Scenario Analysis: A Primer

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1. Background and definitions

The purpose of this briefing is to provide a description of scenarios history and approaches as well as how they have been used in the past within organisational applications. This information is intended to inform understanding of possibilities for organisational level biodiversity scenario development.

Scenario analysis techniques are a strategic planning tool that originated in military applications, notably war game simulations (Swart et al., 2004; Bradfield et al., 2005; Duinker and Greig, 2007). More contemporary interest in scenario analysis arose from the future studies movement of the 1970s[1], which emerged in response to concerns about the sustainable use of natural resources amid expanding global populations and economies. Early applications of scenario analysis (Raskin et al., 2005) encompassed both complex mathematical simulation models (Forrester 1971) and speculative narrative approaches (Kahn et al. 1976). The latter approach was popularised by Royal Dutch Shell in a business context and sought to challenge managerial assumptions and encourage greater creativity regarding future possibilities (Schwartz, 1991). It is claimed that Shell's adoption of scenarios enabled it to anticipate and respond more swiftly and effectively to the 1973 oil crisis compared to its rivals (Schwenker and Wulf, 2013).

A second wave of global scenarios emerged in the late 1980s and early 1990s in response to the release of the *Brundtland Report* by the World Commission on Environment and Development (WCED, 1987) and the convening of the 1992 Rio World Conference on Environment and Development (Swart et al., 2004; Raskin et al. 2005). At around the same time, global energy scenarios were created in response to climate change concerns, underpinned by the creation of the Intergovernmental Panel on Climate Change (IPCC). These scenarios predominantly examined technological change and economic policies and how they would affect organisational operations (Leggett et al. 1992). These scenarios were also underpinned by quantitative climate models to identify likely future climate conditions that would arise from policy, economic and technological responses.

The purpose of scenario analysis, therefore, is to explore uncertainties and identify knowledge gaps as well as the potential consequences of decisions over a range of possible future paths (including both good and bad outcomes), as determined by the values of the group creating the scenarios (Cumming, 2007). Scenario analysis has gained widespread adoption across various domains, including business, community, policymaking, and research, serving a diverse range of purposes, such as enhanced management practices, consciousness-raising, conflict resolution, policy recommendations, and research endeavours (Clark & Munn, 1986; and Mahony, 2014). A key characteristic of scenarios are that they are not definitive predictions or forecasts: rather, they focus on describing possible futures that challenge existing assumptions and expand perspectives (Duinker & Greig, 2007). This is reinformed by the Taskforce on Nature-related Financial Disclosures (TNFD) that notes that "scenarios are not probabilistic forecasts" (see TNFD, 2023a, p.5).

[1] For more information about the future studies movement, please see Henchey (1978); Seefried (2014); and Son (2015).

Scenario definitions / descriptions

- "hypothetical sequences of events constructed for the purpose of focusing attention on causal processes and decision points" (Kahn and Wiener 1967, p. 6).
- "a description of a possible set of events that might reasonably take place" (Jarke et al., 1998, p. 155).
- "descriptions of journeys to possible futures. They reflect different assumptions about how current trends will unfold, how critical uncertainties will play out and what new factors will come into play" (UNEP, 2002, p. 320).
- "plausible, challenging, and relevant stories about how the future might unfold, which can be told in both words and numbers" (Raskin et al., 2005, p. 36).
- "stories about the future built upon 'if-then' propositions that provide a way to explore the implications of unfolding driving forces" (Alcamo & Henrichs, 2008, p. 13).
- "a set of plausible descriptions or narratives about how the future may develop based on a coherent and internally consistent set of assumptions about key driving forces and critical uncertainties" (TNFD 2023a, p.4).[2]

Scenario analysis is also being used in organisational settings where sustainability is being considered with some disclosure initiatives putting scenarios at the heart of their guidance. First, TCFD (the Taskforce on Climate-related Financial Disclosures) recommended the use of climate scenarios for understanding organisational risks and opportunities. Latterly, the TNFD (TNFD, 2023c) has also focused on scenarios to understand future risks and opportunities. Both initiatives recommend the use of scenarios to inform organisational strategy and to navigate uncertainty in an environment that defies complete control. In turn, such an approach is assumed to support organisations to evaluate the resilience of their decision-making processes and identify potential opportunities and challenges that lie ahead. Given the nature of the Earth system, we would anticipate that climate and nature scenarios might be linked to each other.

2. Environmental Scenario Analysis

Human activities (directly or through organisational activities) affect the Earth's climate, land cover, oceans, and underpinning biogeochemical cycles, as well as the diversity of life itself (Steffen et al. 2004). Environmental change threatens the future availability of ecosystem services, defined as the benefits that people obtain from nature (Millennium Ecosystem Assessment, 2003). Organisations are operating within a changing Earth system and need to respond to environmental change that will compel managers and executives to adopt a more holistic approach to operations (Chermack et al. 2001). It is believed that scenario analysis will support companies to investigate and understand combinations of environment-related risks, encompassing both transition and physical risks, that might impact their activities, strategies, and financial performance over time. In brief, transition risks arise from changes in regulatory, shareholder and consumer markets that will change the future operating space for organisations. In contrast, physical risks are impacts that arise from environmental change itself.

Environmental scenario analysis differs from organisational focused scenario analysis in that it places environmental problems and issues at the heart of the analysis (Alcamo & Henrichs, 2008). As a result, environmental scenario analysis is rooted in the environmental sciences as well as being interdisciplinary in nature – spanning both natural and social sciences (Raskin et al., 2005).

[2] Full version of the guidance is available at: https://tnfd.global/wpcontent/uploads/2023/09/Guidance_on_scenario_analysis_V1.pdf

Scenario analysis also adopts varying time horizons from short (e.g. 3 years) to long (e.g. 10 years or more) time frames (environmental system function will also vary as time frames change). Additionally, environmental scenarios encompass diverse topics and scales ranging from global sustainability scenarios to those focusing on specific environmental issues within a particular region or at the county level (Alcamo & Henrichs, 2008).

The literature on scenario analysis has not provided a generally accepted classification for scenarios (Alcamo & Henrichs, 2008). Several studies, however, have identified different scenario approaches (Duinker & Greig, 2007; Raskin et al., 2005; Börjeson et al. 2006; Alcamo & Henrichs, 2008). Table 1 summarises these approaches. A subset of environmental scenarios are those related to biodiversity.

Table 1: Types of scenario approaches

Type of scenario	Definition
Predictive scenarios	Attempt to predict what is going to happen in the future.
Explorative scenarios (also known as descriptive or exploratory scenarios)	Start in the present (i.e. with an initial situation) and a set of assumptions on policies, measures and key driving forces to explore plausible future developments.
Normative scenarios (also known as anticipatory or target-seeking scenarios)	Are constructed to lead to a future that is desired by scenario builders.
Quantitative scenarios	Describe possible futures in numerical form such as graphs or tables of numbers, commonly produced using a model or models.
Qualitative scenarios	Describe possible futures in primarily non-numerical form, for example as outlines, phrases or complete text, or visually as diagrams or pictures.
Reference scenarios (also known as baseline, benchmark or non-intervention scenarios)	Describe the future state of society and the environment in the absence of additional, new, and focused environmental policies.
Policy scenarios (also known as pollution control, mitigation, or intervention scenarios)	Consider new policies or measures in addition to those already adopted or agreed upon.

Source: Authors' own

3. Biodiversity Scenarios

Biodiversity is defined as "the variability among living organisms from all sources including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part. This includes variation in genetic, phenotypic, phylogenetic, and functional attributes, as well as changes in abundance and distribution over time and space within and among species, biological communities and ecosystems" (International Panel on Biodiversity and Ecosystem Services (IPBES), 2023)[3]. Biodiversity underpins global financial and organisational functioning. For example, the World Economic Forum (WEF)[4] suggests more than half of the global GDP, relies *heavily* or *moderately* on the resources and services provided by natural ecosystems (WEF, 2020,

[3] https://www.ipbes.net/glossary/biodiversity
[4] https://www.weforum.org/agenda/2022/09/the-business-of-protecting-biodiversity-and-why-it-s-your-business/

emphasis added) This includes the raw materials extracted from the biosphere, the availability of groundwater for agriculture and industry, and the critical role of pollination in ensuring food security. The kinds of sectors which this dependency (and impact) exist includes agriculture, aquaculture, fisheries, food and beverage production (including the plantation sector), tobacco, forestry, renewable heat utilities, construction, electricity providers, water utilities as well as less obvious sectors like mining, real estate, pharmaceuticals and chemical producers. The range of sectors and companies who are exposed to nature related risks is considerable.

At the same time, biodiversity is experiencing a substantial decline, primarily caused by human activities some of which are mediated by organisational activities. The WEF (2024)[5] suggests that biodiversity loss will be the third most severe global risk over the next ten years behind extreme weather and critical change to Earth systems. Moreover, climate and biodiversity concerns are interrelated. Specifically, the drivers of biodiversity loss include land-use change, direct overexploitation of natural resources, climate change, pollution, and the spread of invasive species[6] (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services - IPBES, 2016). Scenarios have also been identified as a tool that can provide insight into the relationship between nature and people and IPBES defines biodiversity scenarios as "representations of possible futures for one or more components of a system, particularly, in this assessment, for drivers of change in nature and nature's benefits, including alternative policy or management options" (IPBES, 2016, p.8). In summary, it is claimed that "scenario analysis allows organisations to explore the possible consequences of nature loss and climate change, the ways in which governments, markets and society might respond, and the implications of these uncertainties for business strategy and financial planning" (TNFD, 2023a, p.3).

Organisations play a role in biodiversity change through their operations. Boston Consulting Group (2021, p.3)[7] identify that "many business activities—in particular, activities related to resource extraction and cultivation—contribute to the pressures driving biodiversity loss. Currently, more than 90% of man-made pressure on biodiversity is attributable to the operations of four major value chains: food, energy, infrastructure, and fashion".

There have been various applications of biodiversity scenarios to agenda setting, policy design and implementation at global to national scales. For example, at the global level, the Millenium Ecosystem Assessment (MEA) brought together 1,300 experts from 95 countries to develop four (exploratory) scenarios to characterise potential futures for ecosystems and biodiversity, considering different socioeconomic pathways and their impacts on ecosystem services. The four scenarios created were Global Orchestration, Order from Strength, Adapting Mosaic, and Techno Garden[8]. Table 2 outlines the characteristics of MEA's scenarios.

[5] The full report is available at: https://www3.weforum.org/docs/WEF_The_Global_Risks_Report_2024.pdf (Accessed: 11 January 2024).
[6] For more information see https://www.ipbes.net/models-drivers-biodiversity-ecosystem-change
[7] The full report is available at: https://web-assets.bcg.com/fb/5e/74af5531468e9c1d4dd5c9fc0bd7/bcg-the-biodiversity-crisis-is-a-business-crisis-mar-2021-rr.pdf (Accessed: 7 December 2023).
[8] For more information about the MEA scenarios see https://www.millenniumassessment.org/documents/document.332.aspx.pdf

Table 2: Defining characteristics of the MEA's four scenarios.

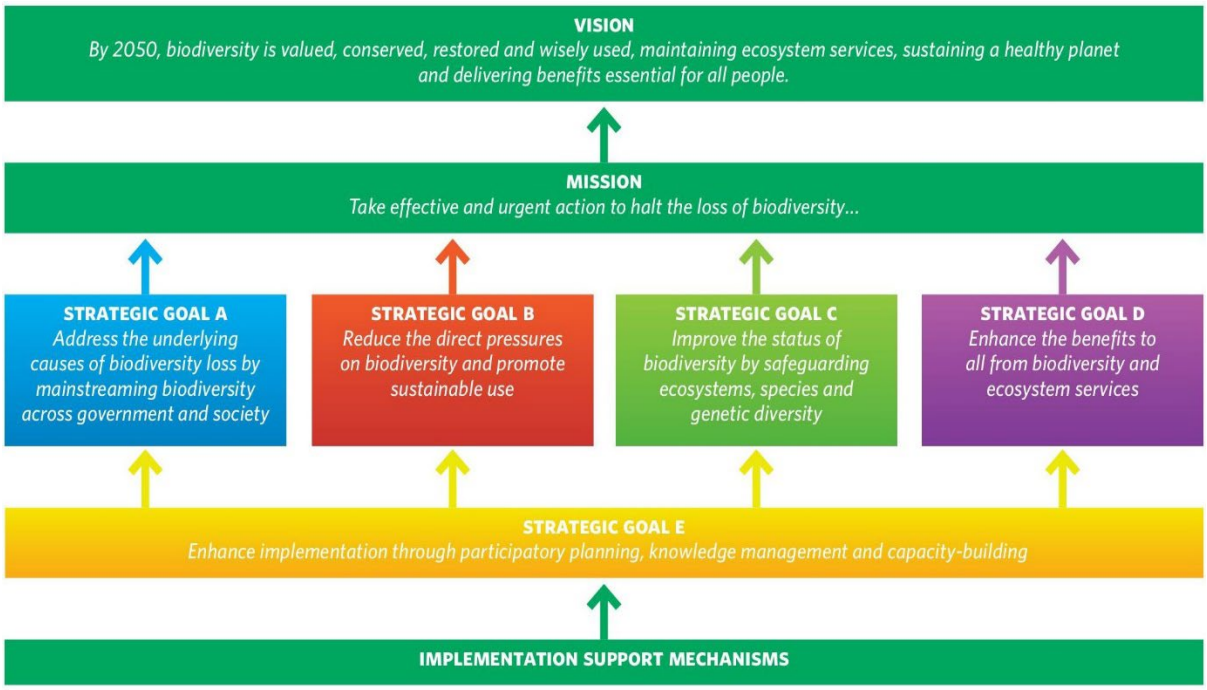
Scenario Name	Dominant Approach for Sustainability	Economic Approach	Social Policy Foci	Dominant Social Organisations
Global Orchestration	Sustainable development; economic growth; public goods.	Fairtrade with the enhancement of global public goods.	Improve world; global public health; global education.	Transnational companies; global NGOs and multilateral organisations.
Order from Strength	Reserves; parks; national-level policies; conservation	Regional trade blocs; mercantilism	Security and protection	Multinational companies
Adapting Mosaic	Local-regional co-management; common-property institutions.	Integration of local rules regulate trade; local nonmarket rights.	Local communities linked to global communities; local equity important.	Cooperatives, global organisations.
Techno Garden	Green technology; eco-efficiency; tradable ecological property rights.	Global reduction of tariff boundaries; fairly free movement of goods, capital, and people; global markets in ecological property.	Technical expertise valued; follow opportunity; competition; openness.	Transnational professional associations; NGOs.

Source: Alcamo et al., 2005

Another global biodiversity scenario exercise was conducted by the Global Biodiversity Outlook (GBO), published by the Convention on Biological Diversity (CBD), in 2014[9]. Their (quantitative) scenario analysis (see Figure 1) is based on two questions: (1) are the Aichi Biodiversity Targets likely to be attained by 2020? and (2) what is needed to achieve the strategic vision for 2050 of the Convention on Biological Diversity?

[9] For more information about the GBO scenarios see https://www.cbd.int/gbo/gbo4/publication/gbo4-en.pdf

Figure 1: The structure of the Strategic Plan for Biodiversity



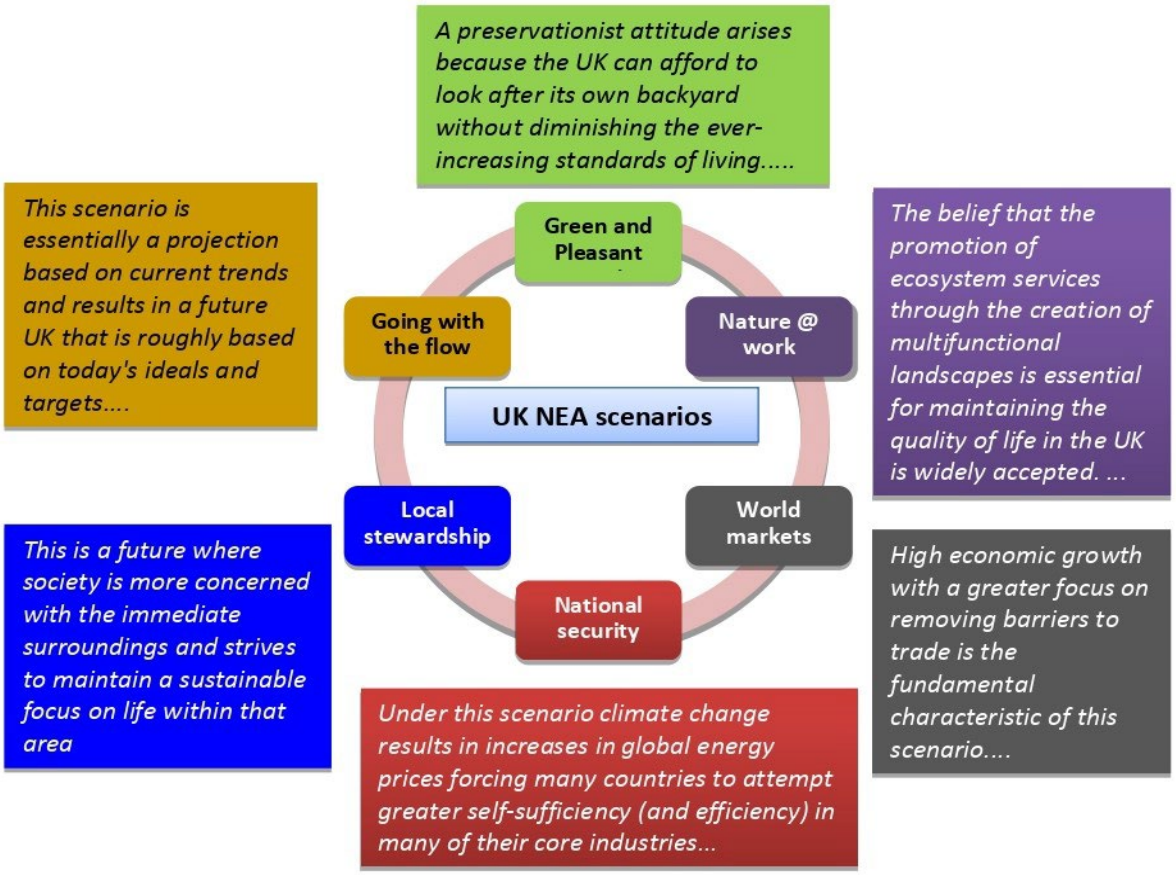
Source: Global Biodiversity Outlook 4 (2015).

At a national level, the United Kingdom employed a National Ecosystem Assessment (NEA, 2011)[10] with exploratory scenarios to examine what changes might occur in ecosystems, ecosystem services and the values of these services over the next 50 years. Figure 2 demonstrates an overview of the UK NEA scenarios.

These global and national biodiversity scenarios, however, may not be easily adapted for organisations, unless an entity operates in a single location. Rather, organisations are likely to have 'touch down' points across many locations (the sites where they operate) and in each location, biodiversity conditions and dynamics might be different.

[10] For more information about United Kingdom National Ecosystem Assessment see http://uknea.unep-wcmc.org/Resources/tabid/82/Default.aspx

Figure 2: An illustration of the UK NEA scenarios



Source: Haines-Young et al., (2014).

4. Organisation focused biodiversity scenarios

The TNFD[11] aims to help organisations understand and manage the financial risks and opportunities posed by nature-related issues by providing them with a standard framework for analysis. Central to this framework is the use of scenarios. The TNFD describe scenarios as hypothetical but plausible narratives that organisations can use to assess their exposure to nature-related risks and opportunities. The TNFD's championing of scenario analysis drew from the TCFD's use of climate scenario analysis frameworks. TNFD scenarios are anticipated to help organisations understand how factors (such as changes in biodiversity, ecosystem services, land use, and resource availability) may affect organisational operations, supply chains, and financial performance (TNFD, 2023a). Scenarios, therefore, are viewed as being valuable because they allow organisations to identify potential risks and to taking proactively mitigate risk. These scenarios often cover a range of possibilities, from best-case to worst-case outcomes, helping organisations to consider different outcomes that will inform action. TNFD scenarios might address environmental and social aspects that will shape the future such as the loss of critical habitats, disruptions in ecosystem services, regulatory changes, and market shifts related to biodiversity and nature. A typology of risks has been elucidated by the TNFD – see Table 3.

[11] TNFD aims to develop a framework that allows organisations to assess, manage, and report on their dependencies and impacts on nature in a way that is financially relevant. For more information see https://tnfd.global/

Table 3: Categories of nature-related risks

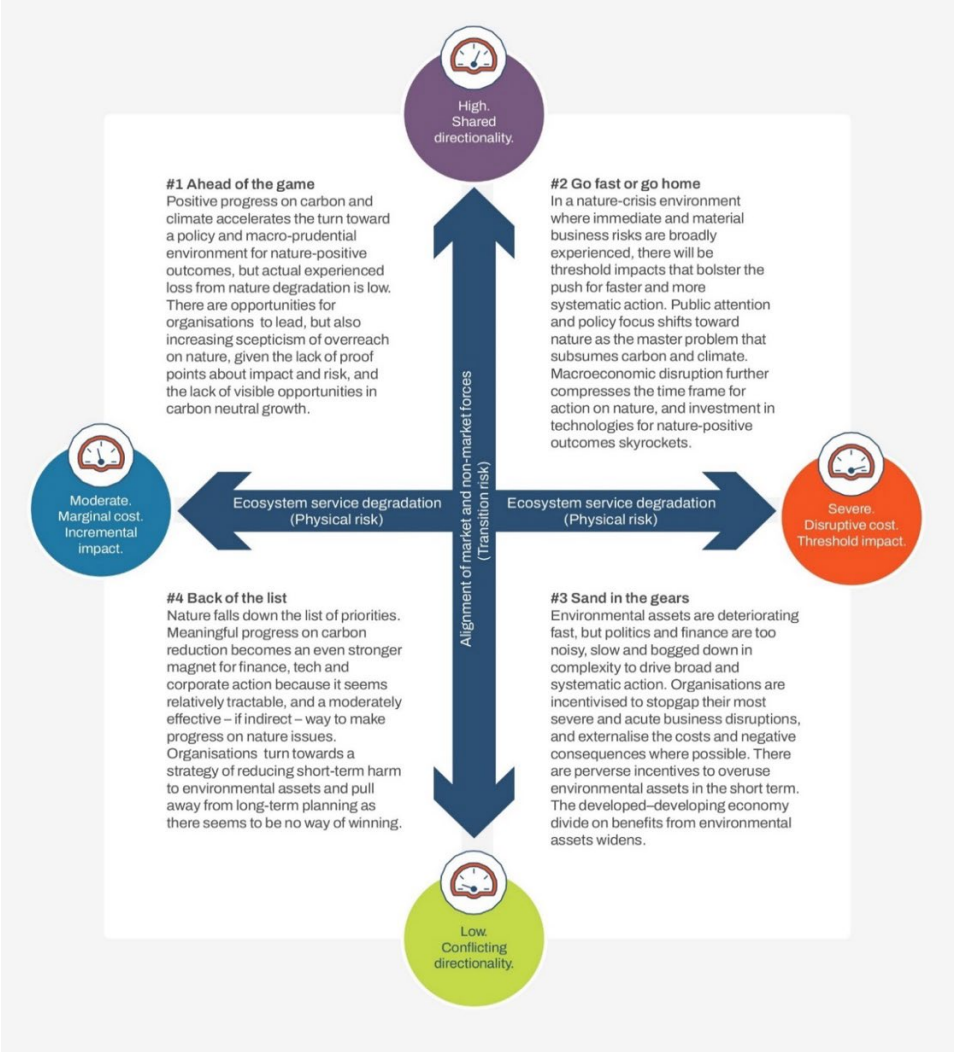
Risk type	Category	Description
Physical risk	Acute risks	Occurrence of short-term, specific events that change the state of nature. For example, oil spills, forest fires or pests affecting a harvest.
	Chronic risks	Chronic risks. Gradual changes to the state of nature. For example, pollution stemming from pesticide use or climate change.
Transition risk	Policy	Changes in the policy context due to new (or enforcement of existing) policies associated with creating positive impacts on nature or mitigating negative impacts on nature.
	Market	Changing dynamics in overall markets, including changes in consumer preferences, which arise from other risk categories because of changing physical, regulatory, technological and reputational conditions and stakeholder dynamics. For example, the market value of a company is affected by assets that have decreased in value because there is insufficient freshwater for the production process, or the value of the business production process is reduced by the emergence of new technologies that require less water to operate.
	Technology	Substitution of products or services with a reduced impact on nature and/or reduced dependency on nature. For example, the replacement of plastics with biodegradable containers.
	Reputational	Changes in perception concerning an organisation's actual or perceived nature impacts, including at the local, economic and societal level. This can result from direct company impacts, industry impacts and/or impacts of activities upstream and/or downstream in a value chain.
	Liability	Liability risks arising directly or indirectly from legal claims. As laws, regulations and case law related to an organisation's preparedness for nature action evolves, the incident or probability of contingent liabilities arising from an organisation may increase.

Source: TNFD Discussion paper on conducting advanced scenario analysis (TNFD, 2023b).

The TNFD recommends that scenario analysis take account of physical and transition risks (as appropriate). By putting physical risks and transition risks at the heart of scenario analysis, TNFD offers a tool for exploring future risks and opportunities related to biodiversity. Figure 3 reproduces the TNFD 2x2 'critical uncertainties' matrix[12] which generates four scenarios, each of which sketch a future in which a company might find itself operating. They focus on two elements: (1) the degradation of ecosystem services and its link to climate change (physical risks); and (2) the alignment between market and non-market forces, including impacts of climate and nature policies (transition risks). From these uncertainties, TNFD proposes four different scenario narratives, showcasing how organisations can use participatory processes to develop their own tailored future visions. The TNFD scenarios are not the only scenarios that an organisation could use to inform management action and support TNFD reporting. Other approaches will be discussed later in this paper.

[12] For more details about TNFD Scenario Toolkit see https://tnfd.global/toolkit-worksheet/tnfd-scenario-toolkit/

Figure 3: The TNFD critical uncertainties matrix



Source: TNFD guidance on scenario analysis (TNFD, 2023a).

In the TNFD guidance on scenario analysis (2023a), two different types of scenarios are presented, namely exploratory scenarios and normative scenarios (see Table 1 for the distinction) and they recommend the use of exploratory scenarios. The stated rationale for this approach is that normative approaches for biodiversity are harder to realise. Specifically, while normative climate scenarios have global common goals and targets to pursue (such as reducing global greenhouse gas emissions to hold global temperature increase to well below 2°C above pre-industrial levels and pursue efforts to limit it to 1.5°C above pre-industrial levels) this is less easy to envision for biodiversity. While globally agreed goals and targets exist, they are not yet specific enough to generate an anchor for a normative biodiversity scenario. The place-based specificity of biodiversity also inhibits the development of globally relevant objectives. This implies that an exploratory approach to developing nature scenarios would be most valuable in the first instance. Exploratory scenarios, guided by "what if?" questions, allow for the identification and aggregation of research and data to assess risks and opportunities related to nature loss in particular locations (TNFD 2023a).

5. Developing organisation-level biodiversity scenarios

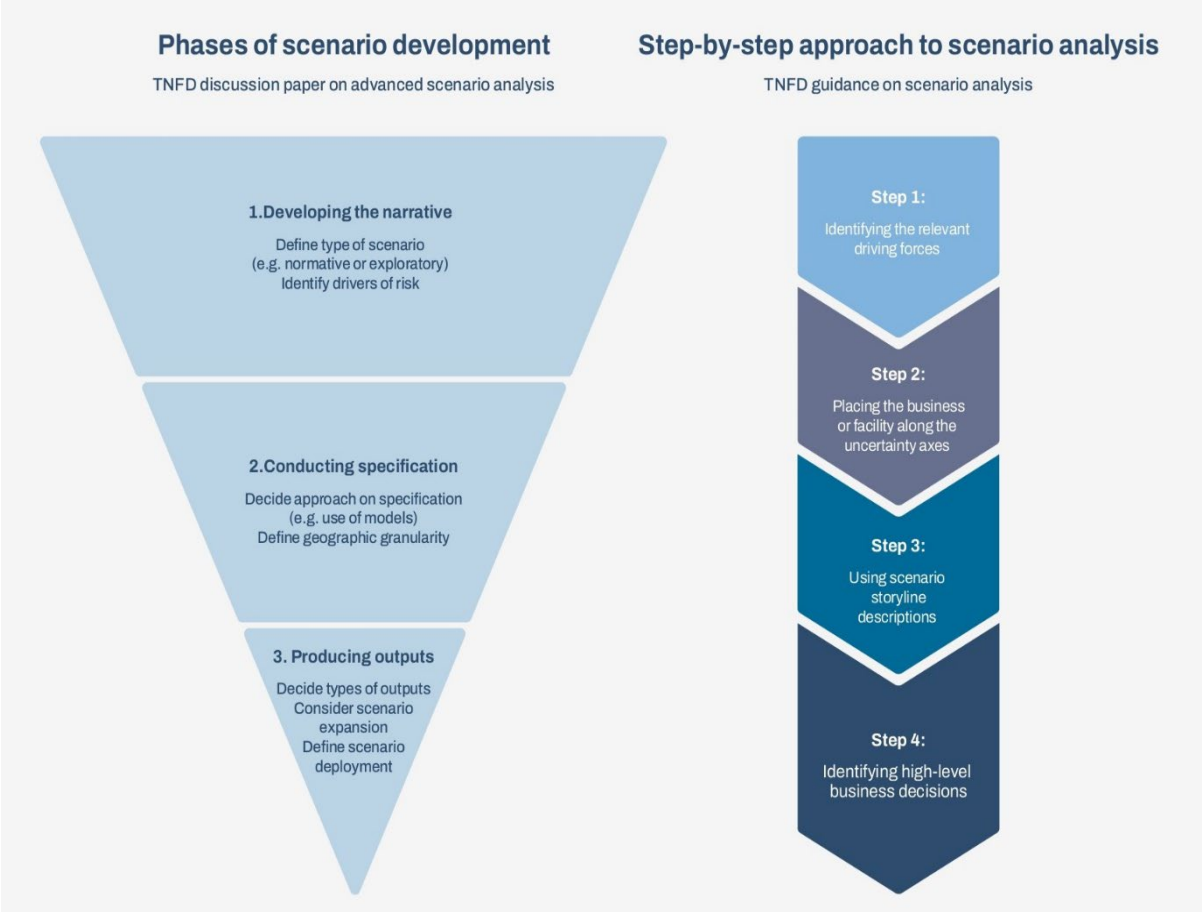
The TNFD also published a more detailed scenario guidance (TNFD, 2023b). This publication provides guidance on three phases of scenario development (see Figure 4), namely:

(1) developing the narrative: defining the type of scenario and identifying drivers of risk,
(2) conducting specification: deciding an approach to specification such as the use of models, and defining geographic granularity, and
(3) producing output: deciding types of outputs, considering scenario expansion, and defining scenario deployment.

These phases can be mapped to the TNFD's four steps to conducting scenario analysis which are:

(1) identifying the relevant driving forces,
(2) placing the organisation or facility along the uncertainty axes,
(3) using scenario storyline descriptions, and
(4) identifying high-level organisational decisions (see also Figure 4).

Figure 4: Phases of scenario development and step-by-step approach to scenario analysis



Source: TNFD Discussion paper on conducting advanced scenario analysis (TNFD, 2023b).

In Figure 4, the first three steps of the TNFD approach are most closely related to developing the narrative and conducting specification (phases 1 and 2). Step 4, however, is most closely linked to phase 3, as organisations utilise the narratives and specifications to uncover insights about how the scenario impacts their approach to operating and strategic decisions. Each phase can be described thus (and see Table 4 for the questions that emerge at each stage).

Developing the narrative (phase 1): Scenario narratives describe potential future developments encompassing social, political, macroeconomic, and environmental changes/trends. These can be created around key uncertainties that organisations might encounter in the future. Each narrative serves as a basis for detailing fundamental elements of a scenario and potential shifts in future risks for the organisations. These narratives do not predict the future; instead, they present plausible events, outlined through storylines to facilitate communication about the aspects explored. Within biodiversity scenarios, narratives serve to describe the characteristics of both the direct and indirect factors influencing nature loss or the economy.

Conducting specification (phase 2): The subsequent stage involves transforming biodiversity scenario narratives into outputs that are valuable for decision-making in organisational risk assessment by using related tools, models and methods. This phase encompasses generating diverse forms of qualitative and quantitative outputs. Qualitative outputs can include directional measures (such as an increase in demand for deforestation-free products or a reduction in deforestation) or categorical outputs (such as laws banning nature-harming practices). Quantitative outputs are based on numerical figures, such as hectares of deforestation in a particular jurisdiction or megatons of deforestation-linked commodities produced.

Producing outputs (phase 3): This phase focuses on ensuring scenarios are decision useful, highlighting different types of outputs. For example, a scenario output could be the directional trend of lower deforestation over time in some areas, which could be compared to trends in other areas. An example of a categorical variable could be the existence of a policy or regulation, such as the existence of laws banning certain practices that harm nature. In contrast, *quantitative outputs* could be a range of different metrics, including physical units, such as ecosystem quality or crop yield, or economic and financial units, such as amount of production, consumer demand or price of a commodity.

Finally, the time horizon of a scenario determines the time over which an organisation evaluates risks and opportunities which could also align with the scenario's scope. For example, the TNFD guidance identifies the year 2030 (the Global Biodiversity Framework's target date for halting and reversing nature loss) as a valuable checkpoint for nature scenario analyses.

Table 4: Scenarios questions across the TNFD phases

Scenario component	Theme	Scenario characteristics
Narrative (phase 1)	Type of scenario	Does the scenario describe what could happen or what should happen? • Is the scenario normative or exploratory? • How is the scenario aligned with the Kunming-Montreal GBF?
	Drivers of risk	What creates risk in the scenario? • Which drivers of risk does the scenario incorporate? Are there multiple sources of risk? Are they relevant to the organisation? • How does the scenario reflect changes in the state of nature? How are the IPBES drivers of nature change accounted for? • How does the scenario incorporate climate-related drivers of risk, if at all? • Are low-probability events incorporated in the narrative? Are tipping points, tail events or systemic risks accounted for?
Specification (phase 2)	Approach to specification	Is the scenario going to produce qualitative and/or quantitative outputs? • Which tools are used to create the scenario? (e.g. models, assumptions) How does the scenario treat different risks? • How are physical risks incorporated? Do the scenario's physical risks overlap with climate? • How are transition risks incorporated? Do the scenario's transition risks overlap with climate? • How are low-probability events treated? • How does the scenario account for opportunities? Which assumptions are used to link narratives to outputs? How are these formulated?
	Geographic granularity	Which locations is the scenario relevant for? What is the geographic granularity of the scenario? (e.g. global, country, local)
Outputs (phase 3)	Type of outputs	Are the scenario outputs qualitative or quantitative? Which kinds of variables are produced?
	Scenario expansion	Are the outputs at the right level of geographic granularity or do they need to be expanded? Do the outputs capture all of the driving forces that the organisation cares about?
	Scenario deployment	What is the scenario's time horizon? Are multiple years considered?

Source: TNFD Discussion paper on conducting advanced scenario analysis (TNFD, 2023b).

The TNFD guidance also emphasises that biodiversity risks and nature risks can overlap, prompting the usefulness of the integration of climate and nature-related risks within scenario narratives. Integrated narratives may blend climate drivers with biodiversity drivers, such as land protection and water scarcity. For instance, an integrated normative scenario could combine a 1.5°C target

with Global Biodiversity Framework (GBF) goals like 30x30[13] (TNFD, 2023b). Table 5 exemplifies risk drivers of climate and nature risk (in a non-exhaustive manner). For example, land protection policies can affect temperature rise, which subsequently influences water availability. Likewise, climate change may disrupt ecosystems, potentially pushing them towards critical thresholds and tipping points. Conversely, biodiversity loss diminishes the carbon storage capacity of ecosystems, exacerbating climate change.

Table 5: Sample risk drivers for climate and nature

Type of risk driver	Climate-related risk drivers	Nature-related risk drivers (additional to climate)
Physical risks	• Temperature rise • Extreme weather events • Rising sea levels	• Pollinator abundance • Soil quality • Water quality • Ocean pH
Transition risks	• Carbon pricing policy • Climate-related reporting obligations • Customer preferences for low-carbon goods and services • Climate performance affecting reputation	• Water supply • Land protection policy • Nature-related reporting obligations • Customer preferences for goods and services with a lower impact on nature • Nature performance affecting reputation

Source: TNFD discussion paper on conducting advanced scenario analysis (TNFD, 2023b).

An early adopter of TNFD, Kao Corporation, was the first organisation to use scenarios in their TNFD report. They used a climate scenario, Shared Socio-economic Pathways (SSPs), to develop their biodiversity scenarios (KAO, 2023)[14]. Hence, we also introduce SSPs scenarios here in addition to the borad scenarios developed by TNFD (see Figure 3). SSPs are a set of narrative-based scenarios that describe future socioeconomic development trajectories (combining aspects of demography, economic growth, technology and governance), reflecting different challenges for climate change mitigation and adaptation (Riahi et al., 2017; O'Neill et al., 2014; An et al., 2022). This approach generates five narrative scenarios (see Table 6).

[13] 30x30 challenges governments to designate 30% of the Earths land and ocean area as protected areas by 2030 (Lo & Jang, 2022).

[14] The full report is available at https://www.kao.com/content/dam/sites/kao/www-kao-com/global/en/sustainability/pdf/biodiversity-tnfd.pdf

Table 6: The summary of five SSP narratives

SSP1	**Sustainability – Taking the Green Road** ***(Low challenges to mitigation and adaptation)*** The world shifts gradually, but pervasively, toward a more sustainable path, emphasizing more inclusive development that respects perceived environmental boundaries. Management of the global commons slowly improves, educational and health investments accelerate the demographic transition, and the emphasis on economic growth shifts toward a broader emphasis on human well-being. Driven by an increasing commitment to achieving development goals, inequality is reduced both across and within countries. Consumption is oriented toward low material growth and lower resource and energy intensity.
SSP2	**Middle of the Road** ***(Medium challenges to mitigation and adaptation)*** The world follows a path in which social, economic, and technological trends do not shift markedly from historical patterns. Development and income growth proceeds unevenly, with some countries making relatively good progress while others fall short of expectations. Global and national institutions work toward but make slow progress in achieving sustainable development goals. Environmental systems experience degradation, although there are some improvements and overall the intensity of resource and energy use declines. Global population growth is moderate and levels off in the second half of the century. Income inequality persists or improves only slowly and challenges to reducing vulnerability to societal and environmental changes remain.
SSP3	**Regional Rivalry – A Rocky Road** ***(High challenges to mitigation and adaptation)*** A resurgent nationalism, concerns about competitiveness and security, and regional conflicts push countries to increasingly focus on domestic or, at most, regional issues. Policies shift over time to become increasingly oriented toward national and regional security issues. Countries focus on achieving energy and food security goals within their own regions at the expense of broader-based development. Investments in education and technological development decline. Economic development is slow, consumption is material-intensive, and inequalities persist or worsen over time. Population growth is low in industrialized and high in developing countries. A low international priority for addressing environmental concerns leads to strong environmental degradation in some regions.
SSP4	**Inequality – A Road Divided** ***(Low challenges to mitigation, high challenges to adaptation)*** Highly unequal investments in human capital, combined with increasing disparities in economic opportunity and political power, lead to increasing inequalities and stratification both across and within countries. Over time, a gap widens between an internationally connected society that contributes to knowledge- and capital-intensive sectors of the global economy, and a fragmented collection of lower-income, poorly educated societies that work in a labour-intensive, low-tech economy. Social cohesion degrades and conflict and unrest become increasingly common. Technology development is high in the high-tech economy and sectors. The globally connected energy sector diversifies, with investments in both carbon-intensive fuels like coal and unconventional oil, but also low-carbon energy sources. Environmental policies focus on local issues around middle and high-income areas.
SSP5	**Fossil-fueled Development – Taking the Highway** ***(High challenges to mitigation, low challenges to adaptation)*** This world places increasing faith in competitive markets, innovation and participatory societies to produce rapid technological progress and development of human capital as the path to sustainable development. Global markets are increasingly integrated. There are also strong investments in health, education, and institutions to enhance human and social capital. At the same time, the push for economic and social development is coupled with the exploitation of abundant fossil fuel resources and the adoption of resource and energy-intensive lifestyles around the world. All these factors lead to rapid growth of the global economy, while the global population peaks and declines in the 21st century. Local environmental problems like air pollution are successfully managed. There is faith in the ability to effectively manage social and ecological systems, including by geo-engineering if necessary.

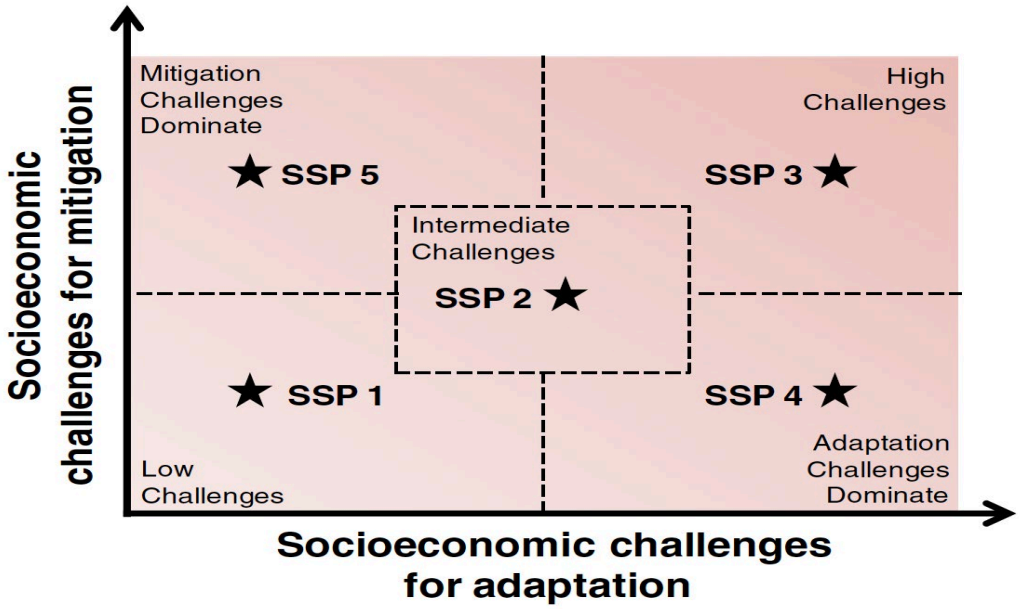
Source: Riahi et al., (2017).

SSPs encompass both narratives (qualitative descriptions) and model-based quantifications of potential future trends such as population growth and economic development. SSPs' five scenarios characteristics articulate uncertainties associated with mitigation and adaptation policies related to different climate and socio-economic futures, thereby, describing the "conditions that will make it more or less difficult for countries to manage a transition to a low-carbon economy" (Maurin et al., 2022, p.11-12).

To ensure that the SSPs adequately capture the full range of potential outcomes and effectively capture the uncertainties associated with climate change mitigation, adaptation, and impacts, O'Neill et al. (2014) define an outcome space that positions socioeconomic and environmental challenges on two axes: one axis for adaptation challenges and the other for mitigation challenges (see Figure 5). This approach allows for a more nuanced understanding of how changes in socioeconomic conditions can influence the effectiveness of climate change mitigation and adaptation efforts. The term "socioeconomic" encompasses a broad spectrum of factors related to society, including demographics, politics, social structures, culture, institutions, lifestyles, economics, and technology. However, it excludes variables directly related to future climate change itself, including ecological factors such as biodiversity. O'Neill et al., (2014, p.390) note that although "climate change and biodiversity in reality interact, the SSP describes a hypothetical future in which biodiversity is not affected by further climate change, so that scenarios can then be developed to estimate the effect of future climate change on biodiversity". SSPs have been combined with other scenarios or climate models to produce a scenario matrix for a better evaluation of different climate policy strategies. For example, SSPs have been combined with climate change Representative Concentration Pathways (RCPs) (van Vuuren et al., 2011; An et al., 2022b; Su et al., 2021).[15] SSPs have also been combined with Integrated Assessment models (Riahi et al., 2015; Wei et al., 2018; Yang and Cui, 2019) to provide a quantitative analysis of key human-Earth system interactions, aiming to inform policy decisions on global environmental change and sustainable development. These models incorporate data from diverse scientific disciplines for a holistic understanding of the coupled human-Earth system.

[15] RCPs are sets of scenarios describing how much greenhouse gases could change and how land might be used, leading to different possible future climates. Climate modelling communities use RCP scenarios to model and anticipate the impacts of climate change.

Figure 5: Five shared socioeconomic pathways (SSPs)



Source: O'Neill et. al. (2014).

The SSPs have also been used to produce biodiversity scenarios at the global or regional level. As highlighted by Maurin et al. (2022), SSPs offer narratives that outline the direct and indirect drivers of biodiversity loss (apart from invasive species pressures). The literature on SSPs has focused on two direct drivers of biodiversity loss: land use and climate change. For example, several bodies, such as the Millennium Ecosystem Assessment (MEA), Global Biodiversity Outlook (GBO), multiple iterations of the Global Environmental Outlook (GEO), and the Intergovernmental Panel on Climate Change (IPCC), have applied scenario analyses to evaluate how socio-economic development paths influence land use, climate change, and their subsequent effects on biodiversity loss. These assessments utilise SSPs and RCPs to quantify the biodiversity and ecosystem services resulting from different scenarios (Pereira et al., 2010; Kim et al., 2018). The main reason for using these two main drivers of biodiversity loss (land use and climate change) to generate biodiversity scenarios is the availability of their quantitative data (Di Marco et al., 2019; Nunez et al., 2020; Simkin et al., 2022; Chaudhary and Mooers, 2018). What this approach leaves unaddressed are biodiversity changes arising from other drivers, such as direct exploitation and invasive species impacts (which have been identified by IPBES as relevant). Depending on the sector in question, these drivers might be more important than land use change and climate change impacts.

6. Summary

In summary, scenario analysis is a longstanding technique that is used to create a range of outcomes that might arise in the future. These potential outcomes are generated from combining, different pressures/drivers/trends that will impact future outcomes. Scenario analysis is not a singular activity. Rather, there are several forms of scenario analysis ranging from exploratory-narrative scenarios to more quantitative modelling of potential future operating environments. Scenarios have been developed with a variety of foci, including socio-economic conditions and climatic regimes. They have also been developed to inform thinking about nature conditions and biodiversity outcomes. This paper summarises what kinds of scenarios exist and how biodiversity scenarios might develop.

Developing biodiversity scenarios that can be used in organisational settings is going to be a complex undertaking and there are many pitfalls that need to be guarded against. It is unlikely that detailed quantitative scenarios can be develop easily (at least not for an organisation of any size with multiple operating sites and global supply chains). This means that it is likely that qualitative and exploratory scenarios will be the most robust approach in the first instance.

Reductionist thinking also needs to be avoided because the natural system acts as a whole and a wider systems appreciation of the context in which future business may evolve is required. There is a danger of confirmation bias where a scenario exercise will evolve in such a way to confirm what a company believes it already knows. There is also a danger that a scenario process might focus on issues from which a company might already have some solutions for. Likewise, focusing narrowly on drivers of change that are well understood and for which resources exist will not be useful for all organisations and sectors. Finally, it is worth remembering that the loss of biodiversity is such that 'business as usual' with some small changes will not be adequate. Well-developed scenario analyses should prompt strategic approaches from organisations' thinking.

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