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The climate resilience cycle: Using scenario analysis to inform climate-resilient business strategies

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Abstract

Climate change affects the business environment, and companies need future-oriented information to build climate resilience. To this end, companies are encouraged to conduct climate change scenario analysis, as recommended by the Task Force on Climate-Related Financial Disclosures (TCFD). However, companies' actual adoption of this practice is limited as they lack a straightforward scenario analysis implementation process and relevant climate change knowledge. This research develops an implementation process by clarifying the concept of resilience into a stability and a change domain and by specifying the type of focal questions for these two domains. Next, a scenario typology guides the selection of reference scenarios, and two standard scenario methods guide the tailoring of these reference scenarios to company-specific scenarios. By structuring this process in five steps and specifying input and process requirements, we provide an implementation process called the climate resilience cycle. By applying the cycle in transdisciplinary teams of climate change experts and company staff with knowledge about the company value chain, we bring in the required knowledge. To become climate resilient, the outcomes of the climate resilience cycle need to be integrated in the business planning and the overall company strategy. We argue that implementing the cycle as a new company routine contributes to the development of dynamic capabilities like sensing, seizing and transforming, which have been proven to be essential for integrating sustainability in company strategies. Once begun, we show how the cycle can become part of a company strategy process.

KEYWORDS

business strategy, climate change, resilience, risks and opportunities, scenario analysis, sustainable development, TCFD

1 | INTRODUCTION

Over half of the world's countries have set net-zero 2050 targets, and one-fifth of the world's largest companies formulated similar aspirations as part of the United Nation's Race to Net Zero Coalition (UNFCCC, 2021). The political, technical and societal transitions to realise these targets will transform value chains,[1] which imposes risks and opportunities for companies. Examples are the shift to electric mobility, which upsets the fossil fuel value chain and establishes a new value chain for car batteries and charging infrastructure, resulting in risks and opportunities for car and oil companies. Companies also experience risks and opportunities of physical climate change impacts,

as acute weather conditions may disrupt operations and supply chains, whereas chronic changes in climate patterns will have socio-economic impacts. That these risks are real has been communicated over decades: among others by Al Gore to spread his message of *an inconvenient truth*[2] to the business community.[3] Although companies have been aware of these risks over a long period, the vigour to take action and get more grip on these risks has been latent following companies' wait-and-see attitude (Slawinski et al., 2017; Todaro et al., 2021).[4] The awareness and urgency for action increased since the recognition of the financial risks of inaction and the recommendations of the Task Force on Climate-related Financial Disclosures (TCFD, 2017) to disclose climate-related risks and opportunities. Several jurisdictions use the TCFD framework to develop regulations for mandatory climate-related disclosures, and it is the proposed reference for a new global accountancy standard (IFRS, 2021). An essential recommendation of the TCFD framework is to undertake climate-related scenario analysis to assess companies' sensitivity and resilience to climate change. However, the actual application of climate change scenario analysis is limited to the largest companies, of whom approximately 10% have done such an analysis (TCFD, 2020). Hence, stakeholders are poorly informed about the resilience of company strategies in, for example, a 2°C scenario (Demaria & Rigot, 2021).

Companies indicate that they experience scenario analysis as a complex and daunting task. Multiple factors contribute hereto, like the lack of a straightforward implementation process, lack of knowledge to perform the analysis and a lack of company relevant climate change data and tools (TCFD, 2021). To reduce these hurdles and to accelerate the uptake of scenario analysis, this research addresses the questions companies face when they start to conduct scenario analysis to inform decision making about climate resiliency. These questions are as follows: What is climate resiliency, and how to achieve it? And, what is climate change scenario analysis, and how to apply it? This research focuses specifically on mid-sized companies, although the research questions and results might also be relevant for small and large companies. This research uses two pilot case studies at two mid-sized companies to capture learnings on conducting scenario analysis. By combining these learnings with literature on climate resilience and scenario analysis, we developed a structured process that we call the climate resilience cycle. By specification of the input, process and output requirements, we operationalised the climate resilience cycle for practical implementation by companies. The research was performed by transdisciplinary teams of staff members of the companies and scientific researchers of the Copernicus Institute for Sustainable Development. Through this approach, this research implements the suggestions to develop corporate capacity and abilities to undertake climate scenario analysis through academic research (O'Dwyer & Unerman, 2020).

Our main findings of this research are the need for a clear distinction in climate resilience by increasing companies' robustness ('stability domain') and transforming the business model or value chain towards climate change ('change domain'). The two different domains have different information needs and result in differences in the design of the scenario analysis process. We consider this distinction in purpose and the resulting design of the scenario analysis process a helpful addition to the TCFD guidance on scenario analysis. Other findings of this research address the use of transdisciplinary teams to organise the knowledge input, the involvement of board-level management in initiating and following up of the scenario analysis process and results, and the need to implement the climate resilience cycle as a new routine[5] within companies. This routine builds the capacity for tailoring global climate change scenarios to company-specific scenarios while overcoming biases and missing out impacts and integrating climate resilience measures into the overall company strategy.

2 | THEORETICAL FRAMEWORK

2.1 | The TCFD framework

The TCFD disclosure framework is designed to provide decision-useful and forward-looking information on the material financial impacts of climate-related risks and opportunities to enable financial markets to price-in climate risks and opportunities in capital allocations. The framework has the potential to become a 'new norm'[6] for climate disclosures and is built upon four core elements: governance, strategy, risk management and metrics and targets. The 'strategy' element requires companies to describe the resilience of the organisation. The TCFD describes the concept of climate resilience as 'organisations developing adaptive capacity to respond to climate change to better manage the associated risks and seize opportunities' and makes a distinction into two categories: (1) risks related to the transition to a lower-carbon economy and (2) risks related to the physical impacts of climate change. Opportunities include developing new products, designing new production processes, improving efficiency and access to new markets. The TCFD recommends companies to perform scenario analysis to explore and develop an understanding how physical and transition risks and opportunities of climate change might plausibly impact the business over time and to identify plausible company responses. The TCFD argues that scenario analysis increases the understanding of climate change dynamics and enables companies to explore plausible futures to support better decision making. As mentioned before, the actual application of climate change scenario analysis by companies is however limited (Demaria & Rigot, 2021; TCFD, 2020).

2.2 | The concept of climate resilience

Resilience comes from the Latin word 'resilio' which means 'to rebound, spring back' and organisational resilience initially referred to the stability of organisations by absorbing shocks or to 'bounce back' after a disturbance. Over time, the concept of organisational resilience has evolved among researchers and practitioners into different views: In addition to the original 'rebound' or 'response', it also includes adapting the business model and value chain (Hillmann & Guenther, 2021). We distinguish between these two domains when

considering climate resilience of companies and refer to them in this article as the 'stability domain' and the 'change domain' (Figure 1). In a business context, the stability domain aims for robust financial performance under different climate conditions. It encompasses all actions to maintain business functions, minimise recovery time and retain access to resources in case of disruptions. This robustness is relevant for current assets and business processes, and the corresponding timeline of interest is the economic lifetime of these assets and operations (e.g., 5 years for supply chain management or 25 years for factories). The relevant company activities involve planning and control processes like risk management and contingency planning. The change domain encompasses all actions related to strategic planning like redesigning the business model or value chain, investing and decommissioning factories, or developing new competencies. The corresponding timelines for such transformations run from 10 years (e.g., new factory planning and development) to more than 30 years (e.g., new technology development and market entry). The relevant company activities towards resilience in the change domain include research and development (R&D), innovation or developing knowledge about new markets or technologies. Resilience in the two domains is complementary and can be considered consecutively. By definition, climate change is not static, and company responses to deal with climate change will change over time.

Climate resilient companies develop robustness towards physical climate change impacts (stability domain) and transform their business model or value chain towards a net-zero economy (change domain). The paradoxical properties of stability and change need to be balanced in resilient organisations (Song, 2021).

The type of climate impacts, the organisational responses and the company capabilities differ in the two domains, and therefore the knowledge needs. Thus, the scenario analysis process needs to fit these different needs. Scenario analysis for the two resilience domains can be performed consecutively and is complementary.

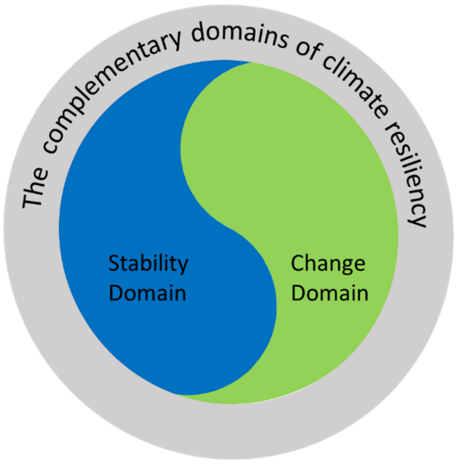

FIGURE 1 Company resilience to climate change

2.3 | The focal question as an anchor for the scenario analysis process

Starting with scenario analysis can be overwhelming for companies due to the wide range of climate change information and the character of climate change being a global, complex and wicked problem.[7] To get a grip on these complexities, theories on the design process of scenario analysis suggest starting with the formulation of the focal question (Cairns & Wright, 2017; Konno et al., 2014). In this research, we use this suggestion to clarify and grasp the concept of climate resilience. More specifically, we postulate that the focal question should address the variables that define organisational resilience (Duchek, 2020; Sanderson et al., 2019). Application of these variables to climate change results in the following variables to scope the focal question:

1. Climate resilience domain: stability or change;
2. Type of impact: specifying physical or transitional climate change impacts;
3. Organisational scope: production location, business unit, business model, or value chain;
4. Time horizon: period for which company resilience matter, depending on the economic lifetime of assets in scope and chosen climate resilience domain;

Focal questions in the stability domain take the form of 'what-if' questions, whereas in the change domain, 'how-to' type of questions are more appropriate. Examples of focal questions might be as follows:

- What if the temperature increases above 2° in the next 5 years in the region(s) where we source critical material X?
- What if a carbon price of €150 per ton is implemented in Europe in 2030 in terms of the financial robustness of business unit A?
- How can we transform our value chain in response to customer demand for plant-based protein in 2030?
- How can we redesign our production processes towards net-zero emissions in 2040?

The formulation of the focal question(s) articulates the information which is needed from the scenario analysis. The scoping along the four variables serves as an anchor.

2.4 | Theory on scenario methodologies to inform company decision making

Scenario analysis is widely applied within companies: It has high practical relevance; however, it has a relatively low rigor of theory and suffers from methodological confusion (Balarezo & Nielsen, 2017). A systematic review of the evolution of 50-year theoretical and practical application of foresight methods, including scenario analysis within companies, shows that the research field has contributed to the

adaptive performance of companies (Gordon et al., 2020). The review reports a correlation between the maturity of foresight practices within companies and company performances; however, there is no evidence that scenario analysis results in 'great strategies that are unique, creative, or distant from the industry status quo' nor direct evidence that scenario analysis improves long-term business performance (Wiebe et al., 2018). Also in the sustainability domain, scenario analysis has shown its practical relevance to inform company decisions (Villamil et al., 2021) with high relevance to assessing and managing climate-related risks and opportunities (Hillmann et al., 2018; Linnenluecke & Griffiths, 2012). However, climate change scenario analysis by non-financial companies is relatively recent with limited best practices (TCFD Status Reports, 2020, 2021). A further complication is that there is limited research on organisational and strategic management of companies in response to climate change (Canevari-Luzardo et al., 2020). To deal with the relatively low rigor of theoretical guidance for effective methodological choices for scenario analysis, we suggest to start with tested and ready available reference scenarios which describe plausible future states of the variables as defined in the focal question.

2.4.1 | Use of reference scenarios

Reference scenarios are provided by (inter)national agencies and research institutes and describe plausible future states of physical climate conditions and transitional pathways following plausible technical, political and socio-economic developments. Appendix A provides background information about suitable reference scenarios. To guide the selection of appropriate reference scenarios, we suggest to use the scenario typology based on the knowledge needs of the user to know what will happen, what can happen, and/or how a predefined target can be achieved (Börjeson et al., 2006, see also Figure 2). The three questions categorise scenarios in predictive, explorative and normative scenarios. The typology connects to the two domains of climate resilience: To identify and assess climate change impacts in the stability domain, predictive and explorative scenarios are most useful: They provide the context to answer what-if questions. To identify and assess the impact of climate change in the change domain, explorative and normative scenarios are the most relevant: they enable answering how-to type of questions.

2.4.2 | Tailoring reference scenarios towards company-specific scenarios

To enable company management to understand the implications of plausible future climate scenarios and impacts of plausible future states of the relevant variables as scoped in the focal question, the scenarios need to be tailored to the companies' business environment. For this tailoring, we present two different methodological approaches from an extensive literature review (ten Brinke, 2020): In response to 'what-if' type of focal questions relevant in the stability domain, we recommend the incasting methodology to tailoring global or regional reference scenarios to the company. The incasting methodology follows a relatively unstructured approach by presenting extreme however plausible potential futures to groups of participants for describing climate impacts on a series of domains, such as technology, regulation or consumer behaviour. The impacts can be estimated most accurately in group discussions among participants, which is best facilitated through a workshop. For the change domain, with 'how-to' type of focal questions, we find that the best approach is to develop 'new' company-specific scenarios, following Wack's internal logic (IL) approach (Wack, 1985). IL is a plausibility-based approach applied in a workshop setting. This approach requires the scenario team members to identify critical driving forces based on high impact and high uncertainty. These driving forces can be derived from reference scenarios and a PESTEL analysis.[8] By discussing the relevance of the driving force in a workshop, participants select the two most critical driving forces from a long list. The extreme outcomes of these two driving forces are explored, resulting in four diverse yet plausible futures. In a follow up of the workshop, the storylines on how the future may evolve from the current situation to these futures are described qualitatively in four narratives. General scenario requirements like internal consistency, plausibility, credibility, thought-provoking and relevance to inform the focal question are boundary conditions in both methodological approaches.

2.4.3 | Theoretical options for company responses

The response options differ in the two resilience domains: In the stability domain, responses will focus on the operational level of a

FIGURE 2 Scenario typology (Börjeson et al., 2006) to guide the selection of reference scenarios

specific entity scope (e.g., production location or processes and supply chain). The aim is to resist or recover as soon as possible from the physical or transitional impacts and maintain the companies' operational and financial performance. The time horizon of the responses depends on the lifetimes of current assets (e.g., 0–25 years). Response examples are contingency plans, embedding climate change in risk management, infrastructural measures to protect assets from extreme weather events or shifts in supply materials and fuels. Specifically, the integration in risk management contributes to a timely identification of emerging risks and opportunities, which can be translated into decision making to sustain the business value chain (Gomez-Valencia et al., 2021).

In the change domain, the responses are focused on the strategic level of a business unit, business model or value chain. The relevant time horizons correspond with investment decision making and future asset lifetimes (e.g., 10–30 years). Examples of responses include market research, technical evaluations and innovations to shift from a linear value chain to a net-zero and circular value chain. Indicators to measure the implementation of the responses for the stability domain measure the inclusion of climate change in the enterprise risk management framework (following COSO or ISO 31000 requirements), the number of contingency plans, and budgets for investments in mitigation and adaptation measures. Example indicators in the change domain include the number of staff with responsibilities to formulate strategic responses to climate change, budgets spent on R&D towards net-zero products or processes, number of climate-related innovations, or alignment of company and individual management targets with a net-zero pathway.

The responses in the two domains are built upon different organisational process and capabilities: robustness requires planning and control processes and plan-do-check-act capabilities, whereas transformation requires R&D, innovation capabilities and personal belief of managers about the benefits of change and sufficient low barriers on the path of action (Kump, 2021). As these different capabilities, processes and outputs for the two domains may create tension within organisations (Linnenluecke, 2017; Song, 2021), the composition of the scenario teams should be aligned with the targeted resilience domain and response options.

2.5 | Research method

To develop, operationalise and refine the above theoretical framework and approaches, two qualitative pilot case studies at two mid-sized companies have been performed. The design of the pilot case studies allowed to apply the feedback loops for case studies (Yin, 2009). The execution of the case studies was performed by two transdisciplinary teams composed of corporate staff and scientific researchers. By working with transdisciplinary teams and learning from experimentation through action research, this research aims to make theory more practical and contribute to the need to upscale research that can rapidly enhance learning to accelerate the response to climate change (Fazey et al., 2018). The theoretical concept of climate resilience and the theories on designing scenario process, are operationalised and refined in two qualitative case studies at two mid-sized companies in the food and biochemical industry.

3 | RESULTS

3.1 | The climate resilience cycle

The above-mentioned operationalisation and refinement of the theoretical framework resulted in the climate resilience cycle (Figure 3). The cycle consists of five logical steps, which start after formulating the focal question to specify the information needs of the company in relation to climate resiliency. The characteristics of the focal question ('what-if' or 'how-to' type question) guides the first step (selection of reference scenarios) of the climate resilience cycle: for what-if type focal questions, predictive and explorative (external) reference scenarios are used, whereas for how-to type questions normative (transformative) and explorative (strategic) scenarios are the most suitable. Appendix A suggests sources for reference scenarios that companies can use.

The next step is to tailor these reference scenarios to company specific scenarios, following one of the suggested approaches as described in Section 2.4.2. The company-specific scenarios provide the basic information to assess and specify plausible impacts on the business unit, business model or value chain of the company (Step 3). The response formulation (Step 4) answers the focal question and results in actionable insights how to build climate resilience in the stability domain.

This domain will be applicable for nearly all companies as acute and chronic climate change impacts are expected to become more severe over time. For energy- and resource-intensive companies, more fundamental shifts are likely needed: Step 5 explores the required transformations of the business model or

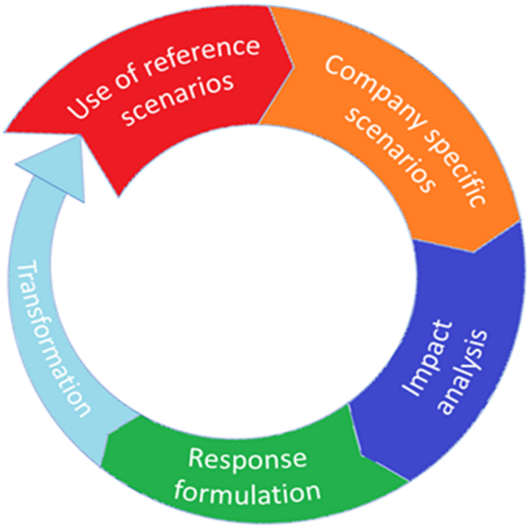

FIGURE 3 Climate resilience cycle

value chain that might be needed to build resilience in the change domain.

3.2 | Application of the climate resilience cycle in two pilot case studies

The two pilot case studies are performed at two mid-sized companies in the biochemical and food industry: Corbion N.V. and Royal FrieslandCampina N.V. (RFC). Corbion is the global market leader in lactic acid and its derivatives, and a leading supplier of emulsifiers, functional enzyme blends, minerals, vitamins and algae ingredients. Royal FrieslandCampina N.V. (RFC) is one of the largest dairy cooperatives in the world, owned by member dairy farmers (17,413), with over 35 production plants, the majority located in the Netherlands. The primary driver to conduct climate scenario analysis for Corbion was compliance with the TCFD Guidelines and for RFC compliance with the Dutch climate policy for industry. Both pilot case studies are set up in collaboration with Utrecht University. At Corbion, the key group consisted of four Corbion and two University employees. Further, four external experts were interviewed and four two-and-a-half-hour workshops (two sets of two) were organised with a total of 12 senior managers (two groups of six). In the RFC study, a group of 15 internal mangers and 3 external stakeholders were involved through interviews and two half-day workshops. From the university, three experts were involved. The subjoined description

TABLE 1 Description of key actions and choices in the two pilot case studies

	Tailoring external scenarios following the Incasting approach (Corbion)	Developing internal scenarios following the Internal Logic approach (RFC)
Initial driver	TCFD disclosure requested by an investor	Dutch Climate Agreement
Focal question	What is our current and future exposure to climate change related risks and opportunities?	How can RFC decarbonise its production processes in NL towards 2030 in accordance with the NL climate agreement targets?
Use of reference scenarios	Ansari & Holz [2020]; IPCC (2014; 2019); McKinsey Global Institute (2020); En-Roads (Climate Interactive, 2020) *Predictive & explorative external*	IPCC RCP 2.6/1.9 (2014;2016) -> Paris climate agreement and National 2030-2050 targets (Climate agreement) *Normative transforming*
Company-specific climate change scenarios	A 1,5-degrees transition scenario and 3-degrees physical impact scenarios were explored to identify trends and impacts at ' 'Corbion's global production and sourcing geographies to create a set of relevant event scenarios (incasting approach) *What-if scenarios*	Following a pestel analysis by interviewing internal and external experts, a long list of driving forces were identified. In a workshop, this input was used to identify most critical change drivers to construct company scenario narratives (IL approach) *How-to scenarios*
Impact analysis	Discussion on selected events (in a participative game setting) to identify and assess impact on margin, profit, compliance and reputation	Identification of operational implications (production volume and production mix) and technical and economic implications to decarbonise production processes
Response formulation	Assign risk owner to most material risks and further address through general enterprise risk management practices	Decarbonisation roadmap for production processes which are robust in identified production volume/production mix scenarios, to inform investments/divestment
Transformation	More awareness of climate-related risks and opportunities on value chain leading to increased capacity to judge and act on climate impacts	Follow up scenario study and economic modelling to explore pathways for the decarbonisation of the dairy value chain.

[Correction added on 31 March 2022, after first online publication: Tables 1 and 2 have been updated in this version.]

TABLE 2 Summary of requirements for scenario analysis for mid-sized companies

Input requirements

Involvement and buy-in of Board level in initiating, execution and follow up of scenario analysis process and results
Selection of (key) group of stakeholders
Formulation of purpose of scenario analysis and the focal question (what-if/how-to)

Process requirements	Output requirements
Selection of reference scenarios for physical and/or transition impact analysis, based upon focal question, geographical scope and time horizon.	Relevant reference scenarios, insight in the assumptions of selected scenarios and identification of communicable format (e.g. simulation model, pathway description).
Active participation of internal stakeholders and (external) climate change experts to explain climate scenarios and facilitator with scenario analysis experiences to co-create company specific scenarios while minimising biases.	Company-specific scenarios in a communicable format (e.g narratives, relevant events), based on company footprint, scope of analysis and plausible climate change drivers.
Stepwise coverage of entire company value chain to identify physical and transitional climate events and to assess the likelihood of, and vulnerability to these events.	Qualitative or quantitative assessment of material risks & opportunities of climate change events (e.g. risk and opportunity matrix) and identification of signpost events.
Clear implementation process to embed scenario analysis and resulting decision making into risk & opportunity management and business planning.	Actionable information like a a business continuity plan or investment planning in responses to material climate risks & opportunities
The process and results are internally and/or externally replicable.	Lays the groundwork/sows the seeds for regular iteration of the cycle in the organisation.

Outcome requirement

Informs internal and external stakeholders how the company is building climate resilience in the stability and/or change domain

provides an overview of the scenario approaches applied in the two pilot case studies (Table 1).

Following the experiences in the two pilot case studies, we have identified the input, process, output, and outcome requirements (Table 2). These requirements are the same for both types of scenario analysis and satisfy condition of having a positive input output balance for mid-sized companies.

The below-described choices, requirements and actions are based upon the two pilot case studies as applied in this research and can be further substantiated and validated in follow-up applications of the climate resilience cycle within companies. The intention at both companies is to continue with the scenario exercises to improve, elaborate on and continuously update the outcomes.

3.3 | Role of the climate resilience cycle in strategy formulation

To become climate resilient, the outcomes of the climate resilience cycle need to be integrated in the overall company strategy development and business planning. This alignment is challenging as current strategies are based upon existing capabilities, resources and operational processes, whereas the integration of a climate resilience responses may require to reconfigure or transform these foundations. Although there is no general theoretical framework on the integration of sustainability into a company strategy (Kitsios et al., 2020), many researchers demonstrate that dynamic capabilities and the underlying organisational routines, have an observable effect on this integration (Bianchi et al., 2021; Mousavi et al., 2018; Zahoor & Lew, 2021). Dynamic capabilities refer to the capacities of companies to 'sense' trends, to 'seize' opportunities and to reconfigure or transform a companies' intangible and tangible assets (Teece, 2007). Scenario analysis strengthens sensing capabilities (Semke & Tiberius, 2020), whereas the other steps of the climate resilience cycle (response formulation and transformation) are equivalent to dynamic capabilities' 'seizing' and 'transformation'. We argue that implementing the climate resilience cycle as an organisational routine contributes to the development of dynamic capabilities as needed to integrate climate resilience responses in the overall company strategy. Likewise, the same barriers and drivers which obstruct or enable dynamic capabilities for sustainability (Bocken & Geradts, 2020), might be applicable. Examples of barriers for the integration of climate change resilience in company strategies include dominant focus on the current business model, uncertainty avoidance, corporate time horizons, whereas relevant

drivers are the valuation of business sustainability, societal stakeholder needs, competitive advantages and top and senior management pursuing sustainability.

In both case study companies, these drivers and barriers are recognisable: both companies have formulated carbon policies, targets and related incentive schemes. However, climate resilience is not yet fully integrated in the company strategy and operational planning, as previous mentioned barriers (reliance on current business model, current assets and related revenues) seem stronger than the mentioned drivers. Following the feedback and follow-up of the companies on the scenario exercises, running the climate resilience cycle appears to strengthen drivers like senior management's valuation of business sustainability, company contributions to societal needs and awareness on risks and competitive advantages. In alignment with the observed effects of dynamic capabilities of companies, we argue that implementing the climate resilience cycle as a company routine can facilitate the integration of climate change resilience in the company strategy.

3.4 | Practical suggestions to implement the cycle as a new company routine

The climate resilience cycle as developed in the two pilot case studies, can be applied almost directly by other companies. It is a matter of satisfying the input requirements and consequently embarking on the first iteration of the climate resilience cycle, while learning from the process and outcomes. The first input requirement: getting board-level support is essential. There is no way around organising the required resources for small and mid-sized companies without board-level support. How to generate this support will differ for each company. Larger companies might initiate a pilot project, supported by a (group of) senior manager(s) and use the results of this initial pilot to convince board members. But in the end, high-level support is required to embed the cycle in the business planning and strategy development.

The second input requirement: Getting together a group of key stakeholders has more flexibility. The key for robust outcomes relies on diversity in the scenario team to eliminate as many biases as possible and on the availability of the required (climate change and scenario analysis) knowledge and capacities. We recommended having at least one external participant to counteract biases. This can be an external facilitator, a climate change specialist, or an external expert. Engaging external experts is feasible through cooperation with climate change research institutions, business network organisations (e.g., regional corporate sustainability and responsibility networks, science-based targets network or the En-ROADS Climate Ambassador Program) or NGOs like the Climate Alliance (Scheltus et al., 2021). In larger companies with sustainability expertise, we consider it feasible to perform the exercise without external participants. In that case, overcoming biases can be organised by including a wide range of company functions in the team, including relevant supply chain- and business operation expertise as well as R&D expertise.

The third input requirement: Determining the purpose of the scenario analysis is really up to the company. The purpose is articulated in the focal question: What do I want to know about becoming climate resilient? However, even though there is considerable freedom here, the purpose must be clearly defined before setting off. If a company has trouble defining a clear purpose, we recommend to follow the Corbion case study's focal question and selecting 1.5° and 3° reference scenarios to assess resiliency to plausible transition- and physical climate-related risks and opportunities.

The experience in the pilot case studies is that in the first iteration of the climate resilience cycle the project team learned how to conduct scenario analysis and developed a first understanding of climate change impacts and plausible responses. We expect that this experience can be generalised and that companies need to repeat the cycle to establish the organisational processes and capabilities for developing consistent and plausible company scenarios and robust responses. The frequency of such repetition is a balance between input of required resources (management time and facilitator) and outcomes (actionable insights). Reiteration can be triggered by uncertainty about the robustness of the outcomes, changes in governmental policies or new market trends, with a minimum of 5 years. How robust the outcomes are hard to measure because climate resilience is a capacity that only manifests itself in the future and can only be measured indirectly by using indicators as mentioned in Section 2.4.3.

We encourage especially energy- and resource-intensive companies to get started with scenario analysis. Such a start might be triggered by investor demand or new disclosure standards; however, when it is considered as a compliance exercise, companies might disregard the value of scenario analysis. The main value results from developing the dynamic capabilities, which enable companies to integrate climate resiliency into the business planning and the company strategy, through the implementation of the cycle as a new routine.

4 | DISCUSSION

Starting scenario analysis without a clear definition of the concept of climate resilience, results in confusion about the purpose of the scenario analysis and thus in confusion of the process. In such confusion, companies may experience the current available guidance on scenario analyses as overwhelming. Through the research question what is climate resilience and how to achieve it?, we found that distinguishing the concept of climate resiliency in two different resilience domains with related variables, clarifies the purpose and process of climate change scenario analysis. The purpose is articulated through the focal question and the variables define the scope of the focal question.

The answering of the second research question: what is climate change scenario analysis and how to apply it? guides the methodological choices of scenario analysis. The first methodologic choice is the selection of a relevant reference scenario, guided by the type of focal question (what if or how to). The second choice is to select the most suitable method for developing company-specific scenarios. This structuring simplifies and standardises, to the extent possible, the application of climate change scenario analysis and is worked out in this research in a stepwise process, which we call the climate

resilience cycle. The cycle is founded on the distinction of climate resilience in the stability and change domain (Section 2.2), the specification of resilience variables to scope the focal question (Section 2.3) and the consequential guidance for selecting reference scenarios (Section 2.4). Further, guidance is provided for company-specific tailoring of the scenarios (Section 2.4.2) and to use the information for actionable insights towards resiliency in the stability and change domain. In the two pilot case studies, the process appeared to be implementable for mid-sized companies and resulted in a good balance between input of resources and output of actionable insights.

We consider the climate resilience cycle a helpful contribution to existing TCFD guidance by addressing hurdles that currently impede companies from applying climate scenario analysis: The hurdle of the lack of a structured process is tackled by providing a structured and implementable process. For the second hurdle, being the lack of utilisable data, the climate resilience cycle circumvents this deficiency by using publicly available reference scenarios and climate change simulation tools like En-ROADS. The use of such a simulation tool facilitates participants to dive from a holistic perspective to particular perspectives of climate change and learn about plausible responses (Rooney-Varga et al., 2020).

We expect that more sector-specific reference scenarios will become available to assess climate change impacts on company value chains and to generate quantitative insights (e.g., future carbon price levels, cost of technologies and consumer preferences). The challenge of tailoring reference scenarios to company-specific scenarios is addressed by considering the type of focal question: for what-if type of questions the incasting approach is most suitable, whereas for how to questions, the IL approach is the best fit.

Other mentioned hurdles for conducting scenario analysis are a lack of knowledge to perform scenario analysis and difficulties to assess and discuss how climate change impacts the current business model. We argue that these hurdles can be reduced by two conditions: conducting scenario analysis in transdisciplinary teams and by implementing the climate resilience cycle as a company routine. Transdisciplinary teams with a climate change scientist and company value chain knowledge increases understanding about impacts and responses and creates urgency. In one of the two pilot case studies, this urgency and understanding was created by taking participants on a journey into the future: video clips prepared them for long-term thinking about climate change and the use of simulation tools enabled participants to project their company in the context of long-term climate change impacts. Further, transdisciplinary teams reduce typical company and individual biases in scenario analysis processes, by bringing heterogeneity and diversity in knowledge, experience and attitudes towards climate change. In the two case studies, the transdisciplinary teams were organised via partnerships between academic researchers and company management.

The second condition, implementing the resilience cycle as a new routine, is necessary to develop the organisational learning within companies to conduct scenario analysis and to identify adequate resilience measures in the stability and change domain and to integrate it in business planning. Iteration is also necessary because of the dynamic nature of climate change, evolving insights regarding climate change and development of climate policies. Iteration of the cycle through a routine improves transparency on scenario assumptions, the replicability of the scenario outcomes and the robustness of company responses. Transparency on assumptions and replicability is especially relevant if qualitative outcomes are quantified and are used to inform external stakeholders about financial impacts of climate change impacts and company responses towards climate resiliency. By implementing the cycle as a new routine, companies will develop the organisational capabilities to use scenario analysis with a good input-and output balance and to integrate the outcomes in the overall company strategy.

4.1 | Limitations

The wide scope of disciplines involved in this research poses limitations on the depth of the research, whereas the pilot case studies pose limitations to the generalisation of the findings. Therefore, we suggest to perform further action research to test and validate the usefulness of the climate resilience cycle to inform decision making about climate resiliency. Multiple iterations of the cycle at multiple companies is needed to assess the usefulness of the foundations of the cycle, like distinguishing between resilience in the stability and change domain. Further, we suggest to perform further research in what extent companies clarify and disclose key parameters, assumptions and other analytical choices made during the tailoring of reference scenarios to company-specific scenarios.

In addition to the above research suggestion, companies would highly benefit from science-based predictive, explorative and normative reference scenarios with geographic- and sector-specific information to identify and understand physical, transitional and socio-economic impacts on companies' value chains. Investors would also benefit from such scenarios because they make the company findings replicable and consistent among their portfolios. Scientific research is essential in developing these reference scenarios. Finally, scientific research is needed to evaluate the effectiveness of company responses towards climate resiliency in the stability and change domain.

As pursued in the two pilot case studies of this research, transdisciplinary research approaches can disseminate such scientific insights into company decision making to accelerate transformative changes towards a net-zero economy.

5 | CONCLUSION

Companies need future-oriented information about plausible climate change impacts and company response to build climate resilience into their value chain. Climate scenario analysis is an essential step in developing this future-oriented information to enable company management to build climate resiliency and allow investors to price climate risks and opportunities in the financial system. The proposed global sustainability accounting and disclosure standard stipulates companies to disclose whether and how they conduct climate scenario analysis (Prototype IFRS Sustainability Disclosure Standard, TRWG, 2021). This standard will shift voluntary climate scenario and

resilience reporting to authoritative reporting. Although this will accelerate climate scenario analysis, companies currently experience climate scenario analysis as a complex and daunting task.

To reduce the complexity and to encourage companies to get started with climate scenario analysis, while improving the input and output balance, we developed the climate resilience cycle. The steps in the cycle are based upon a distinction in climate resilience through increasing the companies' robustness ('stability domain') and through transforming the business model or value chain towards climate change ('change domain'). The two different domains have different information needs and require different designs of the scenario analysis process. By structuring the process in a five-step cycle and by specifying the design parameters, the cycle simplifies and standardizes to the extent possible the application of climate change scenario analysis. The operationalisation and refinement of the cycle in this research's two pilot case studies resulted in the specification of input, process and output requirements. Together with the practical suggestions on how to get started, the climate resilience cycle can serve as an implementation guide for companies. Although primarily developed, operationalised and applied at mid-sized companies, we consider this guidance generally applicable for larger and smaller companies. With this generalisation, we aim for a widespread adoption of this practice.

While this adoption will be driven by new disclosure requirements, we presume that companies can derive most value from the cycle through developing knowledge how to build climate resilience in their value chain and by integrating the identified responses in their overall company strategy. Developing a shared view within the company about robust responses will require multiple iterations of the cycle. We argue therefore that companies should implement the cycle as a new company routine. Such integration is a necessity to put net-zero 2050 ambitions of companies into practice. We argue that the cycle contributes to this integration as it develops dynamic capabilities like sensing, seizing and transforming, which are key to integrate sustainability in company strategies. The implementation of the climate resilience cycle as an organisational routine contributes to developing dynamic capabilities, to facilitate the integration of climate resilience responses in the overall company strategy. Therefore, we recommend companies to get started with climate change scenario analysis by using the climate resilience cycle as a guide and by deriving most value of the cycle by implementing it as a company routine to build the dynamic capabilities for integrating climate resilience into the company strategy.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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ENDNOTES

[1] This research considers a value chain as the full range of activities to bring a product or service from conception, through the different phases of production, delivery to consumers and disposal after use. Value chains are characterised by multiple stakeholder interactions and system operations that can be influenced by climate change impacts.

[2] Documentary film about Al Gore's campaign to educate people about global warming. Al Gore won the 2007 Nobel Peace Prize for his efforts to draw the world's attention to global warming which is centerpieced in the film. The film is identified as the most high-profile environmental risk documentary of all time (Lyons 2019).

[3] The Climate Reality Leadership Corps founded by Al Gore in 2006, to educate (business) leaders on climate change (Gore, 2021).

[4] The 'wait-and-see' attitude of companies towards climate change has been observed by the author U. Huiskamp in climate change audit and consultancy services to multinational companies in the Netherlands in the period 2000–2017.

[5] Routines are defined in this research as the means by which organisations carry out their activities by matching appropriate procedures, strategies, technologies, conventions, cultures and beliefs around which organisations are built and through which they operate.

[6] The international standard setting organisations responsible for issuing global accounting standards (IASSB, IFRS), which determine how companies report on accounting events in their annual financial statements, have decided to issue global sustainability disclosure standards. The prototype standard (TRWG, 2021) is based upon the TCFD recommendations and requires companies a.o. to disclose an analysis of the resiliency to climate-related risks and opportunities, based on scenario analysis. As the IFRS standards are used by the majority of global (listed) companies, the expected issuing of the (draft) standard in 2022, will logically accelerate the use of scenario analysis by global companies.

[7] Wicked problems can be defined as multi-causal with many interdependencies and no clear solution, socially complex due to changing behaviour of stakeholders and often characterised by chronic policy failure.

[8] A PESTEL analysis is a tool to identify change drivers that affect the external business environment of companies. The letters stand for political, economic, social, technological, environmental and legal factors.

[9] The Climate Agreement is part of the Dutch climate policy (http://www.government.nl/topics/climate-change/climate-policy).

[10] IPCC Sixth Assessment Report (2021) uses Shared Socioeconomic Pathways (five scenarios), whereas the fifth assessment report is based on RCP scenarios.

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APPENDIX A.

Reference scenarios describe plausible future states of either physical climate conditions, based upon projected future greenhouse gas emission levels and transitional pathways of plausible technical, political and socio-economic future states in response to climate change. A range of (inter)national agencies and research institutes regularly develop reference scenarios together with scientists and social actors. The involvement of a broad range of experts and iterated feedback loops contributes to the quality and legitimacy of these scenarios. Examples of predictive scenarios on a global level are those of the IPCC, based upon forecasts of global greenhouse gas emissions towards 2100. The IPCC scenarios range from very strongly declining emissions as required by the Paris agreement to rising emissions in case of no policy changes and quantify the related increase in, for example, temperature and sea levels. To assess plausible impacts towards 2030 or 2050, companies are advised by the TCFD to select both low- and high-emission and corresponding temperature scenarios: In practice, this means selecting a 'very low' emission scenario (SSP 1-1.9) and a 'high' scenario (SSP 3-3.7).

User friendly interfaces and visual tools support like IPCC's Interactive Atlas, the World Bank Climate Change Knowledge Portal, the Partnership for Resilience and Preparedness and KNMI climate change atlas, support the use of climate scenarios. To translate the impact of high temperature reference scenario on socio-economic impacts and future business environments, companies can make use of publications from knowledge providers like McKinsey Global Institute.

Reference scenarios on transitional impacts of climate change provide insight in plausible futures stemming from net-zero carbon policies, regulatory changes, technology changes and market shifts. These changes can have a wide range of direct and indirect impacts, especially on energy- and resource-intensive companies. To understand these plausible changes, the use of different scenarios with competing views on the future can be helpful to understand plausible causal relationships between governmental decisions, market shifts and technological developments. Examples of global reference scenarios are the Energy Technology Perspectives 2020 of the International Energy Agency, IRENA's World Energy Transitions Outlook or the Deep Decarbonisation Pathways. Examples of competing views are full employment of mature mitigation technologies (e.g., renewable electricity, bioenergy, nuclear energy and CCS) or massive scale-up of current immature technologies like green hydrogen and synthetic fuel technologies. Storylines help to articulate the assumptions and the logics of the cause-effect relationships. Examples of assumptions include macro-economic parameters, prices of key commodities like carbon credits, policy assumptions, technology developments and market assumptions. When the focal question explicitly specifies transition risks and opportunities with a national or regional scope or a specific part of the companies' value chain, sector-specific reference scenarios can be used. However, we recommend to use these national or sector-specific scenarios in combination with global scenarios to prevent blind spots. Examples of explorative scenarios are those of Ansari and Holz (2019). A new trend can also be seen in the recent availability of climate simulators such as En-ROADS, the NGFS climate scenarios and the energy transition model. Explorative reference scenarios are relevant for both types of focal questions (explorative external for what-if, explorative strategic for how-to) and need to be clear in the assumptions that are being made. The time horizons of reference scenarios should ideally be aligned with the economic lifetime of major company assets (e.g., product patents/production plants) and the companies' investment horizons. Further, it is advised to also align the horizons with national and international climate policy targets. In practice, suitable time horizons are between 10 and 30 years, that is, between 2030 and 2050

Scope of reference scenario	Type of reference scenario	Example reference scenarios
Physical climate change	Predictive	• IPCC-RCP[9] scenarios: Atmospheric concentration pathways (RCPs) project greenhouse gas emission volumes and resulting climate futures. • IPCC Interactive Atlas with regional information of annual mean temperature and precipitation at global warming levels of 1.5–4° global warming levels. • Senses toolkit projects relationships between rising temperatures and six type of extreme events (heatwave, droughts, crop failure, wildfires, river floods and cyclones and discuss uncertainties scenarios • McKinsey global institute, climate risks and responses: Physical hazards and socio-economic impacts, 2020
Transitional climate change	Normative	• National determined contribution plans • IEA technology perspectives: mapping the technologies needed for net-zero emission. • Irena regional energy transition scenarios • Sector specific scenarios: e.g., World Economic Forum Future Scenarios and implications for the industry
	Explorative	• World Energy Outlook scenarios as annually published by the International Energy Agency (IEA) with the announced pledges scenario, stated policy scenario and net-zero scenario to explore future energy trends
Combined physical-transitional climate change scenarios	Predictive/explorative	• IPCC-SSP scenarios: The five SSP scenarios span a wide range of plausible societal and climate futures from potentially 1.5°C to over 3°C warming by 2100 • Ansari & Holz: Anticipating global energy, climate and policy in 2055