks should consider using scenario analysis to help inform their strategic and financial planning processes and disclosing how resilient their strategies are to a range of plausible climate-related scenarios.

In the next section, we discuss the NOU (2018) work, as well as their suggestions for modifications of the TCFD framework.

2.2 Norway's climate risk commission report (NOU, 2018)

As mentioned in the introduction, the NOU (2018) report has a financial focus, but the suggested extension of the recommended TCFD climate-related disclosure approach is general and relevant for all types of risks that a company faces because of climate change. The NOU (2018) suggestions are summarised in Table 3.

The NOU (2018) recommendations follow the basic ideas of the TCFD (2017), but there are some differences, which relate to both main theme headings and content. As for the theme headings, in NOU (2018), the TCFD thematic areas of:

1 governance

2 strategy

3 risk management

4 metrics and targets are replaced by

- governance
- risk description – objectives and strategies
- risk management process
- risk metrics.

The changes are made to obtain a better match between theme heading and its content. For example, theme 2) is about risk description or characterisation in relation to strategies but also other business functions and goals.

The TCFD (2017) report does not define risk and distinguishes between risk and opportunity. In accordance with common generic risk science terminology (SRA, 2015), this distinction actually reflects hazards/threats and opportunities. However, it is often difficult to make such a distinction. That an event (source/factor) represents a hazard/threat means that one has a strong belief that the outcome will be negative. Similarly, one would say that an event (source/factor) represents an opportunity if one has a strong belief that the outcome will be positive. In the TCFD report, the risk factor,

technology, is classified as a hazard/threat but can equally be seen as an opportunity. In NOU (2018) and in the present work, this problem is avoided by adopting risk science terminology, as in SRA (2015), where a distinction is made between events (hazards/threats/opportunities) and risk, as will be explained in more detail in Section 3.

Table 3 Norway's Climate Risk Commission's recommendations on climate risk disclosures for businesses, adjusted from TCFD report

Governance	*Risk description – objectives and strategies*	*Risk management process*	*Risk metrics*
Description of the overall framework and main principles for the management and governance of climate-related risks	Description of climate-related risks wrt to key organisational objectives and strategies	Description of how climate-related risks are reflected in the risk management process.	Disclose key climate-related risk indicators and metrics.
a Describe the board's oversight of the climate-related risks and the overall framework and principles for how they are managed	a Describe the climate-related threats, opportunities and related risks in the long, medium and short-term wrt key organisational objectives and strategies	a Describe how climate-related risks are identified, assessed and managed	a Disclose key climate-related risk indicators and metrics on a national level
b Describe the management's role in assessing and managing climate-related risks	b Describe how climate-related risks influence the company's risks	b Describe how resilience is assessed and managed in relevant scenarios and threats	
	c Describe the resilience of organisational objectives, strategies and functions in relevant scenarios and threats	c Describe how the climate-related risk management is integrated with the overall risk management and governance	

Source: NOU (2018)

For the governance theme, the NOU (2018) has extended the content to highlight the overall framework and main principles for the management and governance of climate-related risks. For the risk description – objectives and strategies theme, the NOU (2018) formulations are more general, with a less finance-focused approach compared to the TCFD report. As for the risk management process theme, the NOU (2018) specifically highlights how resilience is assessed and managed under different scenarios/threats. Finally, for the risk metrics theme, the NOU (2018) limited the disclosure to key climate-related risk indicators and metrics, as climate change risk characterisations in general are covered by the risk description – objectives and strategies theme.

2.3 Other related works on climate risk disclosures

In this section, we discuss briefly other related frameworks and guidance on climate risk disclosures: more specifically, work by the Climate Disclosure Standard Board (CDSB, 2022) and the Sustainability Accounting Standard Board (SASB, 2016).

2.3.1 The CDSB and SASB frameworks

The first CDSB framework was introduced in 2010, and its focus is on risks to and opportunities for an organisation's strategy, financial performance, and condition, due to climate change. The CDSB framework also provides guidance to regulators, policymakers, and international standard setters on the various alternatives for introducing, developing, or establishing environmental and social reporting compliance requirements (CDSB, 2022). The purpose of the CDSB framework is to encourage the standardisation of reporting environmental and social information, as well as to assist organisations in preparing and presenting clear, concise, and comparable information that connects the environmental and social performance of an organisation with its overall strategy, outcomes, and potential. Likewise, the SASB framework identifies the subset of environmental, social, and governance issues that are most critical to business and financial performance in various industries (SASB, 2016). The purpose is to assist organisations in disclosing financially significant sustainability information to their investors. The framework tries to connect climate change and financial outcomes to help decision-makers identify and better understand climate-related risks and opportunities.

Like the TCFD recommendations on climate-related financial disclosures, the CDSB and SASB frameworks have a financial focus but can be used in a variety of reporting contexts, such as annual reports, financial filings, and sustainability reports. The CDSB and SASB have demonstrated a significant effort to align their work with the TCFD recommendations. As shown in Appendix, the similarities in recommended principles and metrics are many. There are, however, some differences. For example, the TCFD highlights balance and objectivity in the disclosures, whereas the CDSB stresses the faithful representation of the disclosure and the SASB points to metrics being fair and neutral (free from biases). These differences could be considered to reflect basically the same ideas, but the emphasis of different words could also mean that there are nuances in perspectives and thinking. Any characterisation of risk is a judgment, and as such it is subjective or inter-subjective – not fully objective or neutral. Analysis and science typically allow for many explanations of the data observed, and it is not always straightforward to make fair and balanced selections, interpretations, and representations of the data. Yet it should be a goal to seek that disclosures are produced according to some quality goals and standards. We will discuss this in more detail in Sections 3 and 4.

3 Fundamental principles

Table 4 presents the fundamental principles that we consider should define and support climate-related risk disclosures. Some of these principles are based on contemporary risk science knowledge, and in particular (Aven et al., 2022), whereas others are more generic criteria for proper disclosures.

Table 4 Overview of fundamental principles that climate-risk disclosures should be based on

Principles
P1
The risk disclosures are based on current risk science knowledge, related to concepts, principles, approaches, and methods addressing: 1 The climate-related risks that the enterprise faces Aspects like these need to be reflected: • All essential risk elements: events, consequences/objectives, barriers, uncertainties, likelihood, knowledge, assumptions, and strength of knowledge. • Uncertainty is a key aspect of risk. • An important source of uncertainty is potential surprises and the unforeseen. • High risks, also considering weaknesses in knowledge and critical assumptions. 2 The risk analysis conducted to understand, assess, characterise, communicate, and handle the climate-related risks Risk analysis here is used in a wide sense, in line with a long tradition of the Society for Risk Analysis (SRA), to include risk assessment, risk characterisation, risk communication, risk handling (risk management, risk governance and policy relating to risk). The risk analysis reflects: • Generic management and governance knowledge, for example: Principles derived from contemporary management science and its practice, covering for example principles stated in ISO 31000 (integrated, structured and comprehensive, customised, inclusive, dynamic, best available information, human and cultural factors, and continual improvement), openness, transparency, etc. and statements like: Put the right people in the right place with the right knowledge, incentives, and resources; clearly define leadership and responsibilities; share knowledge and experience across organisations. • More specific risk analysis and risk science knowledge, for example: a Three major strategies are needed for managing risk: risk-informed, using risk assessments, cautionary/precautionary and discursive strategies. The cautionary/precautionary strategy is also referred to as a strategy of robustness and resilience. Robustness and resilience are fundamental strategies to deal with the uncertainties. In most cases, the appropriate strategy would be a mixture of these three strategies. In addition, codes and standards are used when the activity considered is well known and the uncertainties are small. b Prevention of the occurrence of the potential disaster/crises-initiating hazards/threats (risk source) is a major priority. c Taking risks or increasing risks to take advantage of an opportunity. d 'Management review and judgements' are needed for making appropriate risk management decisions.
P2
The climate-related risk disclosures meet generic principles for disclosures, such as being justified, clear and understandable, complete, balanced, and provided on a timely basis.

We consider principle P1 to be a basic principle that organisations should build their climate risk disclosures on. The organisations should use contemporary scientific risk science knowledge to deliver high-quality disclosures. There can be practical benefits of using standards in an organisation's daily work, as concepts, approaches, methods, and

models are broadly recognised and can be referred to globally. However, standards need to be critically reviewed, as they are not in general based on scientific processes, with justifications and peer-reviews, which allow for and stimulate open discussion in the scientific community; see for example, Aven and Ylönen (2019). There can be a significant gap between standards and current risk science knowledge. Examples will be provided below.

When characterising climate-related risks, all essential risk elements, such as events, consequences, barriers, uncertainties, likelihood, knowledge, assumptions, and strength of knowledge, need to be included. Risk science provides clarity on and foundations for what these concepts mean and how they are related. A prudent risk characterisation is, for example, clear on the importance of expressing the knowledge and judgements of the strength of this knowledge (SoK), supporting the likelihood assessments. Also, considerations of potential surprises relative to this knowledge need to be addressed (Paté-Cornell, 2012; Aven, 2015). This is done by highlighting SoK judgements and in particular critical assumptions, as well as introducing specific procedures to identify, for example, unknown knowns (the analysts do not have the knowledge, but others do). Current risk management standards are not fully updated on these important aspects of risk characterisations (Aven and Ylönen, 2019). Risk characterisations are commonly based on probabilities and expected values, failing to properly reflect uncertainties and knowledge aspects. Using expected values could seriously misguide decision-makers (Haimes, 2015; Paté-Cornell, 1999; Aven, 2012), as they do not provide information about the spectre of potential consequences and losses or the strength of the knowledge supporting the underlying probabilities. A probability judgment could be based on assumptions that could be wrong. Risk associated with deviations from assumptions should be addressed in the risk disclosures (Aven, 2017). Standard risk matrices based on events with assignments of associated consequences and probability should not be used to describe risk, as neither the spectre of consequences nor the strength of knowledge is properly reflected. Instead, characterisations based on fixed categories of consequences should be used, with associated probabilities and strength of knowledge judgements (Aven, 2017).

When characterising the risks, the influence that climate change and climate change risk has on the company's businesses, strategies, and objectives is addressed. Only main risk contributors are highlighted, giving due attention to situations characterised by large uncertainties and weak knowledge. Whereas principle P1i: focuses on the climate-related risks that the enterprise faces, P1ii: is concerned with the risk analysis (interpreted broadly as mentioned in Table 4 to cover understanding, assessing, characterising, communicating, and handling risk) and, particularly, the risk management.

The disclosures should be based on current risk science knowledge on how the risk analysis (risk management) is conducted. This includes both generic management and governance knowledge and more specific risk analysis and risk science knowledge. Generic management and governance refer to principles from contemporary management science and its practice, including principles such as integrated, continual improvement; transparency, etc. see Table 4. The idea is that, in general, risk management is an integral part of an organisation's management and governance. The disclosures should characterise the adopted generic management and governance used to analyse and manage the climate-related risks.

When it comes to the more specific risk science knowledge, the disclosures should characterise the main concepts, principles, and approaches, such as those highlighted in

Table 4. A core principle expresses that the risk should be handled by a mixture of three main strategies: risk-informed using risk assessments, cautionary/precautionary (highlighting robustness/resilience), and discursive strategies. Robustness and resilience are fundamental strategies to deal with the uncertainties. In addition, codes and standards are used when the activity considered is well known and the uncertainties are small (SRA, 2017; Aven and Thekdi, 2022).

Another principle states that prevention of the occurrence of the potential disaster/crises-initiating hazards/threats (risk source) is a major priority. In general, prevention of this type is more attractive than consequence-reducing measures. Reducing the effects of a disease is important, but it is best to avoid the disease if possible.

Business activities are equally about taking risk as reducing risk. In pursuit of values or interests, organisations need to take risks. How is the risk taking handled and balanced against other concerns and, particularly, safety and security issues? The disclosures need to explain this. They also need to describe how 'management review and judgements' (MRJ) are used for making appropriate risk management decisions. Formally, we define MRJ as the process of summarising, interpreting, and deliberating over the results of risk assessments and other assessments, as well as of other relevant issues (not covered by the assessments), in order to make a decision (Aven and Thekdi, 2022). The MRJ is justified, as any assessment has limitations and there are other concerns than those addressed by the assessment. The MRJ acknowledges the importance of management making decisions, informed by assessments and analysts.

Principle P2 reflects the idea that climate-related disclosures should meet and be in line with generic principles for disclosures, such as those highlighted by TCFD (2017), NOU (2018) and other reporting standards, such as the CDSB and SASB frameworks (see Section 2). Although there are some differences among these references, there is considerable overlap, highlighting disclosures being justified, clear and understandable, complete, balanced, and provided on a timely basis. There should be little discussion about the rationale of these principles. The disclosures should be justified, which means that arguments are provided. As a consequence, the disclosures should also be reliable (trusted). Furthermore, the disclosures should be clear and understandable, ensuring correct interpretations and avoiding misunderstandings and misinformation. They should be complete, covering all relevant issues, balanced, meaning reflecting different perspectives and views, and neutral, in the sense of being impartial, not supporting or helping a particular side in a conflict, disagreement, etc. In this sense, it can be argued that the disclosures are also objective, but we avoid this term, as objectivity can also be understood as the antonym of subjectivity, and any risk disclosure is to some degree subjective, reflecting judgements made by the assessors. Finally, the disclosures should be provided on a timely basis, which means produced when needed, to support relevant decision-making.

4 Specific guidance

In this section, from the fundamental principles presented in Section 3, we will provide some specific guidance to businesses on how to formulate climate-related disclosures to deliver relevant information to stakeholders. This guidance will relate to the thematic

areas governance, risk description, risk management process, and risk metrics, inspired by NOU (2018); see Table 5.

Table 5 Integration of fundamental principles into recommendations on climate risk disclosures for businesses

Governance	*Risk description – objectives and strategies*	*Risk management process*	*Risk metrics*
Description of the overall framework and main principles for the management and governance of climate-related risks	Description of climate-related risks wrt to key organisational objectives and strategies	Description of how climate-related risks are reflected in the risk management process	Disclose key climate-related risk indicators and metrics
1 Describe the board's oversight of the climate-related risks and the overall framework and principles for how they are managed.	1 Describe the climate-related threats, opportunities, and related risks in the long, medium, and short-term wrt key organisational objectives and strategies.	1 Describe how climate-related risks are identified, assessed, and managed	1 Disclose key climate-related risk indicators and metrics
Fundamental principles (Table 4)	Fundamental principles (Table 4)	Fundamental principles (Table 4)	Fundamental principles (Table 4)
P1ii, P1ii(a), P2	P1i: climate-related risks that enterprise faces, P2	P1ii: more specific risk analysis and risk science knowledge, P2	P1ii: risk analysis conducted P1ii (b), (d), P2
2 Describe the management's role in assessing and managing climate-related risks.	2 Describe the resilience of organisational objectives, strategies, and functions in relevant scenarios and threats.	2 Describe how resilience is assessed and managed in relevant scenarios and threats.	
Fundamental principles (Table 4)	Fundamental principles (Table 4)	Fundamental principles (Table 4)	
P1ii, P1ii (d), P2	P1ii, P2	P1ii: more specific risk analysis and risk science knowledge P2	
		3 Describe how the climate-related risk management is integrated with the overall risk management and governance.	
		Fundamental principles (Table 4)	
		P1ii, P2	

Source: Adjusted from NOU (2018)

Table 5 integrates the disclosure recommendations under each thematic area with the fundamental principles that organisations should build their climate risk disclosures on to provide relevant information to investors and other stakeholders. Principle P2 is relevant to all elements.

Under the governance theme, the recommendations concern reporting on the board and management's roles in dealing with climate-related risks. The two recommended elements (1 and 2) are the same as those recommended by the TCFD (2017) and NOU (2018). Both elements should be guided by the fundamental principles P1ii, covering both generic management and governance knowledge and the more specific risk analysis and risk science knowledge (see Table 4). For the more specific risk analysis and risk science knowledge in relation to 1, the reporting should, in particular, be clear on the overall ideas and strategies adopted to handle the risk (item a in Table 4), for example on the weight to be given to robustness/resilience to meet the risk. For element 2, *describe the management's role in assessing and managing climate-related risks*, principle P1ii (d) on the need for MRJ is highlighted. The idea and motivation of the MRJ is explained in Section 3. The disclosures should explain which factors and concerns to consider in the decision-making process and how the process is to be carried out.

Under the risk description – objectives and strategies theme, the recommendations concern the reporting about climate-related risks with respect to key organisational objectives and strategies. The recommended elements are the same as those recommended by the TCFD (2017) and NOU (2018), with element 1 covering the two first mentioned elements of the TCFD (2017) and NOU (2018) categorisations, i.e., both (a) and (b) of NOU (2018). The first recommended element 1 *describe the climate-related threats, opportunities, and related risks in the long, medium, and short-term with relation to key organisational objectives and strategies*, aims at ensuring that climate-related risks are properly characterised, reflecting the company's businesses, strategies, and objectives. This element also covers how the climate-related risks influence the company's risks. This element 1 is guided by principle P1i, which focuses on the climate-related risks that the enterprise faces, including all the essential risk elements, such as events, consequences, barriers, uncertainties, likelihood, knowledge, assumptions, and strength of knowledge. Section 3 points to specific knowledge and guidance for how to conduct such characterisations. A key point mentioned in Section 3 is that, in addition to probability assignments, the characterisations should address the knowledge that these assignments are based on and its strength. Standard risk matrices should not be used.

Element 2 *describe the resilience of organisational objectives, strategies and functions in relevant scenarios and threats, should follow principle* P1ii and highlight means and measures that contribute to ensuring such resilience, including (Renn, 2008; Aven and Thekdi, 2022):

- containment (for example, avoiding a fire spread to other areas)
- redundancy (there is a back-up in case of the failure of a component)
- strengthening of the 'immune system'
- diversification (mix completely different types of strategies, for example investments)

- design of systems with flexible response options (in case of some change, disturbance, or stress, avoid a rigid response with no adaptation to the specific situation considered)
- the improvement of conditions for emergency management

The risk management process theme concerns organisations' reporting on how climate-related risks are reflected in the risk management process. The recommended elements are the same as those recommended by the TCFD (2017) and NOU (2018), covering relevant information on how climate-related risk is managed (elements 1 and 3) and, as in NOU (2018), specifically highlighting how resilience is assessed and managed (element 2). Both recommended elements 1 and 3 should be guided by principle P1ii and disclose how the risk assessment, risk characterisation, risk communication, and risk handling are conducted, in line with 'more specific risk analysis and risk science knowledge' but also the 'generic management and governance knowledge', especially for element 3; refer to Section 3 and Table 4. Element 2 can be viewed as a special case of element 1, highlighting resilience. The key is to describe how resilience is assessed and managed, for example on meeting potential surprises and the unforeseen.

Finally, the Risk metrics theme concerns the reporting of key climate-related risk indicators and metrics. The recommended disclosures are inspired by NOU (2018), which limits the disclosures only to key climate-related risk indicators and metrics, differentiating the recommended disclosures to those of the TCFD (2017), which recommends businesses to provide information, under this theme, about the goals, parameters, and methods they use to assess and manage relevant climate-related risks and opportunities, as well as their main climate-related objectives. The recommended element 1 under this theme should be guided by principle P1ii, providing information about the risk analysis conducted for the key climate-related risk indicators and metrics, with special weight on items (b) *prevention of the occurrence of the potential disaster/ crises-initiating hazards/threats (risk source) is a major priority*, to identify the risk indicators of an organisation after considering all prevention measures that have been taken, and item (d) on the need for MRJ, giving information on how the process to decide on risk indicators and metrics has been carried out.

5 Discussion

In this work, we have discussed which fundamental principles should form the basis for business climate risk disclosures, when the scope is all types of risks, not only financial. The work suggests two fundamental principles (see Table 4): P1 stresses that the risk disclosures are based on current risk science knowledge, related to concepts, principles, approaches, and methods, and P2 highlights generic principles for disclosures, such as being justified, clear and understandable, complete, balanced, and provided on a timely basis Based on these principles, we present some recommendations on climate risk disclosures for businesses, related to the thematic areas, governance, risk description, risk management process and risk metrics.

The work can be viewed as providing a risk science foundation for the TCFD (2017) guidance and the related guidance document (NOU, 2018). These guidance documents express some general statements about the climate change risk disclosures but are not explicit on which risk science principles, approaches, and methods to apply. There is a

gap between these general statements and how to form the concrete disclosures. The present paper seeks to fill that gap. It provides knowledge on how to describe the risks using contemporary risk science. This means, for example, that risk should not be characterised only by scenarios and by standard risk matrices, as commonly seen in practice. Alternatives exist, as discussed in Section 3. The basic idea is that the disclosures should be based on risk science knowledge, rather than applying standards. Current risk assessment and management standards need to be critically reviewed, as the standards are not founded on scientific justification processes; see for example discussion about ISO 31000 in Aven and Ylönen (2019).

Building on risk science knowledge is a continuous striving for identifying and using the best available knowledge concerning how to present and conduct the risk disclosures. In applications, there will always be a need to balance the search for this knowledge with what is feasible and practical. It can be a challenge to clarify what is the most up-to-date knowledge; standards can help simplify the analysis and characterisation processes. Lack of a standardised approach can lead to a variety of forms of risk disclosures, which is unfortunate for the risk communication. A standardised approach can contribute, by ensuring the alignment and comparability of climate risk-related disclosures in different settings. Nonetheless, there should also be a critical review process, contrasting the standards with current risk science knowledge. Maintaining the use of traditional risk matrices, for example, could contribute to alignments and recognisability but could lead to poor risk understanding and seriously mislead decision-makers.

6 Conclusions

This paper is built on the TCFD (2017) guidance on climate-related financial disclosures and the guidance document NOU (2018), as well as other related works. It provides fundamental principles and guidance for how to conduct climate risk-related disclosures. The work encourages businesses to use contemporary risk science knowledge for this purpose, instead of solely applying risk management standards that commonly lack scientific justification and are not fully updated on recent risk science advances.

Defining and using the best risk science knowledge can be challenging for businesses. Table 5, with supporting text in Sections 3 and 4, provides some specific guidance under the different thematic areas, governance, risk description, risk management process and Risk metrics. Businesses are encouraged to use this figure and guidance when planning and presenting climate change disclosures. Here are some key points:

- Climate change risk is risk due to climate change and should be characterised by highlighting severe consequence scenarios and events, related likelihoods, and supporting knowledge and knowledge strength. Standard risk matrices based on events with assignments of associated consequences and probability should not be used to describe risk.
- Potential surprises relative to this knowledge need to be addressed, for example by highlighting strength of knowledge judgements and, particularly, critical assumptions, as well as introducing specific procedures to identify, for example, unknown known.

- Scenario analysis is a useful tool but needs to be seen in relation to plausibility (which means considering likelihood and knowledge strength, Glette-Iversen et al., 2022).
- Robustness and resilience need to be given weight, to meet hazardous situations and other types of events, particularly surprising types of events, should they occur. Key robustness and resilience aspects include containment, redundancy, strengthening of the 'immune system', diversification, etc. (see Section 4).

Further work is needed to test the recommended schemes in practical cases.

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Appendix

Table 6 Alignment of CDSB framework and SASB metrics with TCFD principles

TCFD	*CDSB*	*SASB*
Principles for Effective Disclosures	Guiding Principles and Reporting Requirements	SASB Criteria for Accounting Metrics designed to ensure the delivery of material, decision-useful information to the capital markets in a way that is cost-effective.
Intended to 'help achieve high-quality and decision-useful disclosures that enable users to understand the impact of climate change on organisations'.	Principles [P] designed to ensure that environmental information in mainstream reports that are useful to investors is correct and complete and supports assurance activities. Requirements [REQ] designed to encourage standardised disclosure of environmental information that complements and supplements other information in mainstream reports.	
Disclosures should represent relevant information	[P1] Environmental information shall be prepared, applying the principles of relevance and materiality	SASB metrics are applicable to most companies in the industry
Disclosures should be clear, balanced, and understandable	[P2] Disclosures shall be faithfully represented	SASB metrics are complete, capturing a fair representation of performance
Disclosures should be clear, balanced, and understandable	[P5] Disclosures shall be clear and understandable [P3] Disclosures shall relate to other information in the mainstream report	SASB metrics are useful to decision-makers and neutral (free from bias)
Disclosures should be consistent over time	[P4] Disclosures shall be consistent and comparable	SASB metrics are comparable over time
Disclosures should be comparable among companies within a sector, industry, or portfolio	[P4] Disclosures shall be consistent and comparable	SASB metrics are comparable across peers within an industry
Disclosures should be reliable, verifiable, and objective	[P6] Disclosures shall be verifiable	SASB metrics are verifiable
Disclosures should be provided on a timely basis	[REQ 9] Disclosures shall be provided on an annual basis	SASB metrics are useful to decision-makers

Source: SASB (2017)