

# Draft sector guidance

## Technology and communications

January 2026

Open for consultation and feedback

### SICS® industry:

Electronic manufacturing services & original design manufacturing (TC-ES)

Hardware (TC-HW)

Internet media & services (TC-IM)

Semiconductors (TC-SC)

Software & IT services (TC-SI)

Telecommunication services (TC-TL)



Taskforce on Nature-related  
Financial Disclosures



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## Draft sector guidance – open for consultation

This sector guidance is a draft for consultation with market participants and other interested stakeholders. The Taskforce welcomes feedback provided via the [TNFD website](#) by **10 April 2026**, where you will find questions to guide your comments and suggestions

Feedback will be reviewed by the Taskforce and final sector guidance issued by the TNFD by 30 June 2026.



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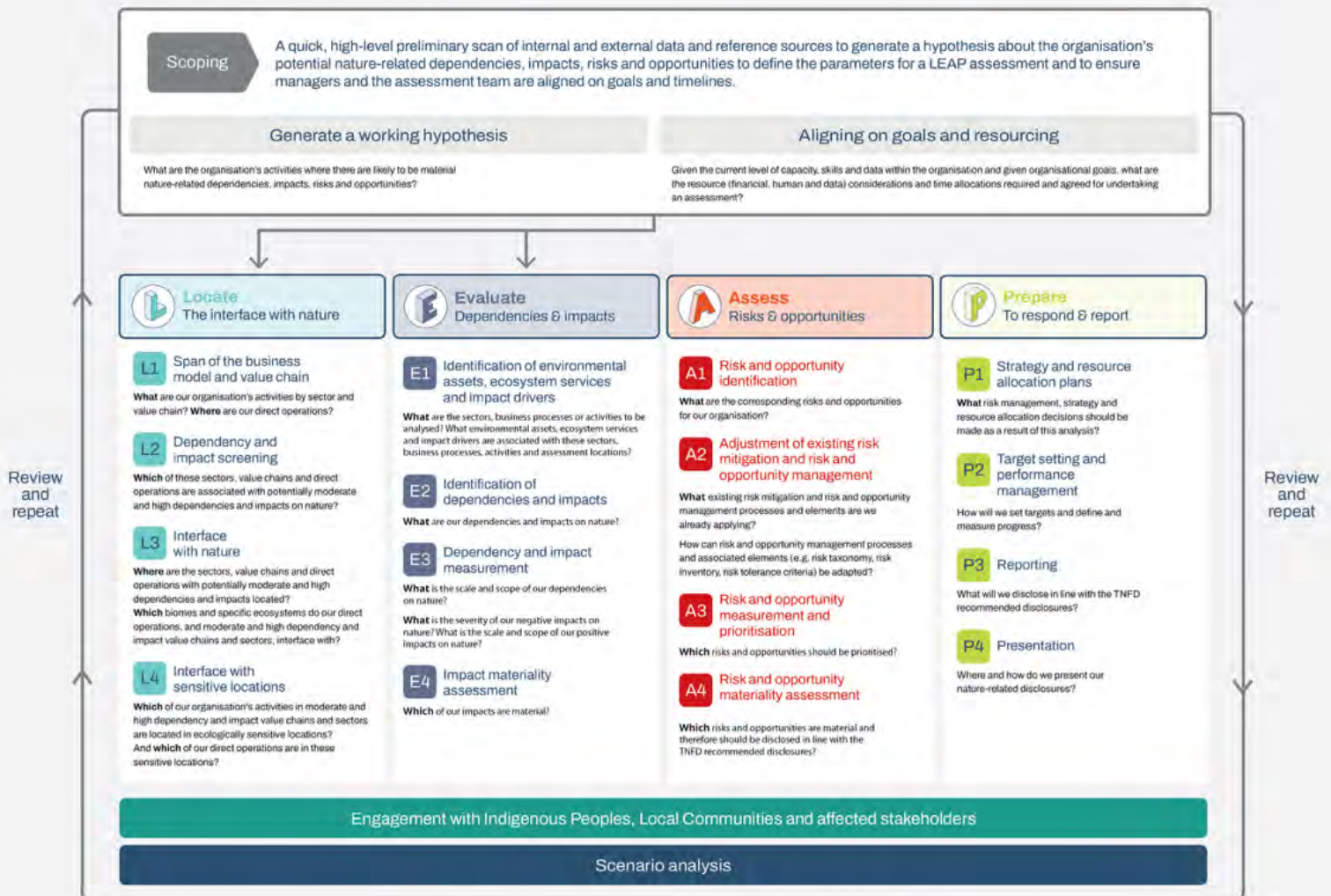
# 1. Introduction

## 1.1. The purpose of this guidance

In September 2023, the TNFD published its [recommendations](#) for disclosure of nature-related issues and supporting implementation guidance. This document provides additional guidance for the technology and communications sector, covering:

- The **assessment of nature-related issues** (dependencies, impacts, risks and opportunities) using the TNFD’s LEAP approach (Section 2); and
- The **disclosure of sector-specific metrics** in line with the TNFD’s recommended approach to metrics (Section 3).

**Figure 1: The TNFD approach for identification and assessment of nature-related issues – LEAP**



The TNFD recognises that there can be significant differences across sectors for organisations applying the LEAP approach.

It has published this additional guidance with input from a range of knowledge partners and market participants to help technology and communications sector participants apply the LEAP approach to their context. The structure of the LEAP approach is set out in Figure 1 above. The guidance in [Section 2](#) follows that structure.

The Taskforce recognises that investors and other stakeholders require quantitative information to compare performance and nature-related issues within sectors. To facilitate that analysis, [Section 3](#) covers:

- Guidance on the application of the core global disclosure indicators and metrics to the technology and communications sector (Section 3.1); and
- Core and additional sector disclosure indicators and metrics (Sections 3.2 and 3.3).

**Figure 2: TNFD disclosure metrics architecture signposted to metrics list**

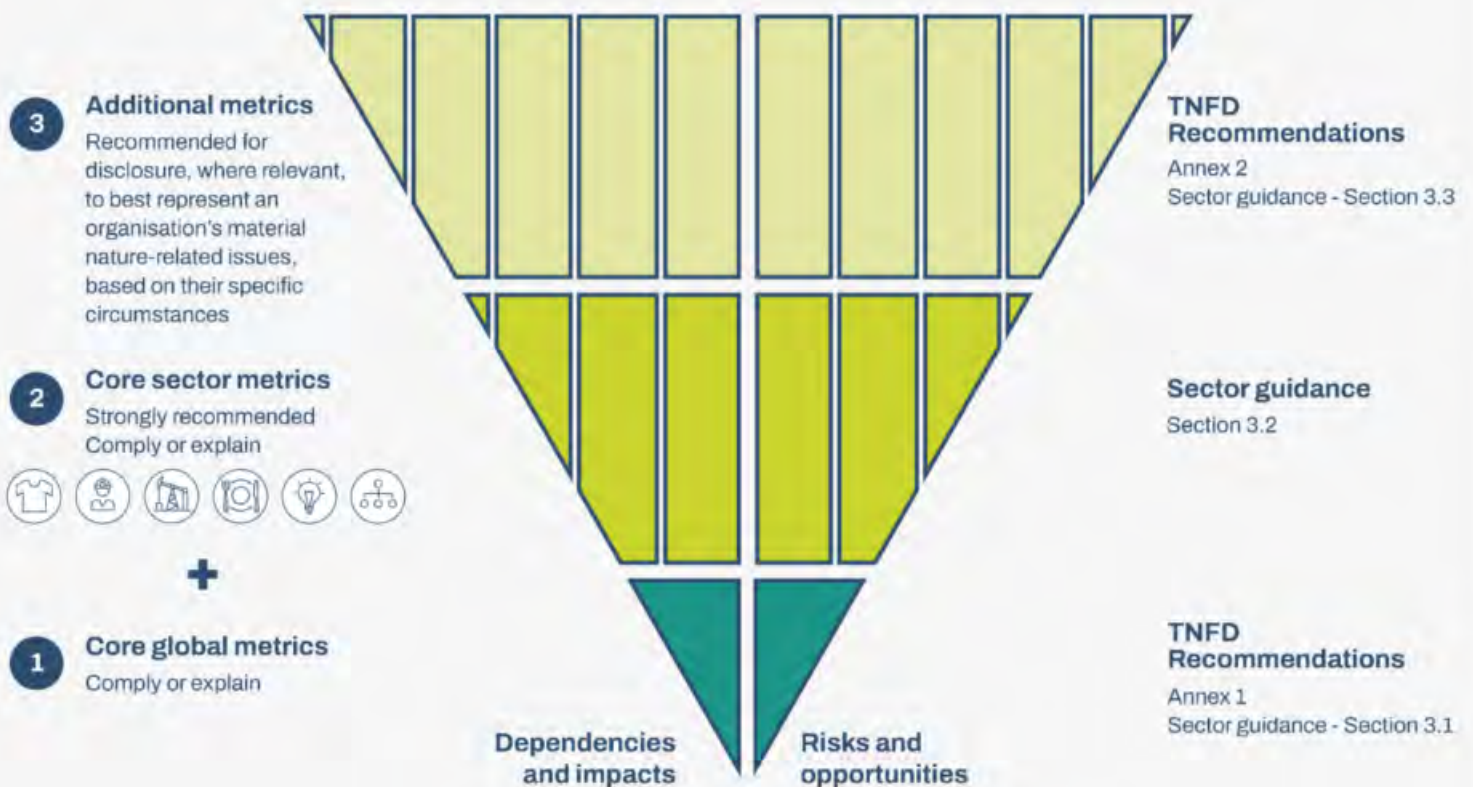


Figure 2 provides an overview of the TNFD disclosure measurement architecture and where indicators and metrics are listed in the [TNFD recommendations](#) and in the sector guidance.



The guidance in Section 3 expands on the disclosure indicators and metrics outlined in Annexes 1 and 2 of the [TNFD recommendations](#) and adds sector-specific information where relevant. The TNFD has incorporated and sought to build on existing industry standards and disclosure metrics wherever possible to leverage current data collection and reporting practices and minimise assessment and reporting costs.

## 1.2. Audience for this guidance

This guidance covers organisations with business models or value chains in the Sustainable Industry Classification System (SICS<sup>®</sup>) Technology & Communications sector. It is relevant to all six industries in this sector: Electronic Manufacturing Services & Original Design Manufacturing; Hardware; Internet Media & Services; Semiconductors; Software & IT Services; and Telecommunication Services, as outlined in [Annex 1](#).

[Figure 3](#) in Section 2 illustrates the value chain that organisations should consider as part of their value chain mapping. It covers all industries in the Technology & Communications SICS<sup>®</sup> sector, while showing the value chain from a nature perspective, from raw materials to end-of-life and circularity. The figure distinguishes ‘manufacture & processing’ from ‘products & services’ to clarify where nature-related dependencies and impacts may arise. For example, consumer electronics are shown within products and services although they sit within the SICS<sup>®</sup> Hardware category. It also makes explicit the role of physical infrastructure, including datacentres (commonly associated with Software & IT Services, but also enabling Internet Media & Services) and telecommunications infrastructure (critical for nature-related issues, though considered within Telecommunication Services in SICS<sup>®</sup>).

This guidance is a supplement to the TNFD’s [Guidance on the identification and assessment of nature-related issues: The LEAP approach](#) and should be read in conjunction with that guidance. Organisations in the technology and communications sector may also find it helpful to refer to the [TNFD biome guidance](#) and [Guidance on engagement with Indigenous Peoples, Local Communities and affected stakeholders](#) to support their assessment. They should also consider interactions with other sectors and can refer to TNFD sector guidance on [metals and mining](#), [engineering, construction and real estate](#), [construction materials](#) and [electric utilities and power generators](#), among others.

The examples in this guidance are intended to be illustrative. They are not exhaustive, universally applicable or recommended for all organisations within the sector. Each organisation’s context, location and interactions with nature are unique. The TNFD encourages all organisations to consult additional sources, including scientific references, industry standards or best practice guides to conduct thorough assessments specific to their operations and value chains. This guidance aims to support, not replace, a tailored assessment, which will be necessary for each organisation.

**Table 1: Areas of LEAP with additional guidance for the technology and communications sector in this guidance document**

<b>Scoping</b>	<input checked="" type="checkbox"/>						
L1	<input checked="" type="checkbox"/>	E1	<input checked="" type="checkbox"/>	A1	<input checked="" type="checkbox"/>	P1	<input checked="" type="checkbox"/>
L2	<input checked="" type="checkbox"/>	E2	<input checked="" type="checkbox"/>	A2	<input type="checkbox"/>	P2	<input checked="" type="checkbox"/>
L3	<input checked="" type="checkbox"/>	E3	<input type="checkbox"/>	A3	<input type="checkbox"/>	P3	<input checked="" type="checkbox"/>
L4	<input checked="" type="checkbox"/>	E4	<input type="checkbox"/>	A4	<input type="checkbox"/>	P4	<input type="checkbox"/>

### 1.3. Sector background

#### Technology’s growing role in the global economy

Technology and communications underpin almost every aspect of modern economic activity and daily life. Demand for digital infrastructure, electronic devices, data processing and connectivity has grown rapidly and is expected to continue to grow, driven by digitalisation, electrification, cloud computing and artificial intelligence. This positions the technology and communications sector as a critical enabler of broader economic development, while increasing the exposure of companies, insurers, capital providers and other stakeholders to nature-related risks.

Across key industries, scale and growth are substantial:

- Around one trillion semiconductors are sold annually<sup>1</sup>, with recent production concentrated in a limited number of geographies.<sup>2</sup>
- More than 11,000 datacentres are operating worldwide, with demand for datacentre capacity expected to grow by approximately 20% per year to 2030.<sup>3</sup>
- The electronic manufacturing services market size stood at USD 647.18 billion in 2025 and is forecast to expand to USD 863.13 billion by 2030 at a 5.93% CAGR.<sup>4</sup>
- Global datacentre build-out is forecast to require around USD 3 trillion by 2030,<sup>5</sup> and global semiconductor chip fabrication plant (fab) spending from 2024 to 2030 is forecast to exceed USD 1.5 trillion.<sup>6</sup>

#### Technology’s relation with nature – dependencies, impacts, financial materiality

The resilience of this sector depends on nature. No semiconductors can be produced without massive volumes of ultrapure water and datacentres are highly dependent on water

<sup>1</sup> SIA (2019) [Global Semiconductor Sales Increase 13.7 Percent to \\$468.8 Billion in 2018](#).

<sup>2</sup> OECD (2025) [The chip landscape geographical distribution of wafer fabrication capacity](#).

<sup>3</sup> Barclays Investment Bank (2025) [AI revolution: Meeting massive AI infrastructure demands](#).

<sup>4</sup> Mordor Intelligence (2026) [Electronics Manufacturing Services Market Size & Share Analysis - Growth Trends and Forecast \(2026 - 2031\)](#).

<sup>5</sup> JLL (2026) [2026 Global Data Center Outlook](#).

<sup>6</sup> PwC (2026) [Semiconductor and beyond 2026](#).

for cooling and for energy. Much of the manufacturing and technological infrastructure is sensitive to droughts and floods, which healthy ecosystems can buffer against. The sector's growth is itself creating a rapidly accelerating impact on nature, which risks eating into the very natural capital it relies upon. Some of the most material impacts include drivers of land use change, water use, minerals and metals extraction and pollution, including of air, soil and water across the value chain.

- **Land use change:** An estimated 160 km<sup>2</sup> of 'powered land' will be needed to support projected datacentre growth over the next five years.<sup>7</sup> An individual datacentre may require two to three square kilometres of land for about one gigawatt of power, with the energy use also requiring significant water resources.<sup>8</sup> Meanwhile, telecommunications towers and subsea cables require space across land and seascapes.
- **Dependence and impact on water basins:** Dependencies and impacts on water basins are highly material. A typical datacentre can use 25 million to 770 million litres of water per year (depending on size),<sup>9</sup> while hyperscale facilities may exceed 2 billion litres annually.<sup>10</sup> Semiconductor manufacturing is even more water intensive: an average single chip fabrication can use around 38 million litres of ultrapure water per day.<sup>11</sup> Healthy watersheds and groundwater sources are crucial for consistent water supply, particularly in the face of droughts or water scarcity. Where operations are located in water-stressed regions, this dependency creates exposure to physical risks such as water scarcity, declining water quality and operational disruption. Over-exploitation of water basins can have major implications for nature and for people – for cities and local communities that rely on healthy water basins, for example, for drinking water and irrigation of crops.
- **Metals and critical minerals:** Semiconductor and electronics manufacturing depend on a wide range of metals and critical minerals, linking the sector to upstream mining-related impacts on land use, pollution, and biodiversity loss, as well as to supply chain concentration and geopolitical risk.
- **Waste streams:** Hardware and electronics manufacturing generate substantial waste streams, including hazardous waste. By 2030, global e-waste is expected to reach 82 billion kg, representing almost 30% growth compared with 2024. Today only about 22% is formally collected and processed in an environmentally responsible manner.<sup>12</sup> Limited recycling rates and waste management practices can result in pollution of soils

<sup>7</sup> Hines Research (2025) [Power Play: The Emerging Powered Land Opportunity](#).

<sup>8</sup> WEF (2025) [Nature Positive: Role of the Technology Sector](#).

<sup>9</sup> Ceres (2025) [Drained by Data: The Cumulative Impact of Data Centers on Regional Water Stress](#).

<sup>10</sup> WEF (2025) [Nature Positive: Role of the Technology Sector](#).

<sup>11</sup> Ceres (2025) [Drained by Data: The Cumulative Impact of Data Centers on Regional Water Stress](#).

<sup>12</sup> Cordelis, P. et al. (2024) [The Global E-waste Monitor 2024](#).



and water bodies, while insufficient circularity can increase pressure on upstream resource extraction and downstream disposal systems.

- **Natural hazard mitigation:** Healthy ecosystems can reduce hazard exposure and support operational resilience. Intact watersheds, wetlands, floodplains and coastal ecosystems can help regulate water flows, reduce flood peaks, limit erosion and sedimentation, improve water quality and sustain groundwater recharge. Investing in nature-based solutions helps buffer the impacts of droughts and extreme rainfall events that can disrupt fab operations, datacentre cooling and wider supply chains.

Dependencies and impacts can occur outside direct operational control but often remain within large companies' scope through sourcing decisions and contractual relationships. The entire technology and communication sector's value chain is interdependent.

Semiconductors require massive volumes of raw materials and water. All electronic hardware, from smaller consumer electronics to large datacentres, contain semiconductors. Software and IT services and internet media and services, are fully dependent on large-scale computing, data storage and video streaming, making 24/7 operational datacentres central to their business model. Telecommunications rely on related network infrastructure with mobile networks and transmission systems.

These dependencies and impacts on nature are also highly financially material. For example, the World Economic Forum reported that since May 2024, USD 64 billion worth of planned US datacentre projects have been blocked or delayed, largely due to local concerns, including concerns about the demand on natural resources and power.<sup>13</sup> The sector's use of water and land is closely linked to energy demand, reinforcing the financial risks and underscoring the importance of considering the climate-nature nexus in decision-making, investments and transition planning.

At the same time, the technology sector can contribute to nature-positive outcomes. Digital technologies, data analytics, sensors, connectivity and software are critical for mapping, monitoring and managing nature-related dependencies and impacts, both within the sector itself and across the wider economy. As highlighted in recent analyses, technology can enable more efficient use of land, water, energy and materials, improve transparency and traceability across value chains, support environmental monitoring and early-warning systems and facilitate better decision-making by businesses, financial institutions, governments, Indigenous Peoples and local communities.

Many of the most material nature-related challenges – land use change, water stewardship, responsible sourcing of materials, circularity and energy efficiency – cannot be addressed by individual companies alone. Collaboration across value chains – with suppliers, customers, utilities, local communities and policymakers – is essential to reduce cumulative

<sup>13</sup> WEF (2025) [Nature Positive: Role of the Technology Sector](#).



impacts and strengthen resilience. The right disclosures should help organisations to demonstrate the results of such collective action.

### **The role of this guidance**

Understanding nature-related dependencies, impacts, risks and opportunities across the full technology value chain is essential. Where the previously mentioned [WEF report](#) provides a general overview of how to think about nature risks and opportunities in the technology sector, this guidance is designed to support organisations in identifying, assessing and disclosing risks and opportunities from the most material nature-related issues and responding in ways that strengthen both business resilience and contributions to nature-positive outcomes.

## 2. Sector-specific LEAP assessment guidance

This guidance is a supplement to the TNFD's [Guidance on the identification and assessment of nature-related issues: The LEAP approach](#) and should be read in conjunction with that guidance.

### Box 1 - Undertaking a LEAP assessment

Organisations should undertake a robust assessment of nature-related issues to inform their disclosures. The TNFD recommends [applying the LEAP approach](#) for this purpose. This section 2 provides additional sector-specific guidance on applying LEAP for technology and communications organisations seeking support in structuring or strengthening their assessment.

Organisations with established processes and strong experience in assessing nature-related issues (including those already applying LEAP) may choose to proceed directly to [Section 3](#) for guidance on sector-specific metrics to disclose.

### 2.1. Scoping a LEAP assessment

This section provides additional guidance to help technology and communications organisations with the Locate phase of the LEAP approach.

**Working hypothesis generation:** What are the organisation's activities where there are likely to be material nature-related dependencies, impacts, risks and opportunities?

#### Value chain considerations when scoping

A technology and communications organisation may operate across different sites and/or have different suppliers and consumers across its value chain that have significant potential nature-related dependencies and impacts.

Many large technology and communications organisations are already required by regulators and investors to assess and disclose across their global enterprises and value chains. However, smaller organisations new to disclosures on nature may choose to start with a narrow scope to create a manageable starting point for the assessment. This could be a small number of high priority sites or areas of the value chain where material nature-related dependencies, impacts, risks and opportunities are most likely to arise. The LEAP approach is designed as an iterative process in line with established risk management



processes and corporate reporting cycles. Organisations may expand the breadth and depth of the assessment over time as they gain experience and maturity in applying the process. Further guidance is available in the [TNFD guidance on value chains](#).

**Goals and resource alignment:** Given the current level of capacity, skills and data within the organisation and given the organisational goals, what are the resource (financial, human and data) considerations and time allocations required and agreed for undertaking an assessment?

### **Data and stakeholders**

The organisation should consider what existing nature, water, biodiversity or climate strategies it has in place and what data are already collected as part of these policies and for regulatory compliance. This should include data collected from suppliers, data from regulatory processes (e.g. Environmental Impact Assessments) and from other sustainability and supply chain engagements that may already provide information relevant to an assessment using the LEAP approach. Key internal stakeholders will also need to be engaged, including but not limited to sustainability teams.



## 2.2. Locate the organisation's interface with nature

This section provides additional guidance to help technology and communications organisations with the Locate phase of the LEAP approach.

### L1: Span of the business model and value chain

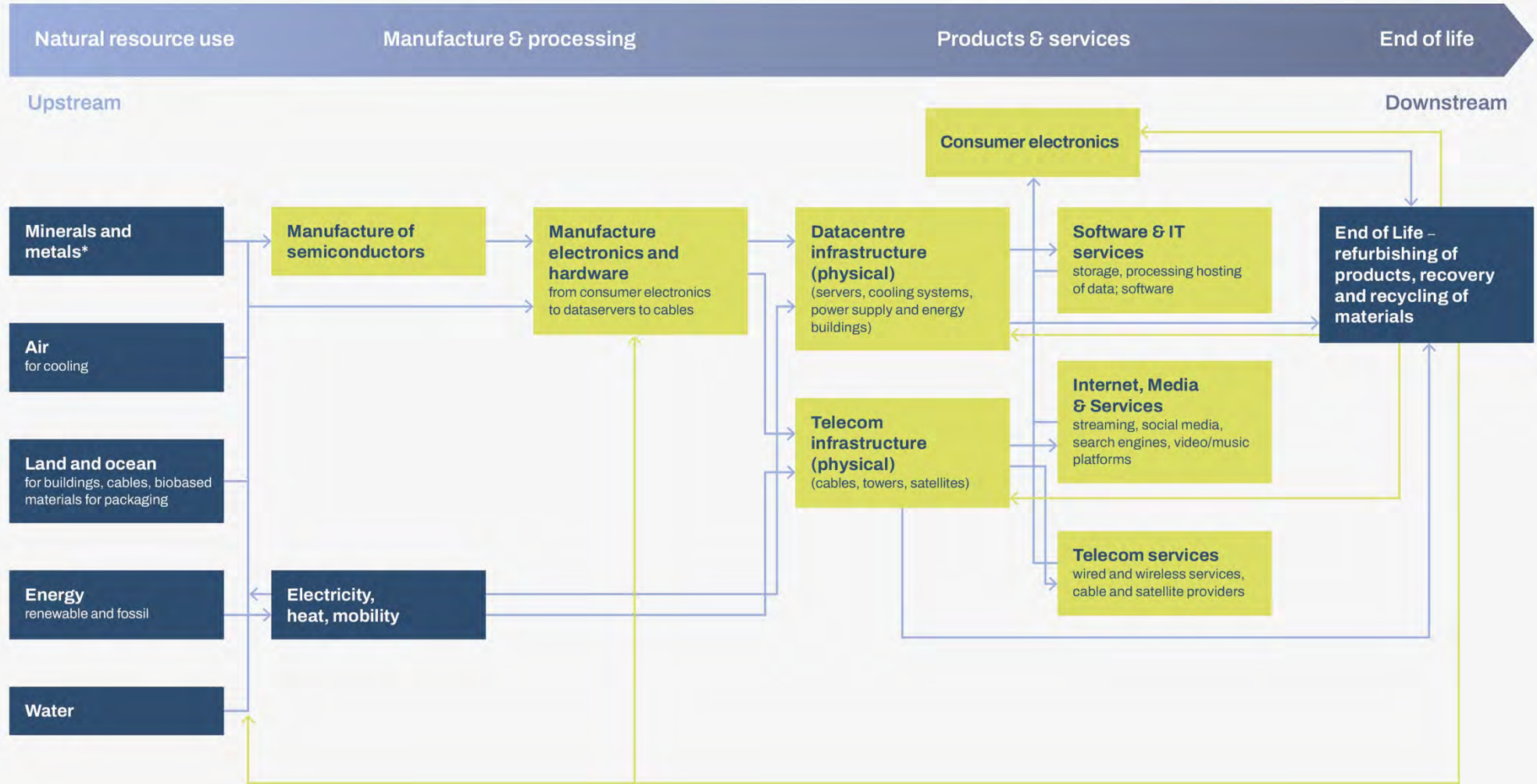
**Guiding questions:** What are our organisation's activities by sector, value chain and geography? Where are our direct operations?

Figure 3 illustrates the value chain that organisations in the sector should consider as part of their value chain mapping. For the technology and communications sector, this typically requires locating activities and assets across multiple value chain segments, such as the extraction and processing of minerals and metals, manufacturing of semiconductors, hardware and other equipment, the siting and operation of datacentres and telecom infrastructure and end-of-life processing and waste management. These activities may occur across multiple geographies and biomes and are often spatially disconnected from the organisation's headquarters or core business functions.

The TNFD recognises that the activities that are part of an individual organisation's direct operations, or upstream or downstream, will vary depending on its specific business. In L1 it is crucial that organisations look beyond their direct operations to the most material dependencies and impacts in the value chain. For large software and IT, internet, media and telecom service companies, such priorities are often upstream, including through datacentres (whether owned, leased or otherwise contracted) and semiconductor fabs or downstream in e-waste management.



**Figure 3: Technology and communications value chain**



Coloured boxes are direct operations within scope of TNFD Technology Sector guidance

\*Refer to TNFD sector guidance on Mining and Metals



Table 2 below should be considered in relation to the value chain graphic in Figure 3. It highlights where organisations in the technology and communications sector should identify locations at different stages of the value chain.

**Table 2: Identifying locations across the technology and communications value chain**

Industry	Inputs/Upstream	Direct operations	OutputsDownstream
Semiconductors	<ul style="list-style-type: none"> <li>Raw materials mining, refining, conversion and processing</li> <li>Water supply for manufacturing</li> </ul>	<ul style="list-style-type: none"> <li>Fabrication plants</li> <li>Semiconductor manufacturing and processing</li> </ul>	<ul style="list-style-type: none"> <li>Wastewater management</li> <li>Chemical waste management</li> <li>Other waste management</li> </ul>
Manufacture of electronics and hardware	<ul style="list-style-type: none"> <li>Raw materials mining, refining, conversion and processing</li> <li>Semiconductors manufacturing</li> <li>Energy supply from suppliers, manufacturing, production, packaging and transportation</li> </ul>	<ul style="list-style-type: none"> <li>Electronic equipment and components manufacturing and processing</li> <li>Water supply for manufacturing electronic components</li> </ul>	<ul style="list-style-type: none"> <li>Wastewater management</li> <li>Chemical waste management</li> <li>E-waste management</li> <li>Other waste management</li> </ul>
Datacentres (infrastructure)	<ul style="list-style-type: none"> <li>Raw materials mining, refining, conversion and processing</li> <li>Electronic equipment and components manufacturing</li> <li>Water supply (direct and through energy procurement)</li> </ul>	<ul style="list-style-type: none"> <li>Datacentre construction and expansion of new facilities</li> <li>Datacentre facilities maintenance</li> </ul>	<ul style="list-style-type: none"> <li>Wastewater management</li> <li>E-waste management</li> <li>Other waste management</li> </ul>
Telecommunications (infrastructure)	<ul style="list-style-type: none"> <li>Water supply and energy procurement for datacentres</li> <li>Raw materials mining, refining, conversion and processing</li> <li>Water supply and energy for telecom infrastructure</li> <li>Procurement of equipment and materials e.g. cables</li> </ul>	<ul style="list-style-type: none"> <li>Construction and expansion of infrastructure</li> <li>Infrastructure maintenance</li> </ul>	<ul style="list-style-type: none"> <li>E-waste management</li> <li>Other waste management</li> </ul>



Industry	Inputs/Upstream	Direct operations	OutputsDownstream
Software and IT services  (for datacentre infrastructure see above)	<ul style="list-style-type: none"> <li>• Datacentre infrastructure and energy and water procurement</li> <li>• Raw materials mining, refining, conversion and processing for manufacturing upstream</li> </ul>	<ul style="list-style-type: none"> <li>• Datacentre operators and associated water and energy procurement for operations</li> </ul>	<ul style="list-style-type: none"> <li>• E-waste management</li> <li>• Other waste management</li> <li>• Wastewater management</li> </ul>
Internet Media and Services (TC-IM)  (for datacentre infrastructure see above)	<ul style="list-style-type: none"> <li>• Datacentre infrastructure and energy and water procurement</li> <li>• Raw materials mining, refining, conversion and processing for manufacturing upstream</li> </ul>	<ul style="list-style-type: none"> <li>• Software and IT operators</li> <li>• Energy and water procurement for own operations</li> </ul>	<ul style="list-style-type: none"> <li>• End of life of products such as electronic equipment and components</li> <li>• Other waste management</li> </ul>
Telecommunications services	<ul style="list-style-type: none"> <li>• Datacentre and telecom, energy and water procurement</li> <li>• Raw materials mining, refining, conversion and processing for manufacturing upstream</li> <li>• Datacentre and telecom infrastructure</li> </ul>	<ul style="list-style-type: none"> <li>• Software and IT service</li> <li>• Cable and satellite services for service provision</li> <li>• Energy and water procurement for own operations</li> </ul>	<ul style="list-style-type: none"> <li>• End of life of products from equipment such as cables, electronic equipment and components</li> <li>• Other waste management</li> </ul>



## **L2: Dependency and impact screening**

**Guiding question:** Which of these sectors, value chains and direct operations are associated with potentially moderate and high dependencies and impacts on nature?

In L2, technology and communications organisations should filter the list of activities identified in L1 to prioritise which should be considered for further analysis.

Table 3 below lists ecosystem services that technology and communications organisations typically depend on. Table 4 lists the typical impact drivers associated with the technology and communications sector. An organisation can use these tables as a first filter to screen sectors and activities across direct operations and value chains with potentially high dependencies and impacts. These tables present global sector averages. Actual dependencies and impacts will vary across organisational and geographical contexts and organisations should use other more targeted or localised datasets to support screening where available. Technology and communications organisations should refer to the associated [TNFD sector guidance](#) and ENCORE materiality ratings for screening activities in other value chain sectors where available (e.g. metals and mining).



Environmental assets & ecosystem services	Dependency	Semi-conductors	Hardware manufacturing	Datacentre infrastructure (physical)	Telecom infrastructure (physical)	Software & IT services	Internet / Media & services	Telecom services	Consumer electronics
Regulating & maintenance services	Water purification	VH	H	H	L	L	L	L	M
	Air filtration (clean intake air / cleanroom requirements)	H	M	M	L	N/A	N/A	L	L
	Local (micro/meso) climate regulation (temperature stability)	M	M	M	L	L	L	L	L
	Global climate regulation	L	L	L	L	L	L	L	L
	Water flow regulation	M	L	M	L	N/A	N/A	L	N/A
	Rainfall pattern regulation	L	L	L	L	N/A	N/A	L	N/A
	Flood mitigation	M	M	H	H	M	M	M	L
	Storm mitigation	M	M	H	H	M	M	M	L
	Soil and sediment retention	L	L	L	L	N/A	N/A	L	N/A
	Solid waste remediation	L	M	M	L	L	L	L	M
	Noise attenuation	N/A	N/A	L	M	N/A	N/A	L	N/A

Environmental assets & ecosystem services	Dependency	Semi-conductors	Hardware manufacturing	Datacentre infrastructure (physical)	Telecom infrastructure (physical)	Software & IT services	Internet / Media & services	Telecom services	Consumer electronics
Cultural services	Recreation-related services	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Visual amenity services	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Education, scientific and research services	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Spiritual, artistic and symbolic services	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Environmental assets	Freshwater (water resources)	VH	H	VH	M	M	M	M	M
	Mineral resources (incl. critical metals)	VH	VH	M	M	L	L	L	H
	Land and physical space	M	M	H	H	L	L	M	L

Legend Rating scale used: VH / H / M / L / VL; ND = No data; N/A = Not applicable

Source Baseline: ENCORE. Adjustments informed by WEF (2025), Ceres (2025), NatureFinance (2025), UNITAR/ITU Global E-waste Monitor (2024), US EPA semiconductor environmental/air emission sources, ITU/World Bank ICT emissions & energy footprint sources, and additional TNFD research.

Source: ENCORE Partners (Global Canopy, UNEP FI and UNEP-WCMC) (2024). ENCORE: Exploring Natural Capital Opportunities, Risks and Exposure. Cambridge, UK: the ENCORE Partners. DOI: <https://doi.org/10.34892/dz3x-y059>; World Economic Forum (2025) [Technology Convergence Report: Insight Report](#) and additional research by TNFD.

**Table 4: Materiality ratings for impact drivers typically relevant for the technology and communications sector**

Drivers of nature change	Impact drivers	Semi-conductors	Hardware manufacturing	Datacentre infrastructure (physical)	Telecom infrastructure (physical)	Software & IT services	Internet / Media & services	Telecom services	Consumer electronics	End-of-life / recycling
Land, freshwater and ocean use change	Land ecosystem use	M	M	H	H	L	L	L	L	L
	Freshwater ecosystem use	VH	H	H	L	L	L	L	M	L
	Ocean ecosystem use	ND	ND	ND	M	ND	ND	ND	ND	ND
Climate change	Greenhouse gas (GHG) emissions	H	H	VH	M	M	M	M	M	M
Pollution/ pollution removal	Non-GHG air pollutants	H	H	M	M	L	L	L	L	H
	Toxic soil and water pollutants	VH	H	M	M	L	L	L	L	H
	Nutrient soil and water pollutants	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Solid waste	M	H	M	M	L	L	L	M	H
	Disturbances (e.g. noise, light)	M	M	H	H	L	L	M	L	M



Drivers of nature change	Impact drivers	Semi-conductors	Hardware manufacturing	Datacentre infrastructure (physical)	Telecom infrastructure (physical)	Software & IT services	Internet / Media & services	Telecom services	Consumer electronics	End-of-life / recycling
Resource use/ replenishment	Water use	VH	H	H*	L	L	L	L	M	L
	Other biotic resource extraction (e.g. fish, timber)	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Other abiotic resource extraction	VH	VH	M	M	L	L	L	L	H
Invasive alien species introduction/ removal	Introduction of invasive alien species	L	L	M	M	ND	ND	M	L	L

Legend Rating scale used: VH / H / M / L / VL; ND = No data; N/A = Not applicable

Source Baseline: ENCORE. Adjustments informed by WEF (2025), Ceres (2025), NatureFinance (2025), UNITAR/ITU Global E-waste Monitor (2024), US EPA semiconductor environmental/air emission sources, ITU/World Bank ICT emissions & energy footprint sources, and additional TNFD research.

H\* Direct water use by a datacenter facility itself is rated High. Indirect water use linked to electricity generation for continuous (24.7) operations is excluded and could increase overall water footprint to VH

Source: ENCORE Partners (Global Canopy, UNEP FI and UNEP-WCMC) (2024). ENCORE: Exploring Natural Capital Opportunities, Risks and Exposure. Cambridge, UK: the ENCORE Partners. DOI: <https://doi.org/10.34892/dz3x-y059>; World Economic Forum (2025) [Technology Convergence Report: Insight Report](#) and additional research by TNFD.

Organisations can also consider the [WWF Risk Filter](#) and the [SBTN High Impact Commodities List](#) or refer to locally defined standards or international standards that set out nature-related dependencies and impacts of the technology and communications sector.



### **L3: Interface with nature**

**Guiding questions:** Where are the sectors, value chains and direct operations with potentially moderate and high dependencies and impacts located? Which biomes and specific ecosystems do our direct operations and moderate and high dependency and impact value chains and sectors, interface with?

In L3 an organisation identifies the locations of activities and commodities in its direct operations and those in the value chain prioritised in L2. It then associates these and the locations of direct operations with biomes and ecosystems. Looking back at Table 2, the organisation can determine the type of ecosystems in which these activities are located. It can consider, for example, where raw materials are mined and where semiconductor fabs are located. These are often in or near water basins. Datacentre and manufacturing facilities and telecommunication towers could be located in a wide range of ecosystems. Given that datacentres run 24/7 and water use via energy procured could be material, ecosystems affected by energy production should also be considered. Telecommunication cables under seabeds potentially impact marine ecosystems and marine wildlife.

Organisations may refer to the [TNFD biome guidance](#) for more guidance when analysing their interfaces with biomes.

### **L4: Interface with sensitive locations**

**Guiding questions:** For our organisation's activities in moderate and high dependency and impact value chains and sectors, which of these are in ecologically sensitive locations? And which of our direct operations are in sensitive locations?

Following on L3, the organisation should consider which of these locations are ecologically sensitive.

For direct operations, some of this information may have been identified through environmental impact assessments and regulatory processes. An organisation should repeat this process during the Evaluate phase to understand interfaces with potentially sensitive locations outside the site boundary. This includes considering buffer zones and understanding ecological connections with surrounding habitats in the wider landscape, basin or seascape.

Ecologically sensitive locations include areas important for biodiversity, areas of high physical water risk and areas important for ecosystem service provision (including benefits to Indigenous Peoples, Local Communities and other stakeholders).

Given the materiality of water use in many of the industries in this sector, it is especially important to consider water risk locations within the value chain. In practice, there can be a strong overlap in high biodiversity, physical water risk and strong dependence on water by other stakeholders in the same water basin. Organisations should work with other actors in



these water basins (and in other landscapes, basins or seascapes) to understand the sensitivity of the location, including for the delivery of ecosystem services.

Organisations can use primary spatial data (e.g. point coordinates or polygons of spatial footprint of assets) and local data (e.g. point coordinates of water abstraction) to overlay assets and activities with spatial data on sensitive locations, such as areas of known high physical water risk.

Below is a list of sources of further information, datasets and tools:

- [Integrated Biodiversity Assessment Tool \(IBAT\)](#)
- [UN Biodiversity Lab](#)
- [Global Lakes and Wetlands Database](#)
- [WRI Aqueduct](#)
- [WWF Biodiversity Risk Filter](#)
- [WWF Water Risk Filter](#)

Further tools are provided in the TNFD guidance on the LEAP approach, the [TNFD guidance on engagement with Indigenous Peoples, Local Communities and affected stakeholders](#), [TNFD Tools Catalogue](#) and [SBTN's Step 1 Toolbox](#).



## 2.3. Evaluate dependencies and impacts on nature

This section provides additional guidance to help technology and communications organisations with the Evaluate phase of the LEAP approach.

### **E1: Identification of environmental assets, ecosystem services and impact drivers**

**Guiding questions:** What are the business processes and activities to be analysed? What environmental assets, ecosystem services and impact drivers are associated with these business processes, activities and assessment locations?

Guidance for components E1 and E2 is provided together under E2.

### **E2: Identification of dependencies and impacts**

**Guiding question:** What are our dependencies and impacts on nature?

In the Evaluate phase, organisations move beyond the global averages used for screening in L2 to consider dependencies and impacts in the context of the organisation's actual operations and specific locations. Dependencies and impacts on nature arise across technology and communications organisations' direct operations and upstream and downstream value chains.

Tables 5 and 6 below provide illustrative dependency and impact pathways for the technology and communications sector. Organisations should refer to relevant TNFD sector guidances (see [Section 1.2](#)) for dependencies and impacts upstream and downstream.

#### **Dependencies on nature**

Table 5 provides examples of dependency pathways relevant to technology and communications. It is not intended to be comprehensive and an organisation will need to consider if these or other examples apply in their particular context.



**Table 5: Examples of dependency pathways in the technology and communications sector, by activity.**

Business activity	Environmental assets and ecosystem services depended on	Description of dependencies
<b>Semiconductors</b>		
<p><b>Procurement of raw materials including metals and minerals</b></p>	<p><b>Environmental assets</b></p> <ul style="list-style-type: none"> <li>• Underwater mineral and energy resources</li> <li>• Marine ecosystems</li> <li>• Land</li> <li>• Terrestrial and subterranean terrestrial ecosystems</li> <li>• Mineral and energy resources</li> <li>• Water resources</li> <li>• Freshwater ecosystems</li> </ul> <p><b>Ecosystem services</b></p> <ul style="list-style-type: none"> <li>• Soil and sediment retention</li> <li>• Flood mitigation</li> <li>• Water flow regulation</li> <li>• Rainfall pattern regulation</li> <li>• Local and global climate regulation</li> <li>• Storm mitigation</li> </ul>	<p>The semiconductors industry depends on a wide range of components, including minerals (including but not limited to silicon and indium)<sup>14</sup>, rare earth elements (REEs) and critical and precious metals (gold, silver, copper, aluminium, platinum, palladium). As such, they depend on natural processes that create these resources.</p> <p>The semiconductors industry also relies on regulating and maintenance ecosystem services for the operation of mining activities to supply the sector’s components (e.g. chips). Ecosystem services that support mining infrastructure and its operations include effective flood mitigation, rainfall pattern regulation, storm mitigation to reduce risks such as excessive rainfall and flooding and local climate regulation. This supports microclimates and soil and sediment retention that reduces erosion and reservoir sedimentation.</p> <p>More information on dependencies can be accessed in <a href="#">TNFD’s Metals and Mining guidance</a>.</p>

<sup>14</sup> Goswami, O. (2023) [Chipping in: Critical minerals for semiconductor manufacturing in the US](#).



<p><b>Processing and fabrication</b></p>	<p><b>Environmental assets</b></p> <ul style="list-style-type: none"> <li>• Water resources</li> <li>• Freshwater ecosystems</li> </ul> <p><b>Ecosystem services</b></p> <ul style="list-style-type: none"> <li>• Water supply</li> <li>• Water flow regulation</li> <li>• Water purification</li> <li>• Rainfall pattern regulation</li> </ul>	<p>Water is critical for semiconductor manufacturing and for operating facilities. It is notably used for air purification, temperature control, water purification and cooling systems in very high volumes.</p> <p>As a direct physical input, organisations are dependent on sufficient freshwater from both surface water and ground water for their manufacturing processes. The availability of this water, in turn, depends on reliable rainfall and the wider hydrological cycle to recharge water bodies. For example, in Taiwan, the absence of rainfall has reduced capacity to capture and store water, contributing to drought conditions that have forced manufacturers to rely on hundreds of water trucks to maintain their operations.<sup>15</sup></p>
<p><b>Manufacture of electronics and hardware</b></p>		
<p><b>Procurement of semiconductors</b></p>	<p>For more information on environmental assets and ecosystem services, refer to semiconductors.</p>	<p>For more information, refer to the section on semiconductors.</p> <p>One example that illustrates the industry’s dependence on services like flood mitigation, rainfall pattern regulation and storm mitigation are floods in Thailand that severely disrupted electronics manufacturing and caused global shortages, leading to significant price spikes for electronic components.<sup>16</sup></p>
<p><b>Datacentres (infrastructure)</b></p>		
<p><b>Procurement of electronics and hardware</b></p>	<p>For more information on environmental assets and ecosystem services, refer to manufacture of electronics and hardware and semiconductors.</p>	<p>For more information, refer to manufacture of electronics and hardware, and semiconductors.</p>

<sup>15</sup> Roussilhe, G. et al. (2024) [From silicon shield to carbon lock-in? The environmental footprint of electronic components manufacturing in Taiwan \(2015–2020\)](#).

<sup>16</sup> Ploy Ten, K. and Kim, C.R. (2011) [Thai floods batter global electronics, auto supply chains](#).



<p><b>Procurement of energy</b></p>	<p><b>Environmental assets</b></p> <ul style="list-style-type: none"> <li>• Water resources</li> <li>• Freshwater ecosystems</li> </ul> <p><b>Ecosystem services</b></p> <ul style="list-style-type: none"> <li>• Water supply</li> <li>• Water flow regulation</li> </ul>	<p>Datacentres depend on water resources to produce electricity that allows them to run continuously. Reliance on water is exacerbated when the source of electricity is fossil fuels compared to renewable sources like solar or wind. As such datacentres rely on the hydrologic cycle to recharge groundwater sources, regulate river flows and maintain surface water flows, notably groundwater and lake water tables.</p>
<p><b>Datacentre land use and management</b></p>	<p><b>Environmental assets</b></p> <ul style="list-style-type: none"> <li>• Land</li> <li>• Terrestrial (land-based) ecosystems</li> <li>• Subterranean terrestrial ecosystems</li> </ul> <p><b>Ecosystem services</b></p> <ul style="list-style-type: none"> <li>• Rainfall pattern regulation</li> <li>• Flood mitigation</li> <li>• Soil and sediment retention</li> <li>• Storm mitigation</li> </ul>	<p>Datacentres depend on land and the provision of its associated ecosystem services to operate. Ecosystems surrounding datacentres provide regulating and maintenance services that protect operations from natural hazards such as floods and storms and help to stabilise the surrounding soil, supporting operations and reducing the risk of landslides.</p>
<p><b>Cooling of datacentres</b></p>	<p><b>Environmental assets</b></p> <ul style="list-style-type: none"> <li>• Water resources</li> <li>• Freshwater ecosystems</li> <li>• <i>Ecosystem services</i></li> <li>• Water supply</li> <li>• Water flow regulation</li> </ul>	<p>Datacentres depend on water supply as water is used in their cooling systems. As such, datacentres rely on healthy water basins, where the hydrologic cycle can recharge groundwater sources, regulate river flows and maintain surface water flows, notably groundwater and lake water tables.</p>
<p><b>Telecommunications (infrastructure)</b></p>		
<p><b>Construction and maintenance of telecom infrastructure (e.g. towers, cables)</b></p>	<p><b>Environmental assets</b></p> <ul style="list-style-type: none"> <li>• Land</li> <li>• Terrestrial (land-based) ecosystems</li> <li>• Subterranean terrestrial ecosystems</li> <li>• Marine (ocean) ecosystems</li> <li>• Subterranean marine and coastal ecosystems</li> </ul> <p><b>Ecosystem services</b></p> <ul style="list-style-type: none"> <li>• Rain pattern regulation</li> </ul>	<p>Building telecommunication infrastructure requires land for facilities, including the installation of towers, cables for transmission lines and ground stations associated with broadcasting satellites.</p>



	<ul style="list-style-type: none"><li>• Flood mitigation</li><li>• Soil and sediment retention</li><li>• Storm mitigation</li></ul>	<p>Submarine cable systems depend on the stability of the seafloor along their entire route, where sediment regimes, seabed stability, ocean conditions and climatic patterns are all contributing factors.<sup>17</sup></p> <p>To ensure cable protection and long-term stability, their placement must intentionally avoid sensitive habitats based on accurate environmental information, including the distribution of benthic habitats, the nature of seafloor substrates and sediment dynamics.<sup>18</sup></p>
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<sup>17</sup> Bricheno, L. et al. (2024) [The diversity, frequency and severity of natural hazard impacts on subsea telecommunications networks](#).

<sup>18</sup> UNEP-WCMC (2025) [Submarine cables and marine biodiversity](#).

Table 6 provides examples of impact pathways relevant to technology and communications organisations. It is not intended to be comprehensive and an organisation will need to consider if and how the examples apply to its particular context. Impacts can also be positive if a technology and communications organisation improves the state of nature in its direct operations or across the value chain.

**Table 6: Examples of impact pathways for the technology and communications sector, by activity**

Business activity	Impact driver	Impact on nature (description)	Environmental assets and ecosystem services affected
<b>Semiconductors</b>			
<b>Procurement of raw materials</b>	Resource use/ replenishment and others	The growth in this industry has driven demand for certain elements, including Critical Raw Materials (CRMs), which are at risk of limited supply. Global recycling rates for many specialty elements from e-waste remain very low, often below 1%, <sup>19</sup> which means primary extraction continues to be the main source.  Refer to the <a href="#">TNFD sector guidance for Metals and Mining</a> for more information.	Environmental assets <ul style="list-style-type: none"> <li>• Mineral and energy resource</li> <li>• Underwater mineral and energy resource</li> </ul> Ecosystem services <ul style="list-style-type: none"> <li>• Potentially all</li> </ul>
<b>Semiconductor fabrication</b>	Resource use/ replenishment	A large semiconductor fabrication plant (fab) uses up to 38 million litres of water per day, equivalent to the daily water consumption of ±300,000 people in Germany. Water is primarily used for ultrapure water (UPW) production, a complex process that involves multi-stage treatments. The environmental impacts of this water consumption can be severe. Water reuse and recycling are common on-site practices in certain regions of the world. <sup>20</sup>	Environmental assets <ul style="list-style-type: none"> <li>• Water resources</li> <li>• Freshwater ecosystems</li> </ul> Ecosystem services <ul style="list-style-type: none"> <li>• Water supply</li> <li>• Water flow regulation</li> </ul>
<b>Direct operations:</b>	Pollution/pollution removal	Semiconductor manufacturing generates a variety of air pollutants beyond greenhouse gases, notably VOCs, acidic gases and particulate matter (primarily PM10 and smaller), each posing distinct environmental	Environmental assets <ul style="list-style-type: none"> <li>• Atmospheric systems</li> </ul> Ecosystem services

<sup>19</sup> Buechler, D. T. et al. (2020). [Comprehensive elemental analysis of consumer electronic devices: rare earth, precious, and critical elements.](#)

<sup>20</sup> Hess, J.C. (2024) [Chip Production's Ecological Production: Mapping Climate and Environmental Impact.](#)

Business activity	Impact driver	Impact on nature (description)	Environmental assets and ecosystem services affected
<b>Non GHG-emissions to air from manufacturing processes</b>		risks. Due to the diverse production technologies used in the semiconductor industry, the source profiles of different pollutants differ significantly. <sup>21</sup>	<ul style="list-style-type: none"> <li>Local (micro and meso) climate regulation</li> <li>Global climate regulation</li> <li>Air filtration</li> </ul>
<b>Waste management and recycling</b>	Pollution/pollution removal	Semiconductor production leads to a significant amount of hazardous and non-hazardous waste. Waste typically consists of heavy metals, solvents and corrosive compounds in both solid and liquid forms. Solid waste is often processed at designated hazardous waste disposal facilities. In some cases, the heavy metals can be recycled. Release of waste without proper treatment can cause severe environmental impacts. <sup>22</sup>	<p>Environmental assets</p> <ul style="list-style-type: none"> <li>Land</li> <li>Terrestrial (land based) ecosystems</li> <li>Freshwater ecosystems</li> <li>Marine (ocean) ecosystems</li> </ul> <p>Ecosystem services</p> <ul style="list-style-type: none"> <li>Water supply</li> <li>Water purification</li> <li>Soil quality regulation</li> <li>Solid waste remediation</li> </ul>
<b>Downstream: Wastewater discharge</b>	Pollution/pollution removal	Wastewater is often treated and recycled on site. It contains a range of harmful contaminants (e.g. solvents, arsenic, fine oxide particles) with risks to the environment and human health. Proper treatment is crucial to contain toxic components and recycle chemicals. <sup>23</sup>	<p>Environmental assets</p> <ul style="list-style-type: none"> <li>Freshwater ecosystems</li> <li>Subterranean freshwater ecosystems</li> <li>Marine (ocean) ecosystems</li> </ul> <p>Ecosystem services</p> <ul style="list-style-type: none"> <li>Water supply</li> <li>Water purification</li> <li>Soil quality regulation</li> </ul>

<sup>21</sup> Yin, Y., and Yang, Y. (2025) [Sustainable Transition of the Global Semiconductor Industry: Challenges, Strategies, and Future Directions](#).

<sup>22</sup> Veolia (2022) [The CHIPS Act: Balancing Manufacturing Capacity and Waste Generation](#).

<sup>23</sup> Hess, J.C. (2024) [Chip Production's Ecological Production: Mapping Climate and Environmental Impact](#).

Business activity	Impact driver	Impact on nature (description)	Environmental assets and ecosystem services affected
Manufacture of electronics and hardware			
<b>Procurement of semiconductors</b>	See impacts under semiconductors.	See impacts under semiconductors.	See impacts under semiconductors.
<b>Manufacturing of electronics and hardware</b>	Resource use/ replenishment and others Water withdrawal and consumption	<p>Water-related impacts occur throughout the electronics and hardware manufacturing process, as semiconductor fabrication is extremely water-intensive. For example, producing a single smartphone requires approximately 3,190 gallons (12,760 litres) of water, much of which represents grey water needed to dilute and treat wastewater generated during manufacturing.<sup>24</sup></p> <p>These impacts become even more acute during the dry season, particularly in regions with a small number of stressed reservoirs, where freshwater availability is already limited and local environmental boundaries for water use are exceeded. Reduced water supply lowers dilution capacity, exacerbates pollution risks and creates operational vulnerabilities for both industry and local ecosystems.<sup>25</sup></p>	<p><b>Environmental assets</b></p> <ul style="list-style-type: none"> <li>• Freshwater ecosystems</li> <li>• Water resources</li> </ul> <p><b>Ecosystem services</b></p> <ul style="list-style-type: none"> <li>• Water supply</li> <li>• Water purification</li> <li>• Water flow regulation</li> </ul>
<b>Waste management and recycling</b>	Pollution/pollution removal	Significant quantities of wastewater are generated during the processing of electronic components. <sup>26</sup> Such wastewater results from processes like cleaning, fabrication operations, electroplating and printed circuit board production. They can contain multiple pollutants, including acids and alkalis, heavy metals, organic solvents and fluxes. <sup>27</sup>	<p><b>Environmental assets</b></p> <ul style="list-style-type: none"> <li>• Land (terrestrial) ecosystems</li> <li>• Freshwater ecosystems</li> <li>• Water resources</li> <li>• Marine (ocean) ecosystems</li> </ul> <p><b>Ecosystem services</b></p>

<sup>24</sup> Water Footprint Calculator (2022) [The Hidden Water in Everyday Products](#).

<sup>25</sup> Roussilhe, G. et al. (2024) [From silicon shield to carbon lock-in? The environmental footprint of electronic components manufacturing in Taiwan \(2015–2020\)](#).

<sup>26</sup> Yadav, N. (n.d.) [Electronic Industry Waste Water](#).

<sup>27</sup> ENCORE Partners (2024) [ENCORE: Exploring Natural Capital Opportunities, Risks and Exposure](#).

Business activity	Impact driver	Impact on nature (description)	Environmental assets and ecosystem services affected
		<p>For example, wastewater arising from printed circuit boards (PCB) production is heavily contaminated with copper, iron and organic matter, which represents a potential pollution source.<sup>28</sup></p> <p>Water pollution can worsen when factories operate without adequate wastewater treatment systems. Toxic wastewater may impact the environment, including by direct release into rivers through stormwater pipes, via raw sewage overflowing without purification or through leaks from storage tanks.<sup>29</sup></p>	<ul style="list-style-type: none"> <li>• Provisioning (water supply)</li> <li>• Water purification</li> <li>• Soil and sediment retention</li> <li>• Water flow regulation</li> </ul>
<b>End of life of products treatment</b>	Pollution/pollution removal	<p>Hardware and electronics production leads to over 60 billion kilogrammes of e-waste produced each year. <sup>30</sup>With millions of devices discarded every year, this is one of the fastest growing waste streams on the planet.<sup>31</sup></p> <p>E-waste covers plastics and other waste from electronic devices. Many of these contain toxic and persistent substances such as mercury and flame retardants. For example, televisions, personal computers, tablets and smartphones contain substantial volumes of plastics.<sup>32</sup></p> <p>Most flame retardants (80%) are found in screens and monitors. The recycling of these represents a major challenge because of the cost of</p>	<p>Environmental assets</p> <ul style="list-style-type: none"> <li>• Land</li> <li>• Terrestrial ecosystems</li> <li>• Freshwater ecosystems</li> <li>• Water resources</li> <li>• Marine (ocean) ecosystems</li> </ul> <p>Ecosystem services</p> <ul style="list-style-type: none"> <li>• Water supply</li> <li>• Water purification</li> <li>• Soil and sediment retention</li> <li>• Soil quality regulation</li> <li>• Global climate regulation</li> </ul>

<sup>28</sup> Geric, M. et al. (2017) [Environmental risk assessment of wastewaters from printed circuit board production: A multibiomarker approach using human cells.](#)

<sup>29</sup> Ellis, B. (2000) [Environmental issues in electronics manufacturing: a review.](#)

<sup>30</sup> WEF (2025) [Nature Positive: Role of the Technology Sector.](#)

<sup>31</sup> UNITAR (2018) [E-Waste Statistics: Guidelines on Classification Reporting and Indicators.](#)

<sup>32</sup> Cordelis, P. et al. (2024) [The Global E-waste Monitor 2024.](#)



Business activity	Impact driver	Impact on nature (description)	Environmental assets and ecosystem services affected
		<p>separating retardants from other plastics.</p> <p>Globally, properly collected and recycled e-waste averages 20%; the remaining 80% is undocumented, with much ending up buried underground as landfill.<sup>33</sup></p> <p>These waste streams place sustained pressure on terrestrial and freshwater ecosystems through soil contamination, leaching of toxic substances and long-term persistence of hazardous compounds. In regions lacking safe waste management, e-waste disposal contributes to biodiversity loss and ecosystem degradation by altering habitats and contaminating food webs.</p>	<ul style="list-style-type: none"> <li>• Nursery population and habitat maintenance</li> <li>• Solid waste remediation</li> <li>• Recreation-related services</li> <li>• Visual amenity services</li> </ul>
<b>Datacentres</b>			
<p><b>Procurement of electronic equipment</b></p>	<p>See the impacts under semiconductors and manufacture of electronics and hardware</p>	<p>Land ecosystem use for mining high-risk natural commodities for IT equipment. This can include land clearing (surface layers including vegetation, water and soils) for open cut mining, underground mining portals, haul ways and waste rock dump deposition. Refer to the <a href="#">Metals and Mining TNFD sector guidance</a> for more information.</p>	<p>Environmental assets</p> <ul style="list-style-type: none"> <li>• Land</li> <li>• Terrestrial (land-based) ecosystems</li> <li>• Mineral and energy resources</li> <li>• Subterranean terrestrial ecosystems</li> <li>• Ecosystem services</li> <li>• Potentially all. Refer to the <a href="#">Metals and Mining sector TNFD guidance</a> for more information.</li> </ul>

<sup>33</sup> Geneva Environment Network (2025) [The Growing Environmental Risks of E-Waste – Geneva Environment Network](#).

Business activity	Impact driver	Impact on nature (description)	Environmental assets and ecosystem services affected
<b>Procurement of energy</b>	Resource use/ replenishment	The indirect water consumption of datacentres from power generation sources require significant water withdrawal and consumption (e.g. hydroelectric, coal-fired plants). Indirect water consumption can reach 75% of the total water consumption of a facility, which poses a significant risk to freshwater resources. Refer to <a href="#">Electric utilities and power generators TNFD sector guidance</a> for more details.	Environmental assets <ul style="list-style-type: none"> <li>• Water resources</li> <li>• Freshwater ecosystems</li> </ul> Ecosystem services <ul style="list-style-type: none"> <li>• Water supply</li> <li>• Water flow regulation</li> </ul>
<b>Land use and land use change of datacentres</b>	Land/freshwater/ocean use change	Building datacentres requires large scale land clearance and consequent destruction of habitats with impermeable steel, concrete and paved surfaces. Further indirect land use change arises from the construction of access roads and other auxiliary infrastructure and the increased access to the area this creates for wider human activities. Refer to <a href="#">Engineering, Construction and Real Estate TNFD sector guidance</a> for more details.	Environmental assets <ul style="list-style-type: none"> <li>• Land</li> <li>• Terrestrial (land based) ecosystems</li> </ul> Ecosystem services <ul style="list-style-type: none"> <li>• Biomass provisioning</li> <li>• Flood mitigation</li> <li>• Soil quality regulation</li> <li>• Water flow regulation</li> </ul>
<b>Datacentre cooling (with or without water recycling)</b>	Resource use/ replenishment	Historically, electric-powered air cooling could meet the requirements of datacentres with server rack power densities of 20 kW or less. As rack densities have increased, direct-to-chip water cooling has become the preferred method, given its higher capability. Liquid cooling methods can be extremely water intensive. On average, a hyperscale facility can use 2.1 million litres of water per day, while a retail facility may use around 68,000. With an average of 60% of water use consumed by evaporation and the remaining 40% going into local wastewater systems, managing water use is a key area for reducing datacentres' impacts on local water supply. <sup>34</sup>	Environmental assets <ul style="list-style-type: none"> <li>• Water resources</li> <li>• Freshwater ecosystems</li> </ul> Ecosystem services <ul style="list-style-type: none"> <li>• Water supply</li> <li>• Water flow regulation</li> </ul>
<b>Datacentre operations OR waste management?</b>	Pollution/pollution removal	As datacentres are built to run around the clock, to ensure service continuity during grid outages, the rapid growth of datacentres is	Environmental assets <ul style="list-style-type: none"> <li>• Atmospheric systems</li> </ul> Ecosystem services

<sup>34</sup> WEF (2025) [Nature Positive: Role of the Technology Sector](#).

Business activity	Impact driver	Impact on nature (description)	Environmental assets and ecosystem services affected
		accompanied by a surge in on-site backup generator installations. <sup>35</sup> These diesel generators can be massive, ranging in size from 1.5 MW to over 3 MW each. Most generators are designed to provide 1.5 to 2 times the total connected load. These generators emit significant amounts of particulate matter (PM), nitrogen oxides (NOx), sulfur dioxide (SO <sub>2</sub> ) and carbon dioxide (CO <sub>2</sub> )—pollutants that degrade air quality, contribute to climate change and pose serious health risks to nearby communities. <sup>36</sup>	<ul style="list-style-type: none"> <li>Local (micro and meso) climate regulation</li> <li>Global climate regulation</li> <li>Air filtration</li> </ul>
<b>Waste management and recycling</b>	Pollution/pollution removal	As water circulates within the system of a datacentre, it absorbs heat, resulting in effluent temperatures of 30 to 40°C, while accumulating chemical additives like anticorrosive (e.g., molybdate), biocides and leached metals (Cu, Zn). Blowdown from cooling towers can concentrate total dissolved solids (TDS) to 2,000 ppm. Discharge without proper treatment can cause impacts to downstream environments from thermal pollution and chemical excesses. <sup>37</sup>	Environmental assets <ul style="list-style-type: none"> <li>Terrestrial (land based) ecosystems</li> <li>Freshwater ecosystems</li> </ul> Ecosystem services <ul style="list-style-type: none"> <li>Soil quality regulation</li> <li>Water supply</li> <li>Water regulation</li> </ul>
<b>Downstream: E-waste management and disposal</b>	Pollution/pollution removal	For more information on the impacts of e-waste, refer to hardware and electronics section.	For more information on the impacts of e-waste, refer to hardware and electronics section.
<b>Telecommunications infrastructure</b>			
<b>Procurement of electronic equipment for operations</b>	Refer to the section on manufacture of	Refer to the section on manufacture of electronics and hardware.	Refer to the section on manufacture of electronics and hardware.

<sup>35</sup> Ren, S. and Wierman, A. (2025) [Mitigating the Public Health Impacts of AI Data Centers](#).

<sup>36</sup> Stax Engineering (2025) [The environmental impact of data centers](#).

<sup>37</sup> Chelsey, J. (2025) [Data Center Water Treatment Systems: In Theory and in Practice](#).

Business activity	Impact driver	Impact on nature (description)	Environmental assets and ecosystem services affected
	electronics and hardware.		
<b>Land use change linked to construction and expansion and deployment of infrastructure and ocean use change linked to installation of communications equipment</b>	Land/freshwater/ocean use change	<p>Construction requires clearing land, disrupting habitats and reducing biodiversity. Towers often occupy 50 to 200 square metres per site.<sup>38</sup></p> <p>Telecommunication towers can present risks to birds and wildlife, particularly during migration, as collisions can cause injuries or fatalities. In addition, tower construction and maintenance can disturb habitats, fragment ecosystems and disrupt wildlife corridors.<sup>39</sup></p> <p>Towers can also impact the visual and cultural landscape, especially in scenic or densely populated areas, requiring thoughtful planning, design and community engagement to balance infrastructure needs with environmental and aesthetic considerations.<sup>40</sup></p> <p>The installation and maintenance of submarine cable systems can impact the seafloor's benthic habitats. Therefore, their placement should intentionally avoid disturbing sensitive habitats and should consider the distribution of benthic habitats, the nature of the seafloor and sediment dynamics.</p> <p>Refer to <a href="#">Engineering, Construction and Real Estate TNFD sector guidance</a> for more details.</p>	<p>Environmental assets</p> <ul style="list-style-type: none"> <li>• Land</li> <li>• Terrestrial (land-based) ecosystems</li> </ul> <p>Ecosystem services</p> <ul style="list-style-type: none"> <li>• Nursery population and habitat maintenance services</li> <li>• Recreation-related services</li> <li>• Visual amenity services</li> <li>• Spiritual, artistic and symbolic services</li> </ul>
<b>Waste management and recycling</b>	Pollution/pollution removal	For telecommunication organisations, waste includes material waste from telecommunication infrastructure, including towers, cables and satellites. Other sources of waste can relate to e-waste. For e-waste, refer to manufacture of electronics and hardware for more information.	<p>Environmental assets</p> <ul style="list-style-type: none"> <li>• Land</li> <li>• Terrestrial (land-based) ecosystems</li> </ul>

<sup>38</sup> IFC (2007) [Environmental, Health, and Safety Guidelines for Telecommunications](#).

<sup>39</sup> American Bird Conservancy (n.d.) [Bird Collisions and Communications Towers - American Bird Conservancy](#).

<sup>40</sup> IFC (2007) [Environmental, Health, and Safety Guidelines for Telecommunications](#).



Business activity	Impact driver	Impact on nature (description)	Environmental assets and ecosystem services affected
			<ul style="list-style-type: none"> <li>• Water resources</li> </ul> <p>Ecosystem services</p> <ul style="list-style-type: none"> <li>• Water purification</li> <li>• Soil and sediment retention</li> <li>• Soil quality regulation</li> <li>• Global climate regulation</li> <li>• Nursery population and habitat maintenance</li> <li>• Solid waste remediation</li> </ul>

To identify their nature-related dependencies and impacts, organisations operating in the software and IT, internet media and services and telecom services industries can refer to the relevant industries upstream and downstream in their value chain, as identified in components L1 – L4.



### **E3: Dependency and impact measurement**

**Guiding questions:** What is the scale and scope of our dependencies on nature? What is the severity of our negative impacts on nature? What is the scale and scope of our positive impacts on nature?

As for all components, refer to the [Guidance on the identification and assessment of nature-related issues: The LEAP approach](#).

For the quantification of dependencies and impacts, technology and communications organisations may find it useful to refer to the TNFD sector metrics for the technology and communications sector in Section 3. For datacentres, indirect water consumption can be estimated using methods such as WRI's [Guidance for Calculating Water Use Embedded in Purchased Electricity](#)

### **E4: Impact materiality assessment**

**Guiding question:** Which of our impacts are material?

As for all components, refer to the [Guidance on the identification and assessment of nature-related issues: The LEAP approach](#).



## 2.4. Assess nature-related risks and opportunities

This section provides additional guidance to help technology and communications organisations with the Assess phase of the LEAP approach.

### A1: Risk and opportunity identification

**Guiding question:** What are the corresponding risks and opportunities for our organisation?

Tables 7 and 8 provide illustrative examples of nature-related risks and opportunities for the technology and communications sector.

**Table 7: Illustrative nature-related risks in the technology and communications sector**

Nature-related dependency/ impact	Risk category		Exposure pathway	Primary business effect	Potential response options
Land conversion	Transition	Market	Land developments require conservation measures as investor and community expectations change. <sup>41</sup>	Costs associated with conservation initiatives.	Rehabilitation, conservation initiatives.
Water and soil pollution	Transition	Liability	Long-term persistence and bioaccumulation of PFAS and other chemicals when not managed adequately. <sup>42</sup>	Increase in contingent liabilities as regulations become more stringent on PFAS and other chemicals.	Use of less toxic alternative and substitution materials.

<sup>41</sup> European Committee of the Regions (n.d.) [Ecological compensation to offset environmental impact of new data centre.](#)

<sup>42</sup> Hess, J.C. (2024) [Chip Production's Ecological Production: Mapping Climate and Environmental Impact.](#)



Nature-related dependency/ impact	Risk category	Exposure pathway	Primary business effect	Potential response options	
		Technology	Lack of timely investments into treatment technology to meet increased regulatory requirements to manage novel substances of concern. <sup>43</sup>	Increase in costs linked to fines/penalties due to pollution and to new waste treatment technologies.	Invest in new waste treatment technologies.
Soil and water pollution	Transition	Liability	Retrospective litigation for toxification of water or soil because of poor pollutant management measures. <sup>44</sup>	Costs of litigation and fines. Clean-up costs.	Implement stricter pollutant management strategies.  Use of less toxic alternative and substitution materials.
Waste generation and disposal	Transition	Policy	Stricter waste disposal requirements. <sup>45</sup>	Costs associated with fixing inappropriate waste disposal.	Implement stricter waste management strategies.
			Stricter policies for waste circularity and e-waste management. <sup>46</sup>	Increased costs to transition to circular procurement and improved waste management practices.	Material efficiency and circular economy initiatives.

<sup>43</sup> Hess, J.C. (2024) [Chip Production’s Ecological Production: Mapping Climate and Environmental Impact](#).

<sup>44</sup> Tozzi, C. (2025) [4 Ways to Eliminating Data Center Water Pollution](#).

<sup>45</sup> Tozzi, C. (2025) [4 Ways to Eliminating Data Center Water Pollution](#).

<sup>46</sup> Gu, H. (2024) [The Hidden Environmental Cost of Data Center Growth – Millions of Tons of E-Waste](#).



Nature-related dependency/ impact	Risk category	Exposure pathway	Primary business effect	Potential response options	
		Reputational	Informal or non-compliant e-waste recycling and landfill disposal.	Reduction in revenue due to reduced brand value.	Implement suppliers' certification programmes.
Non-GHG air pollution	Transition	Policy	Stricter national emission regulations. <sup>47</sup>	Increase in cost of damage payouts (e.g. compensation) caused by noncompliance.	Implement stricter air pollution mitigation strategies.
		Reputational	Association of the company with poor management of polluting substances increases regulatory and stakeholder scrutiny of applications for new sites. <sup>48</sup>	Downward revisions to business growth forecasts due to inability to expand and gain access new sites.	Implement improved pollution management policies.  Invest in rehabilitation, conservation initiatives.

<sup>47</sup> Lu, H.H. et al. (2023) [Continuous Improvements and Future Challenges of Air Pollution Control at an Advanced Semiconductor Fab.](#)

<sup>48</sup> Chow, A.R. (2025) ['We are the Last of the Forgotten:' Inside the Memphis Community Battling Eton Elon Musk's xAI.](#)



Nature-related dependency/ impact	Risk category		Exposure pathway	Primary business effect	Potential response options
Acute or chronic water stress	Physical	Acute and/or chronic	Over-abstraction for business processes stressing water resources and freshwater ecosystems. <sup>49</sup>	<p>Cost of disruption to operations due to cooling and humidification disruptions and increase in the cost of water management and control.<sup>50</sup></p> <p>Decline in value of business assets due to lack of availability of natural resources.</p>	<p>Implement stricter water management policies</p> <p>Water catchment management schemes.</p> <p>Develop water use efficiency strategy.</p>
	Transition	Policy	Stricter water quantity and/or quality regulation. <sup>51</sup>	<p>Increase in costs due to fines for failure to meet regulatory limits on water use or water quality requirements.</p> <p>Increase in taxes leading to increase in expenditure.</p>	<p>Implement stricter water management policies.</p> <p>Develop water use efficiency strategy.</p>

<sup>49</sup> Zhang, K. (2024) [How Water Scarcity Threatens Taiwan's Semiconductor Industry](#).

<sup>50</sup> S&P Global (2025) [Beneath the surface: Water stress in data centers](#).

<sup>51</sup> S&P Global (2025) [Beneath the surface: Water stress in data centers](#).



Nature-related dependency/ impact	Risk category	Exposure pathway	Primary business effect	Potential response options	
			Cost of operational interruptions due to permit denials linked to failure to meet legally binding targets to reduce water use.		
		Market	Conflict with other water users over limited water resources. <sup>52</sup>	Increased costs of recycling or alternative sources of water to ensure supply in the face of increased competition over access.	Contribute to collaborative water catchment management schemes.
		Reputational	Reputational damage caused by increasing water stress due to over abstraction from the catchment. <sup>53</sup>	Cost of operational interruptions due to community conflict or unexpected nature protection activity.	Contribute to water-related conservation initiatives.

<sup>52</sup> Starr, S. (2025) [Water levels across the Great Lakes are falling – just as US data centers move in.](#)

<sup>53</sup> Starr, S. (2025) [Water levels across the Great Lakes are falling – just as US data centers move in.](#)



Nature-related dependency/ impact	Risk category		Exposure pathway	Primary business effect	Potential response options
Raw materials scarcity/ depletion	Physical	Acute or chronic	Disruption of operations due to reduced availability of raw materials. <sup>54</sup>	Increased costs for procuring raw materials for manufacturing processes.	Use of alternative and substitutions materials.  Invest in material efficiency and circularity.
	Transition	Reputational	Increased stakeholder concerns due to high demand for raw materials, including metals, minerals and rare earth elements used in manufacturing.	Reduction in revenue due to reduced brand value, leading to potential loss of contracts or market access and leads.	Implement suppliers' certification programs and schemes.  Responsible sourcing policies.

<sup>54</sup> Morphy, E. (2024) [Two mines in North Carolina are the world's only producer of the quartz necessary for semiconductor manufacturing.](#)



**Table 8: Illustrative opportunities in the technology and communications sector**

Nature-related dependency/ impact	Opportunity type	Illustrative opportunity in the technology and communications sector	Primary business benefit/magnitude indicators
Reduced land use	Resource efficiency	Sharing tower infrastructure reduces the need for single-tenant sites, lowering overall resource use for construction, operation and maintenance of telecommunications infrastructure. <sup>55</sup>	Cost reductions by reducing deployment, maintenance and material costs over the asset lifetime. <sup>56</sup>
Land restoration	Ecosystem protection, restoration and regeneration	Creation of buffer zones around infrastructure to increase ecosystem condition and reduce associated risks such as flooding, landslides and others. <sup>57</sup>	Increase in ecosystem extent and condition.  Reduced revenue losses associated with infrastructure resilience.
Waste minimised, reused or recycled	Resource efficiency	Recycling provides an in-house source (prompt or manufacturing scrap) or a domestic source (post-consumer scrap) of critical materials, reducing reliance on virgin extraction. <sup>58</sup>  Take-back programmes, reverse logistics and collection systems facilitate the recovery of critical materials from end-of-life electronics and other products. <sup>59</sup>	Cost reductions tied to depletion of natural resources (e.g. depleting critical materials).  Reduced exposure to raw material and natural resource price volatility.

<sup>55</sup> OECD (2025) [The Environmental Sustainability of Communication Networks](#).

<sup>56</sup> World Bank Group (2024) [Resilient telecommunications infrastructure: A practitioner’s guide](#).

<sup>57</sup> Esbenshade, R. (2025) [Biodiversity and nature-based solutions for data centres: development and optional strategies](#).

<sup>58</sup> Global Electronics Council (2021) [State of Sustainability Research: Sustainable Use of Resources](#).

<sup>59</sup> Gaustad, G. et al. (2018) [Circular economy strategies for mitigating critical material supply issues](#).



Nature-related dependency/ impact	Opportunity type	Illustrative opportunity in the technology and communications sector	Primary business benefit/magnitude indicators
		Increased use of recycled, reused, refurbished equipment, such as recycling of cable materials reduces demand for virgin resource extraction and reintroduces materials into supply chain. <sup>60</sup>	Reduced costs linked to reduced reliance on new materials.
	New products and services	Recycling or recovery of materials that can be repurposed by other industries. <sup>61</sup> For example, cable recovery unlocks economic opportunities through new products and business models in the circular economy. <sup>62</sup>	New revenue streams from recovered and/or recycled materials.
		Investment in research and development to find alternatives for hazardous chemicals and gases used in manufacturing. <sup>63</sup>	Increased resilience due to business diversification.
Wastewater pollutants reduction	Resource efficiency	Use of efficient technology and management practices, including wastewater treatment and reuse, helping to maintain sustainable water supplies within watersheds. <sup>64</sup>	Reduction in operational costs due to improved readiness and response to regulatory changes.
	Products and services	Advanced electrochemical wastewater treatment, such as electrocoagulation, addresses the risks associated with heavy	Reduced costs associated with wastewater management.

<sup>60</sup> Swinhoe, D. (2022) [Re-use, refurb, recycle: Circular economy thinking and data center IT assets](#).

<sup>61</sup> Hess, J.C. (2024) [Chip Production’s Ecological Production: Mapping Climate and Environmental Impact](#).

<sup>62</sup> UNEP-WCMC (2025) [Keeping connected: submarine communications cables and ocean life](#).

<sup>63</sup> Hess, J.C. (2024) [Chip Production’s Ecological Production: Mapping Climate and Environmental Impact](#).

<sup>64</sup> WEF (2024) [Why circular water solutions are key to sustainable data centers](#).



Nature-related dependency/ impact	Opportunity type	Illustrative opportunity in the technology and communications sector	Primary business benefit/magnitude indicators
		metal and chemical discharges from electronics manufacturing and metal processing.	
	Reputational capital	Enhanced sustainability performance, supporting a positive corporate reputation through responsible management of potential pollutants discharged.	Increased revenue from improved brand perception.
Non-GHG air pollutants reduction	Business performance	Utilising scrubbers.  Implement a comprehensive air pollution control strategy.	Avoided penalties from meeting national regulations.
Water replenishment	Resource efficiency	Use of efficient technology and management practices, including wastewater treatment and reuse, to maintain sustainable water supplies within watershed. <sup>65</sup>	Reduced operational costs due to improved readiness and response to regulatory changes.
		Investments in nature-based solutions in the watershed e.g. restoration of wetlands, forests and other ecosystems. <sup>66</sup>	Reduced costs of water treatment and risk of water stress via restoration of water resources.
		Use of smart water management technology to reduce water loss and leaks. <sup>67</sup>	Operational cost savings associated with improved water management practices.

<sup>65</sup> BW Water (2025) [Net water positive: Can semiconductor fabs get there?](#)

<sup>66</sup> Craske, B. (2025) [What Role Do NBSs Have In Sustainable Data Centre Strategy?](#)

<sup>67</sup> Alert Labs (2025) [How Water Leak Detection Systems for Data Centers Minimize Damage & Downtime.](#)



## **A2: Adjustment of existing risk mitigation and risk and opportunity management**

**Guiding questions:** What existing risk mitigation and risk and opportunity management processes and elements are we already applying? How can risk and opportunity management processes and associated elements (e.g. risk taxonomy, risk inventory, risk appetite) be adapted?

As for all components, refer to the [Guidance on the identification and assessment of nature-related issues: The LEAP approach](#).

## **A3: Risk and opportunity measurement and prioritisation**

**Guiding question:** Which risks and opportunities should be prioritised?

As for all components, refer to the [Guidance on the identification and assessment of nature-related issues: The LEAP approach](#).

## **A4: Risk and opportunity materiality assessment**

**Guiding question:** Which risks and opportunities are material and therefore should be disclosed in line with the TNFD recommended disclosures?

As for all components, refer to the [Guidance on the identification and assessment of nature-related issues: The LEAP approach](#).

## 2.5. Prepare to respond and report

This section provides additional guidance to help technology and communications organisations with the Prepare phase of the LEAP approach.

The mission of the Kunming-Montreal Global Biodiversity Framework (GBF) is to "halt and reverse biodiversity loss" by 2030, with a 2050 vision of "a world living in harmony with nature". Delivering the transition implied by the GBF will require significant changes to business practices across all sectors. The TNFD has published [guidance on nature in transition plans](#). Transition planning offers a way to manage an organisation's responses and contributions to this transition in a coherent, structured way. The LEAP Prepare phase provides initial guidance for addressing dependencies, impacts, risks and opportunities, laying the groundwork for a nature transition plan.

### P1: Strategy and resource allocation plans

**Guiding question:** What risk management, strategy and resource allocation decisions should be made as a result of this analysis?

Technology and communications organisations need to consider the most effective actions based on the dependencies, impacts, risks and opportunities identified in earlier phases of LEAP. This typically involves developing a multi-year action plan, prioritising actions over time as access to data improves and an organisation's strategy is developed with relevant stakeholders across the value chain.

The TNFD advises organisations to consider actions within the context of the Science Based Target Network's (SBTN's) AR3T framework (Figure 4). This includes four types of actions: avoid and reduce negative impacts; restore and regenerate; transformation of business models, products, services, markets and investments; and contribute to needed systemic change inside and outside value chains.

As this sector guidance is in draft form for public consultation, the illustrative examples included in this section will be further refined following feedback received.

Figure 4: SBTN's AR3T framework





Table 9 below presents illustrative examples of actions that technology and communications organisations may want to consider, based on the material dependencies, impacts, risks and opportunities identified in the Locate, Evaluate and Assess phases of LEAP. The actions are mapped using TNFD’s interpretation of the AR3T framework and are intended to support organisations in planning and sequencing actions across their sphere of control and influence. Actions may vary significantly by business model and across industries within the sector.

**Table 9: Illustrative actions for technology and communications sector mapped to AR3T**

Dependency/ Impact driver	Risks to be mitigated	Examples of actions / responses	SBTN Action Framework (AR3T)				
			Avoid	Reduce	Restore	Regenerate	Transform
Land/ freshwater/ ocean use change	Reduced access to freshwater, vulnerability to extreme weather events including droughts and floods	Invest in nature-based solutions in the watershed, such as wetland construction, restoration and conservation, to increase resilience by reducing risk of storm flood and drought through improved water flow and climate regulating ecosystem services in the watershed.	X	X	X	X	
	Land impacts due to expansion and new infrastructure developments.	Prioritise new developments in brownfield areas to avoid net new impact.	X				
Pollution/ pollution removal	Contaminated wastewater or pollutants discharged to air, soil and/or local water bodies.	Avoid pollution and contaminants (e.g. wastewater, waste heat, solid waste) impacting the environment by using advanced waste control systems and setting zero-waste-to landfill standards (e.g. UL2799).	X	X			
		Rehabilitate areas damaged by pollutants and waste by investing in and supporting land and water restoration efforts.			X	X	



Dependency/ Impact driver	Risks to be mitigated	Examples of actions / responses	SBTN Action Framework (AR3T)				
			Avoid	Reduce	Restore	Regenerate	Transform
	Pollution from hazardous substances and process chemicals/gases (including wastewater contaminants and air emissions), leading to impacts on freshwater and ecosystems and increased regulatory/ reputational risks.	Implement substitution and controls to reduce the use and release of hazardous substances, including adopting lower-impact chemicals and gases and applying best available abatement and wastewater treatment systems.		X			X
	Increased e-waste generation, loss of valuable materials, and upstream resource pressures from primary material demand.	Design products and equipment for circularity, including durability, modularity, repairability and reuse, supported by take-back programmes and recovery of materials through refurbishment and recycling pathways.	X	X			X
Water use/ replenishment	Significant water volumes used towards cooling of datacentre facilities.	Invest in water recycling to reduce water withdrawal from natural water bodies.		X			X
		Invest in sustainable water basin management plans with other stakeholders in the landscape, including conservation and/or restoration of watersheds			X	X	X
		For new and existing facilities, incorporate vegetation to reduce cooling and heating needs.		X			X
		Monitor and optimise cooling systems for efficiency and conditions (e.g. updating technology, climate	X				X



Dependency/ Impact driver	Risks to be mitigated	Examples of actions / responses	SBTN Action Framework (AR3T)				
			Avoid	Reduce	Restore	Regenerate	Transform
		monitoring to switch to free air cooling when conditions allow, raising operating temperatures).					
Resource use/ replenishment	Over reliance on raw commodities, including metals and mining, puts natural resources at risk of depletion.	Optimise hardware and process design with circularity in mind, e.g. utilise recycled materials and design with a modular focus to support repairability.	X	X			X
	Supply disruption risks from impacts of upstream extraction and processing of materials (including metals and minerals), with potential exposure to regulatory, reputational and operational risks.	Engage suppliers and other value chain partners on traceability, responsible sourcing and supplier performance, supported by procurement policies, supplier due diligence and monitoring.		X			X



For additional illustrative examples of corporate responses to mitigate and manage nature-related dependencies, impacts, risks and opportunities (DIROs), organisations may refer to the World Economic Forum report [Nature Positive: Role of the Technology Sector](#) (2025). The report includes examples of actions focused on semiconductors, hardware and electronics, and datacentres. Figure 5 provides a categorisation of selected actions, tiered as Foundational, Leading and Aspirational.

While the scope of the WEF report is narrower than the full Technology & Communications sector as defined in SICs® (and does not cover all sector business models), the examples can be relevant for many organisations in the sector, including where material dependencies and impacts arise across value chains.

Large technology and communications organisations that do not have direct operations where the most significant nature-related dependencies and impacts occur (including those in software and IT services, internet media and services and telecommunication services) can engage with suppliers and other value chain partners to support and encourage implementation of such actions beyond their own direct operations.

**Figure 5: Tiering actions based on nature leadership**

Foundational	Leading	Aspirational
Foundational, often incremental actions that are or are becoming common practice	Actions adopted by several leaders that expand nature benefits and competitive advantage	Ambitious, often transformative and less common practices that shape the value chain
1.1 Review sites for water stress	1.3 Assess complete water footprint	1.5 Restore local watersheds
1.2 Design & operate for efficiency	1.4 Closed-loop & water reuse	2.3 Embed digital circularity practices
2.2 Extend equipment lifespan	2.1 Design for circularity/repairability	2.4 Develop repair infrastructure
2.7 Adopt pollution & waste controls	2.5 Establish collection programmes	2.6 E-waste recycling infrastructure
3.1 Mon or for direct GHG leaks	3.2 Utilise gas scrubbers	2.8 Invest in pollution rehabilitation
4.6 Engage community stakeholders	3.4 Invest in carbon credits	3.3 Design to lower embodied carbon
5.1 Low-carbon onsite energy or PPAs	4.1 Prioritise brownfield development	4.2 Assess biodiversity risk in sites
5.3 Design power-efficient buildings	4.4 Green roofs, native vegetation	4.3 Establish biodiversity baseline
6.1 Suppliers with sustainability certificates	5.2 Sponsor low-carbon capacity	4.5 Invest in biodiversity offsets
7.2 Report nature Impacts	5.4 Optimize cooling systems	6.2 Lower-impact metals, minerals
	5.5 Dynamic: process management	6.5 R&D low impact chemical, gasses
	6.3 Lower-impact chemicals, gasses	7.3 Sector-level nature benchmarks
	6.4 Lower-carbon building materials	
	6.6 Set supply chain commitments	
	7.1 Proactively engage policy-makers	

■ Water use ■ Pollution and waste ■ Greenhouse gas emissions ■ Land use ■ Electricity use ■ Supply chain engagement ■ Policy and external engagement

Source: WEF (2025) [Nature Positive: The role of the technology sector](#).



## **P2: Target setting and performance management**

**Guiding question:** How will we set targets and define and measure progress?

Technology and communications organisations may find it useful to consider the following resources to set targets:

- [SBTN methods](#) for setting science-based targets related to [freshwater](#), [land](#) and [ocean](#) and how these methods support [biodiversity](#);
- The [CEO Water Mandate guidance](#) on setting effective site water targets informed by catchment context (contextual water targets);
- The [International Water Stewardship Standard Version 2.0](#) for setting water-related targets; and
- IUCN's [Rapid High-Integrity Nature-positive Outcomes \(RHINO\)](#) approach, which helps organisations guide interventions to deliver nature-positive outcomes by determining actions to reduce species extinction risk, specifically for vertebrate species.

## **P3: Reporting**

**Guiding question:** What will we disclose in line with the TNFD recommended disclosures?

As for all components, refer to the [Guidance on the identification and assessment of nature-related issues: The LEAP approach](#).

Additionally, when considering international interoperability throughout their disclosure process, organisations may find it helpful to refer to the following documents:

- TNFD – European Financial Reporting Advisory Group (EFRAG) [Correspondence Mapping](#);
- TNFD – Global Reporting Initiative (GRI) Standards [Interoperability Mapping](#);
- [Guidance on Integrating nature-related aspects in Business Responsibility & Sustainability Reporting \(BRSR\) disclosures using the TNFD recommendations](#) for organisations in India; and
- TNFD-CDP [Correspondence Mapping](#).



## **P4: Presentation**

**Guiding question:** Where and how do we present our nature-related disclosures?

As for all components, refer to the [Guidance on the identification and assessment of nature-related issues: The LEAP approach](#).

### **List of datasets and tools**

A list of datasets and tools relevant to the technology and communications sector are provided in the References in [Annex 4](#).

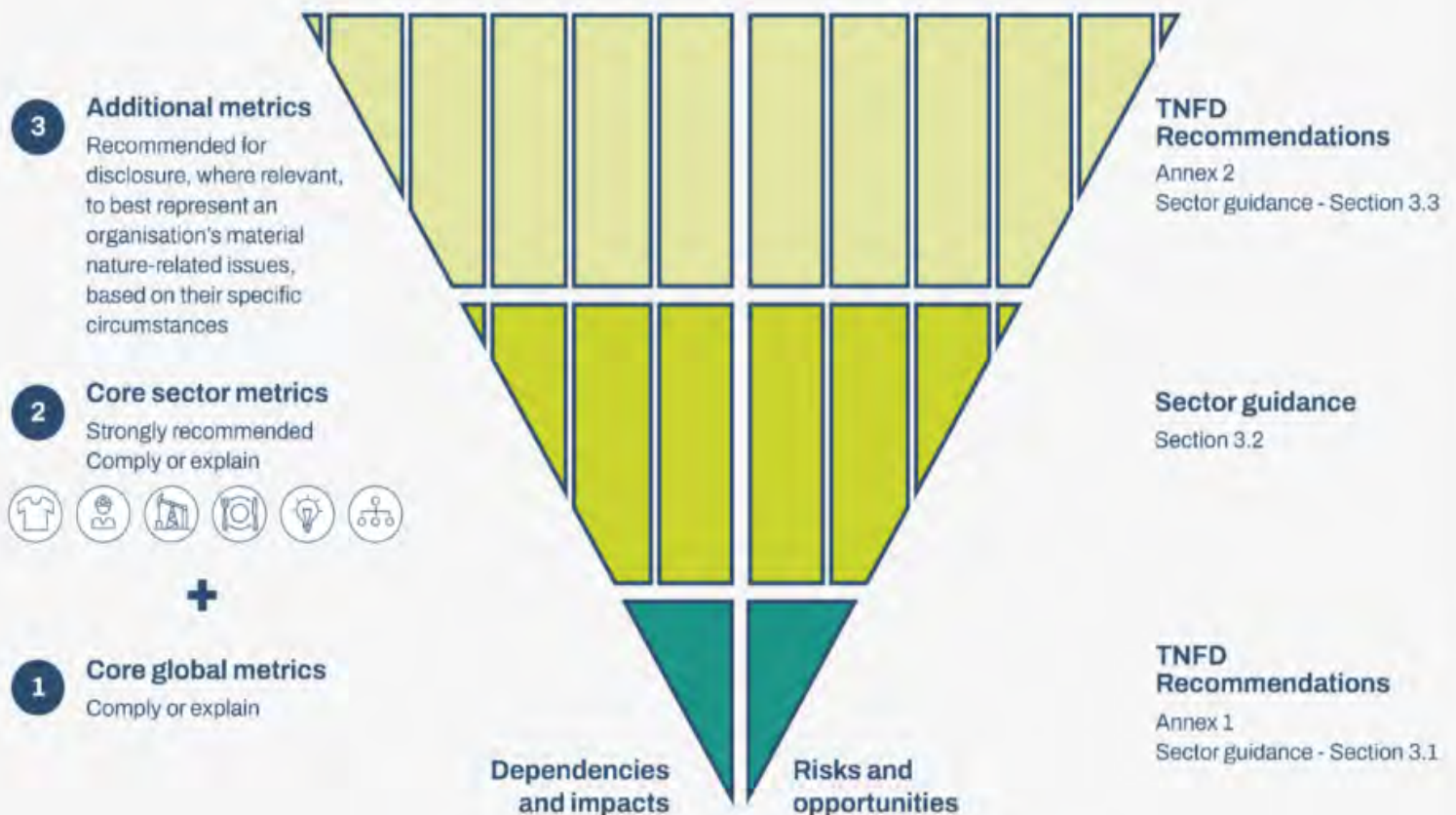
### 3. Sector-specific disclosure metrics and related guidance

Sector-specific metrics form an important part of the TNFD’s measurement architecture (see Figure 6). This reflects the diversity of business models across value chains and their interface with nature across and within sectors. Sector-specific metrics help financial institutions to compare organisations within the same sector, which often face similar nature-related issues.

This section provides the TNFD sector-specific metrics for the technology and communications sector. It includes:

- Guidance on the application of the core global disclosure indicators and metrics to the technology and communications sector (Section 3.1); and
- Core and additional disclosure indicators and metrics for the technology and communications sector (Sections 3.2 and 3.3).

Figure 6: TNFD disclosure metrics architecture signposted to metrics lists





Where available, the TNFD's recommended metrics for disclosure draw from a range of existing standards and frameworks including the IFRS Sustainability Disclosure Standards, Sustainability Accounting Standards Board (SASB) Standards, GRI Standards, the CDP disclosure platform, the Kunming-Montreal Global Biodiversity Framework and other relevant UN frameworks, the European Sustainability Reporting Standards (ESRS) and others.

Several organisations, including standard-setting organisations, continue to work on identifying relevant sector-level assessment and reporting metrics. The Taskforce recommends that report preparers stay engaged with year-on-year progress on these developments and implement the latest definitions within their risk management processes and disclosures.

Organisations in the technology and communications sector should refer to Annex 1 of the TNFD's 2023 [recommendations](#) for further information on the core global disclosure metrics. These core global disclosure metrics should be reported on a comply or explain basis, except for the placeholder metrics. Where organisations are unable to report against any of the core global metrics, they should provide a short explanatory statement as to why they have not reported those metrics. An organisation should report on the core global disclosure metrics unless:

- It has not been identified as relevant and material to the organisation, e.g. not relevant to business activities or the location the organisation is operating in, or not found to be a material issue for the organisation; or
- It has been identified as relevant and material, but the organisation is unable to measure it due to limitations with methodologies, access to data or because the information is commercially sensitive. In this case, organisations should explain how they plan to address this in future. An organisation should report on the same basis for the core sector disclosure metrics outlined in Section 3.2.

Organisations are also encouraged to draw on the TNFD additional sector disclosure indicators and metrics outlined in Section 3.3 and any other relevant metrics to represent most accurately the organisation's nature-related dependencies, impacts, risks and opportunities.



## **Box 2: Guidance for disclosing metrics for value chain dependencies and impacts (including but not limited to leased datacentres)**

For many technology companies, material nature-related dependencies and impacts may arise primarily upstream and downstream in the value chain rather than in direct operations. In this sector, business models of large software, media and telecom companies are often strongly dependent on datacentre infrastructure, whether owned, leased or otherwise contracted (such datacentres in turn rely on semiconductors and other electronic components). Core metrics disclosed should be based on an assessment of nature-related issues, irrespective of the degree of operational control.

For example, a large service company (whether cloud based or streaming) that has material nature-related risks related to significant dependence on datacentres for their business model, would disclose the TNFD core global and core sector disclosure metrics under 'datacentres'. If they lease 10 datacentres for 50% of their capacity each, and these datacentres each withdraw 200,000 m<sup>3</sup>/year, then the service company would disclose that its business model has upstream impact of 1 million m<sup>3</sup>/year via datacentres.

The same logic applies to all core metrics for material nature-related dependencies and impacts, irrespective of their position in the value chain. Where primary data are not yet available, proxy data can be used. As with all core metrics, the comply or explain principle applies in value chain disclosure. See for the use of proxy data Box 5 on page 67, and for how to apply the comply or explain principle, Annex 1 on page 81 of the TNFD [recommendations](#) (2023).

Organisations should work with supply chain partners to improve data availability and quality over time.

### **3.1. Proposed guidance on the application of the core global disclosure metrics**

This section provides guidance, where relevant, on how to apply the TNFD core global disclosure metrics in the technology and communications sector. If no further sector-specific guidance is provided, organisations should refer to the core global disclosure metrics in the TNFD [recommendations](#). As outlined above, core global disclosure metrics should be reported on a comply or explain basis, following the guidance for the technology and communications sector, where provided.

The TNFD encourages organisations to consider and report against placeholder indicators on invasive alien species and the state of nature, where possible, but these are not expected on a comply or explain basis. There are not yet widely accepted metrics for these indicators, but the Taskforce recognises their importance and will continue to work with knowledge partners to develop further guidance on these metrics.



In line with existing TNFD guidance, the following disclosure guidance is intended for a) direct operations of industries mentioned in bold under the column ‘Proposed guidance for this sector’ and b) for industries with business operations that have material nature-related issues via other industries in their value chains. Industries under b) should specify disclosures on the values (e.g. km<sup>2</sup>, m<sup>3</sup>) impacted or depended on by their own direct operations and the values impacted or depended on through their value chain. For reference, see the sections on value chain reporting and Box 5 on the use of secondary data on pages 66 and 67 of TNFD’s 2023 recommendations.

In Table 10, ‘no further sector specific guidance’ does not mean no disclosure is required. In such cases, organisations are referred to the existing disclosure metrics guidance in Annex 1 of the TNFD [recommendations](#).

**Table 10: Proposed guidance on the application of the core global disclosure metrics**

Metri c no.	Core global indicator	Core global metric	Proposed guidance for this sector	Source
<b>Driver of nature change: Land/freshwater/ocean-use change</b>				
C1.0	Total spatial footprint	Total spatial footprint (km <sup>2</sup> ) (sum of): <ul style="list-style-type: none"> <li>Total surface area controlled/managed by the organisation, where the organisation has control (km<sup>2</sup>);</li> <li>Total disturbed area (km<sup>2</sup>); and</li> <li>Total rehabilitated/restored area (km<sup>2</sup>).</li> </ul>	<p><b>Semiconductors, Electronics and Hardware</b></p> <p>No further sector specific guidance for direct operations; refer to the core global disclosure metric. For value chain impacts, see other industries.</p> <p><b>Datacentres</b></p> <p>In reporting total spatial footprint, an organisation should include the land area, measured in km<sup>2</sup>, used to operate the datacentre. This should cover the footprint of the physical building(s), as well as land for associated operations, such as outdoor power and cooling equipment, modules, parking lots and other operational infrastructure.</p> <p>Any land cleared of vegetation for drainage, setback or buffer requirements should also be included. Where a datacentre is located on a campus or industrial site with multiple activities, an</p>	TNFD adapted from Schneider Electric (2023)



Metri c no.	Core global indicator	Core global metric	Proposed guidance for this sector	Source
			<p>appropriate proportion of the total land area should be attributed to the datacentre. The methodology used to determine allocation should be disclosed.</p> <p>Where energy or telecommunications infrastructure is constructed primarily to serve a specific datacentre (e.g. dedicated infrastructure), organisations should include the associated land footprint in the total spatial footprint of the datacentre operations. Where such infrastructure is shared or serves multiple purposes, organisations should apply a proportionate and transparent allocation approach.</p> <p><b>Telecommunications Infrastructure</b></p> <p>Please refer to TNFD's <a href="#">Additional sector guidance on engineering, construction and real estate</a>.</p> <p><b>Software &amp; IT, Internet Media &amp; Services, Telecommunications Services</b></p> <p>No further sector specific guidance for direct operations; refer to the core global disclosure metric. For value chain impacts, see other industries.</p>	
C1.1	Extent of land/ freshwater/ocean use change	Extent of land/freshwater/ocean ecosystem use change (km <sup>2</sup> ) by: <ul style="list-style-type: none"> <li>Type of ecosystem;<sup>68</sup> and</li> <li>Type of business activity.</li> </ul>	<p><b>Semiconductors, Electronics and Hardware, Software &amp; IT, Internet Media &amp; Services, Telecommunications Services</b></p> <p>No further sector specific guidance for direct operations; refer to the core global disclosure metric. For value chain impacts, see other industries.</p>	TNFD

<sup>68</sup> When disclosing on extent of ecosystem types of users should refer to the International Union for Conservation of nature [Global Ecosystem Typology](#).



Metri c no.	Core global indicator	Core global metric	Proposed guidance for this sector	Source
			<p><b>Datacentres, Telecommunications Infrastructure</b></p> <p>In reporting this core global disclosure metric, an organisation should include land-use change resulting from the construction of new facilities and the expansion of existing facilities for operational purposes.</p> <ul style="list-style-type: none"> <li>• Please refer to IUCN Global Ecosystem Typology (GET) to define the type of ecosystem.</li> <li>• Please refer to TNFD's <a href="#">Additional sector guidance on engineering, construction and real estate</a>.</li> </ul>	
	Extent of land/ freshwater/ ocean use change	Extent of land/freshwater/ocean ecosystem conserved or restored (km <sup>2</sup> ), split into: <ul style="list-style-type: none"> <li>• Voluntary; and</li> <li>• Required by statutes or regulations.</li> </ul>	<p><b>All Technology industries</b></p> <p>No further sector specific guidance; refer to the core global disclosure metric.</p>	
		Extent of land/freshwater/ocean ecosystem sustainably managed <sup>69</sup> (km <sup>2</sup> ) by: <ul style="list-style-type: none"> <li>• Type of ecosystem;<sup>70</sup> and</li> <li>• Type of business activity.</li> </ul>	<p><b>All Technology industries</b></p> <p>No further sector specific guidance; refer to the core global disclosure metric.</p>	

<sup>69</sup> Refer to [TNFD Glossary](#)

<sup>70</sup> When disclosing on extent of ecosystem types of users should refer to the International Union for Conservation of nature [Global Ecosystem Typology](#).

Metric no.	Core global indicator	Core global metric	Proposed guidance for this sector	Source
<b>Driver of nature change: Pollution/pollution removal</b>				
C2.0	Pollutants released to soil split by type	Pollutants released to soil (tonnes) by type, referring to sector specific guidance on types of pollutants.	<p><b>Semiconductors, Electronics and Hardware, Datacentres</b></p> <p>In reporting this core global disclosure metric, an organisation should identify and quantify relevant pollutants referring to the environmental quality standards in <a href="#">Annex 2</a> of this guidance.</p> <p><b>Telecommunications Infrastructure, Software &amp; IT, Internet Media &amp; Services, Telecommunications Services</b></p> <p>No further sector specific guidance for direct operations; refer to the core global disclosure metric. For value chain impacts, see other industries.</p>	TNFD
C2.1	Wastewater discharged	<p>Volume of water discharged (m3), split into:</p> <ul style="list-style-type: none"> <li>• Total;</li> <li>• Freshwater; and</li> <li>• Other.<sup>71</sup></li> </ul> <p>Including:</p> <ul style="list-style-type: none"> <li>• Concentrations of key pollutants in the wastewater discharged, by type of</li> </ul>	<p><b>Semiconductors</b></p> <p>In reporting this core global disclosure metric, an organisation should disclose:</p> <p>Volume of water discharged (m3) by destination (m3): surface water; groundwater; seawater and third-party water.<sup>72</sup></p> <p>Volume of water discharged (m3) to areas facing high physical water risk (quality)<sup>73</sup> risk split into:</p> <ul style="list-style-type: none"> <li>• Total;</li> </ul>	<p><b>Semiconductors:</b> TNFD GRI 303 (2018) Sandhu, S. et al. (2025)</p> <p><b>Datacentres:</b> TNFD GRI 303 (2018) Tozzi, C. (2025) APDL</p>

<sup>71</sup> Freshwater: (≤1,000 mg/L Total Dissolved Solids). Other: (>1,000 mg/L Total Dissolved Solids). Reference: [GRI \(2018\) GRI 303-4 Water discharge](#).

<sup>72</sup> For definitions of surface water; groundwater; seawater and third-party water refer to GRI (2018) [Water and Effluents Glossary](#).

<sup>73</sup> For physical water risk refer to [WRI Aqueduct Water Risk Atlas](#) and [WWF Water Risk Filter](#).



Metric no.	Core global indicator	Core global metric	Proposed guidance for this sector	Source
		<p>pollutant, referring to sector specific guidance for types of pollutants; and</p> <ul style="list-style-type: none"> <li>• Temperature of water discharged, where relevant.</li> </ul>	<ul style="list-style-type: none"> <li>• Freshwater; and</li> <li>• Other water.</li> </ul> <p>For each site, an organisation should consider disclosing the following pollutants:</p> <ul style="list-style-type: none"> <li>• pH (acidity/alkalinity);</li> <li>• Per- and polyfluoroalkyl substances/PFAS (parts per trillion);</li> <li>• Chemical oxygen demand/COD (mg/L);</li> <li>• Total solids (Ts) (mg/L);</li> <li>• Copper (mg/L);</li> <li>• Heavy metals (Zn, NI, etc.) (mg/L);</li> <li>• TDS (Total Dissolved Solids) (lbs/day);</li> <li>• Recalcitrant organics (TMAH (g/L);</li> <li>• Azoles (ng/L), etc.); and</li> <li>• Fine particulates (mg/L).</li> </ul> <p>Pollutant calculations should be an average over the reporting period.</p> <p><b>Datacentres</b></p> <p>Volume of water discharged (m3) by destination: surface water; groundwater; seawater; third-party water.</p>	<p>(n.d.) CDC (2025) SA Water (2021)</p>



Metric no.	Core global indicator	Core global metric	Proposed guidance for this sector	Source
			<p>Volume of water discharged (m3) to areas facing high physical water risk (quality)<sup>74</sup> split into treated and untreated water discharged.</p> <p>Volume of cooling effluent discharged, or other proprietary chemical blends (including waterless and non-conductive blends) (m<sup>3</sup>) split into:</p> <ul style="list-style-type: none"> <li>• Total;</li> <li>• Freshwater; and</li> <li>• Other water.</li> </ul> <p>Volume of heated water discharged (m3), defined as water discharged at temperatures greater than 30°C or 2-3°C above ambient levels at its final destination.</p> <p>Concentrations of key pollutants in the wastewater discharged (mg/m<sup>3</sup>) by destination: surface water; groundwater; seawater; third-party water.<sup>75</sup></p> <p>For each site, an organisation should consider disclosing the following pollutants:</p> <ul style="list-style-type: none"> <li>• Chemical additives: Biocides and corrosion inhibitors (prevent microbial growth and protect metal components respectively);</li> <li>• Heavy metals: (zinc, copper, chromium);</li> </ul>	

<sup>74</sup> For physical water risk refer to [WRI Aqueduct Water Risk Atlas](#) and [WWF Water Risk Filter](#).

<sup>75</sup> For definitions of surface water; groundwater; seawater and third-party water refer to GRI (2018) [Water and Effluents Glossary](#).



Metri c no.	Core global indicator	Core global metric	Proposed guidance for this sector	Source
			<ul style="list-style-type: none"> <li>Total Dissolved Solids (TDS): concentration of dissolved minerals and salts in water used for cooling and humidification systems;</li> <li>Other and emerging pollutants used in cooling systems; and</li> <li>Legionella bacteria.</li> </ul> <p><b>Electronics and Hardware, Telecommunications Infrastructure, Software &amp; IT, Internet Media &amp; Services, Telecommunications Services</b></p> <p>No further sector guidance for direct operations; refer to the core global disclosure metric. For value chain impacts, see other industries.</p>	
C2.2	Waste generation and disposal	<p>Weight of hazardous and non-hazardous waste generated by type (tonnes), referring to sector-specific guidance for types of waste. Weight of hazardous and non-hazardous waste (tonnes) disposed of, split into:</p> <ul style="list-style-type: none"> <li>Waste incinerated (with and without energy recovery);</li> <li>Waste sent to landfill; and</li> <li>Other disposal methods.</li> </ul> <p>Weight of hazardous and non-hazardous waste (tonnes) diverted from landfill, split into waste:</p> <ul style="list-style-type: none"> <li>Reused;</li> <li>Recycled; and</li> </ul>	<p><b>Semiconductors</b></p> <p>In reporting this core global disclosure metric, an organisation should disclose waste generated per unit produced (tonnes).<sup>76</sup></p> <p>Organisations should specify any other disposal methods used, including the weight of waste (tonnes) disposed using each method.</p> <p><b>Electronics and Hardware, Datacentre, Telecom Infrastructure</b></p>	<p><b>Semiconductors</b></p> <p>TSMC (2020) TSMC (2024)</p> <p><b>Electronics and Hardware</b></p> <p>Schneider Electric (2023) Open Compute Project (2024)</p>

<sup>76</sup> Refers to a semiconductor unit.



Metric no.	Core global indicator	Core global metric	Proposed guidance for this sector	Source
		<ul style="list-style-type: none"> <li>Other recovery operations.</li> </ul>	<p>In reporting this core global disclosure metric, an organisation should disclose:</p> <ul style="list-style-type: none"> <li>Weight of waste (tonnes) generated from the upgrading, replacement or refurbishment of IT equipment, electronics and hardware;</li> <li>Weight of e-waste (tonnes) generated from the facility’s operational processes, including proportion (%) of the facility’s total waste generated;</li> <li>Weight of e-waste (tonnes) diverted from landfill and processed through certified recyclers, including proportion (%) of total e-waste generated; and</li> <li>Weight of battery waste (tonnes) generated from the facility’s operational processes, including proportion (%) of the facility’s total waste generated.</li> </ul> <p>For further clarification on e-waste and batteries waste, please refer to Annex 3 (Glossary).</p> <p><b>Software &amp; IT, Internet Media &amp; Services, Telecommunications Services</b></p> <p>No further sector guidance for direct operations; refer to the core global disclosure metric. For value chain impacts, see other industries.</p>	
C2.3	Plastic pollution	<p>Plastic footprint as measured by total weight (tonnes) of plastics (polymers, durable goods and packaging) used or sold broken down into the raw material content. For plastic packaging, percentage of plastics that is:</p> <ul style="list-style-type: none"> <li>Reusable;</li> </ul>	<p><b>Electronics and Hardware</b></p> <p>In reporting this core global disclosure metric, an organisation should disclose the weight of plastics (tonnes) incorporated in the</p>	<p>TNFD Cordelis, P. et al. (2024)</p>



Metric no.	Core global indicator	Core global metric	Proposed guidance for this sector	Source
		<ul style="list-style-type: none"> <li>Compostable;</li> <li>Technically recyclable; and</li> <li>Recyclable in practice and at scale.</li> </ul>	<p>final product.</p> <p>The organisation should also disclose:</p> <ul style="list-style-type: none"> <li>Weight of plastics (tonnes) by major polymer type (e.g. acrylonitrile butadiene styrene (ABS), polycarbonate (PC), ABS+PC blend); and</li> <li>Weight of plastics (tonnes) containing halogenated additives, including brominated or chlorinated flame retardants.</li> </ul> <p><b>Semiconductors, Datacentres, Telecommunications Infrastructure, Software &amp; IT, Internet Media &amp; Services, Telecommunications Services</b></p> <p>No further sector guidance for direct operations; refer to the core global disclosure metric. For value chain impacts, see other industries.</p>	<p>EnviroPass (n.d.) A&amp;C Plastics (n.d)</p>
C2.4	Non-GHG air pollutants	<p>Non-GHG air pollutants (tonnes) by type:</p> <ul style="list-style-type: none"> <li>Particulate matter (PM<sub>2.5</sub> and/or PM<sub>10</sub>);</li> <li>Nitrogen oxides (NO<sub>2</sub>, NO and NO<sub>3</sub>);</li> <li>Volatile organic; compounds;</li> <li>(VOC or NMVOC);</li> <li>Sulphur oxides (SO<sub>2</sub>, SO, SO<sub>3</sub>, SO<sub>x</sub>); and</li> <li>Ammonia (NH<sub>3</sub>).</li> </ul>	<p><b>Semiconductors</b></p> <p>In reporting this core global disclosure metric, an organisation should disclose the following additional non-GHG air pollutants (tonnes):</p> <ul style="list-style-type: none"> <li>Acidic gases (e.g. H<sub>2</sub>SO<sub>4</sub>, HF, HCl, HNO<sub>3</sub> and H<sub>3</sub>PO<sub>4</sub>);</li> <li>Alkaline gases (e.g. NH<sub>3</sub>);</li> <li>Hazardous air pollutants/toxic gases: PH<sub>3</sub>, AsH<sub>3</sub>, B<sub>2</sub>H<sub>6</sub>, Cl<sub>2</sub>, O<sub>3</sub>, SiCl<sub>2</sub>H<sub>2</sub>, WF<sub>6</sub>, SiH<sub>4</sub>.</li> </ul>	<p><b>Semiconductors:</b></p> <p>EPA (2025) Nguyen, M.T.N. and Lee, J.S. (2024) Yin, Y. and Yang, Y. (2025)</p> <p><b>Datacentres:</b></p>



Metri c no.	Core global indicator	Core global metric	Proposed guidance for this sector	Source
			<p><b>Datacentres</b></p> <p>In reporting this core global disclosure metric, an organisation should disclose the following additional non-GHG air pollutants (tonnes):</p> <ul style="list-style-type: none"> <li>• Carbon monoxide (CO);</li> <li>• Heavy metals (Pb, Hg, Cd, As, Cr, Ni); and</li> <li>• Hazardous Air Pollutants (HAPs).</li> </ul> <p><b>Electronics and Hardware, Telecommunications Infrastructure, Software &amp; IT, Internet Media &amp; Services, Telecommunications Services</b></p> <p>No further sector guidance for direct operations; refer to the core global disclosure metric. For value chain impacts, see other industries.</p>	<p>GRI 305 (2016) EPA (2025) EU Industrial Emissions Directive (2010)</p>
<b>Driver of nature change: Resource use/replenishment</b>				
C3.0	Water withdrawal and consumption from areas of water scarcity	Water withdrawal and consumption <sup>77</sup> (m <sup>3</sup> ) from areas of water scarcity, including identification of water source.	<p><b>Semiconductors</b></p> <p>In reporting this core global disclosure metric, an organisation should provide a split of water consumption (m<sup>3</sup>) by use: process (production); scrubber; cooling; drinking water and other (specified).</p> <p>An organisation should also disclose:</p>	<p><b>Semiconductors:</b></p> <p>TNFD TSMC (2020) Hess, J.C. (2024) Jones, C. and Vacuum, E. (2022)</p>

<sup>77</sup> Water consumption is equal to water withdrawal less water discharge. Reference: [GRI \(2018\) GRI 303-5](#).



Metric no.	Core global indicator	Core global metric	Proposed guidance for this sector	Source
			<ul style="list-style-type: none"> <li>Water consumption (m<sup>3</sup>) per unit produced; and</li> <li>Water recycling rate (% per year): recycled water/total water consumption. Within this context, total water consumption is defined as sum of recycled water used and new water intake. Any volume of water reused multiple times shall be counted as recycled each time it is recycled and reused.</li> </ul> <p><b>Datacentres</b></p> <p>In reporting this core global disclosure metric, an organisation should disclose:</p> <ul style="list-style-type: none"> <li>Direct water consumption in datacentre operations (m<sup>3</sup>) split by the following uses where possible: cooling; humidification; drinking water and other (specified);</li> <li>Indirect water consumption (m<sup>3</sup>), defined as water consumed for electricity generation. Please refer to the TNFD's <a href="#">Additional sector guidance on electric utilities and power generators</a>; <sup>78</sup></li> <li>Water usage effectiveness ratio of the annual water usage for the datacentre operations (m<sup>3</sup>), divided by the annual energy consumption of the IT computing equipment (kWh). Organisations should disclose the methodology used; and</li> <li>Cycles of concentration: number of times water circulates through a cooling system before discharge becomes</li> </ul>	<p><b>Datacentres:</b></p> <p>TNFD GRI 303 (2018) Genesis Water Tech (2025) Lei, N. et al. (2025)</p>

<sup>78</sup> Refer to metric C3.0. in the [TNFD Sector Guidance Electric Utilities and Power Generators \(p64\)](#).



Metric no.	Core global indicator	Core global metric	Proposed guidance for this sector	Source
			<p>necessary. The calculation compares dissolved solids concentration in circulating water to makeup water concentration. Organisations should disclose the methodology used.</p> <p><b>Electronics and Hardware, Telecommunications Infrastructure, Software &amp; IT, Internet &amp; Media, Telecom Services</b></p> <p>No further sector guidance for direct operations; refer to the core global disclosure metric. For value chain impacts, see other industries.</p>	
C3.1	Quantity of high-risk natural commodities sourced from land/ocean/freshwater	Quantity of high-risk natural commodities (tonnes) sourced from land/ocean/freshwater, split into types, including proportion of total natural commodities.	<p><b>Semiconductors, Electronics and Hardware</b></p> <p>In reporting this core global disclosure metric, an organisation should disclose high-risk natural commodities used in manufacturing and assembly operations, such as metals, minerals and rare earth elements. This disclosure should include the quantities (tonnes) split by type of commodity. Potential sources additional to <a href="#">SBTN's High Impact Commodity List</a>, include:</p> <ul style="list-style-type: none"> <li>• <a href="#">IEC 62474</a>;</li> <li>• <a href="#">EU Critical Raw Materials</a>; and</li> <li>• Any other relevant national or local regulation on critical material designation.</li> </ul> <p><b>Datacentres</b></p> <p>In reporting this core global disclosure metric, an organisation should first identify the high-risk natural commodities used in its</p>	<p><b>Electronics and hardware:</b> TNFD Althaf, S. and Babbitt, C.W. (2020)</p>



Metri c no.	Core global indicator	Core global metric	Proposed guidance for this sector	Source
			<p>operations, particularly for critical IT components in datacentres (e.g. gold, silver, copper, aluminium, platinum, palladium and rare earth metals). An indicative, non-exhaustive list (additional to additional to <a href="#">SBTN's High Impact Commodity List</a>) is included in <a href="#">Althaf and Babbitt (2021)</a>.</p> <p><b>Telecommunications Infrastructure, Software &amp; IT, Internet &amp; Media, Telecommunications Services</b></p> <p>No further sector guidance for direct operations; refer to the core global disclosure metric. For value chain impacts, see other industries.</p>	
		Quantity of high-risk natural commodities (tonnes) sourced under a sustainable management plan or certification programme, including proportion of total high-risk natural commodities.	<p><b>Semiconductors, Electronics and Hardware</b></p> <p>In reporting this core global disclosure metric, an organisation should also express the metric as a proportion (%) of total high-risk natural commodities integrated in the final product, by certification programme.</p> <p><b>Datacentres, Telecommunications Services Telecommunications Infrastructure, Software &amp; IT, Internet &amp; Media, Telecommunications Services</b></p> <p>No further sector guidance for direct operations; refer to core global disclosure metric. For value chain impacts, see other industries.</p>	TNFD
C4.0	Placeholder indicator:	Proportion of high-risk activities operated under appropriate measures to prevent unintentional introduction of IAS, or low risk designed activities.	No further sector specific guidance; refer to the core global disclosure metric.	



Metri c no.	Core global indicator	Core global metric	Proposed guidance for this sector	Source
	Measures against unintentional introduction of invasive alien species (IAS)			
C5.0	Placeholder indicator: Ecosystem condition	For those organisations that choose to report on State of Nature metrics, the TNFD encourages them to report the following indicators and to refer to the TNFD additional guidance on measurement of the State of Nature in Annex 2 of the <a href="#">LEAP approach</a> : <ul style="list-style-type: none"> <li>• Level of ecosystem condition by type of ecosystem and business activity</li> <li>• Species extinction risk.</li> </ul>	No further sector specific guidance; refer to the core global disclosure metric.	
	Placeholder indicator: Species extinction risk	There are a number of different measurement options for these indicators. The TNFD continues to work with knowledge partners to increase alignment.	No further sector specific guidance; refer to the core global disclosure metric.	



### 3.2. Proposed core sector disclosure indicators and metrics

The proposed TNFD core sector disclosure metrics for the technology and communications sector are outlined below. These metrics are recommended by the TNFD to be disclosed by all report preparers in the technology and communications sector on a comply or explain basis in addition to reporting the core global metrics outlined above.

**Table 11: Proposed core sector disclosure indicators and metrics**

Metric no.	Metric category	Metric subcategory	Core sector disclosure indicator or metric	Source
<b>T.C2.0</b>	Impact driver	Pollution/pollution removal	Number of incidents of significant pollution to soil within the reporting period associated with hazardous substances during manufacturing, assembly processes. ‘Significant’ needs to be defined by the organisation based on its risk assessment and applicable regulatory thresholds (with the definition of ‘significant’ disclosed).	TNFD
<b>T.C22.0</b>	Response	Cross-impact	Provide information on the organisation’s traceability and due diligence systems	TNFD

### 3.3. Proposed additional sector disclosure indicators and metrics

Table 12 includes disclosure metrics that are proposed by the TNFD. The TNFD welcomes feedback on the relevance, efficiency and effectiveness of these metrics during the public consultation period. The TNFD will consider whether to add these metrics as:

- Core sector disclosure metrics, which technology and communications organisations should disclose on a comply or explain basis if it applies to a nature-related issue material to them; or
- Additional disclosure metrics which are recommended for disclosure, where relevant, to best represent an organisation’s material nature-related issues, based on their specific circumstances.

**Table 12: Proposed additional sector disclosure indicators and metrics**

Metric no.	Metric category	Metric subcategory	Additional sector disclosure indicators	Potential new core sector or additional sector disclosure metrics (all on an annual basis/volumes per year)
T.A3.0	Impact driver	Resource use/ replenishment	Water-related permit violations	Number of cases of water-related permit violations that include water withdrawals and discharge.
T.A3.1	Impact driver	Resource use/ replenishment	Daily and monthly water withdrawal	Monthly water withdrawal (m <sup>3</sup> ). Daily peak withdrawal (m <sup>3</sup> ).
T.A3.2	Impact driver	Resource use/ replenishment	Cooling system operation	Hours in each cooling mode: evaporative; mechanical/DX; chilled water and hybrid.  An organisation also should disclose: <ul style="list-style-type: none"> <li>• Water used per cooling mode (m3);</li> <li>• Seasonal operation pattern (summer/winter cooling profile);</li> <li>• On-site water storage capacity (m3);</li> <li>• Maximum cooling hours supported without external supply (m3); and</li> <li>• Evidence of any drought-triggered operational changes.</li> </ul>
T.A3.3	Impact driver	Resource use/ replenishment	Local water environment	Local water stress score (e.g. WRI Aqueduct).  Dependency ratio: proportion (%) of water sourced from potable municipal supply vs alternative sources.



Metric no.	Metric category	Metric subcategory	Additional sector disclosure indicators	Potential new core sector or additional sector disclosure metrics (all on an annual basis/volumes per year)
				An organisation should also provide details of: <ul style="list-style-type: none"> <li>Any abstraction permits or volume caps;</li> <li>Local authority drought status; and</li> <li>Restrictions applied during high-stress periods.</li> </ul>
T.A3.4	Impact driver	Resource use/ replenishment	Metering coverage	Proportion (%) of water inflows metered vs estimated.  Proportion (%) of outflow/wastewater metered.  An organisation should provide details of sub-metering for cooling towers, adiabatic units, humidifiers, etc.
T.A3.5	Impact driver	Resource use/ replenishment	Water use effectiveness	Four alternative disclosure metric options: <ul style="list-style-type: none"> <li>Monthly water use effectiveness WUE;<sup>79</sup></li> <li>12-month rolling average water use effectiveness;</li> <li>Water use effectiveness excluding/including reclaimed water; (providers must state which formula applies); and</li> <li>Water use effectiveness for regions with high water stress.</li> </ul>
T.A3.6	Impact driver	Resource use/ replenishment	Water-to-energy ratio	Water used (m <sup>3</sup> ) per kWh delivered to IT. (Links water impact directly to workload density for fairer cross-site comparison).
T.A3.7	Impact driver	Resource use/ replenishment	Water use of installed IT capacity	Water use (m <sup>3</sup> ) per megawatt (MW) of installed IT capacity.

<sup>79</sup> The Green Grid (2011) [WP#35 - Water Usage Effectiveness \(WUE\): A Green Grid Data Center Sustainability Metric.](#)



Metric no.	Metric category	Metric subcategory	Additional sector disclosure indicators	Potential new core sector or additional sector disclosure metrics (all on an annual basis/volumes per year)
T.A3.8	Impact driver	Resource use/ replenishment	AI/HPC water intensity	For Graphics Processing Units (GPU)-heavy sites: <ul style="list-style-type: none"> <li>• Water per GPU per hour;</li> <li>• Water per kWh delivered to GPU racks; and</li> <li>• Water per model training run (if the customer requests structured reporting).</li> </ul>
T.A3.9	Impact driver	Resource use/ replenishment	Water resilience	Number of water resilience hours, where water resilience is defined as the ability to maintain cooling during supply interruption.  Ratio of peak-day water use to average daily use.
T.A3.10	Response	Dependency, impact, risk and opportunity management: Changes to nature (dependency and impact): mitigation hierarchy steps	Water circularity	Proportion (%) of cooling water recirculated.  Proportion (%) of wastewater reclaimed internally.  Proportion (%) of potable dependency reduction year-on-year.



# Annex 1: SICS<sup>®</sup> industries in scope

## Box 3: SICS<sup>®</sup> industries in the scope of this guidance document

The Technology & Communications sector covers the industries below.

### Electronic Manufacturing Services (EMS) & Original Design Manufacturing (ODM)

The EMS and ODM industry consists of two main segments. EMS entities provide assembly, logistics and after-market services for original equipment manufacturers. ODM entities provide engineering and design services for original equipment manufacturers and may own significant intellectual property. Although EMS and ODM entities produce equipment for a variety of sectors, the industry is associated closely with the Hardware industry, which consists of entities that design technology hardware products such as personal computers, consumer electronics and storage devices for both personal consumers and businesses.

#### Hardware

Hardware industry entities design and sell technology hardware products, including computers, consumer electronics, communications equipment, storage devices, components and peripherals. Many entities in the industry rely heavily upon the Electronic Manufacturing Services and Original Design Manufacturing (EMS & ODM) industry for manufacturing services. The industry is expected to continue to grow as technology use rapidly increases, especially among emerging market consumers.

#### Semiconductors

Semiconductors industry entities design or manufacture semiconductor devices, integrated circuits, their raw materials and components, or capital equipment. Some entities in the industry provide outsourced manufacturing, assembly or other services for designers of semiconductor devices.

#### Software & Information Technology (IT) Services

The Software & IT Services industry offers products and services globally to retail, business and government customers and includes entities that develop and sell applications software, infrastructure software and middleware. The industry generally is competitive but with dominant players in some segments. Although relatively immature, the industry is characterised by high-growth entities that place a heavy emphasis on innovation and depend on human and intellectual capital. The industry also includes IT services entities delivering specialised IT functions, such as consulting and outsourced services. New industry business models include cloud computing, software as a service, virtualisation, machine-to-machine communication, big data analysis and



machine learning. Additionally, brand value is important for entities in the industry to scale and achieve network effects, whereby wide adoption of a particular software product may result in self-perpetuating growth in sales.

### **Telecommunications Services**

Telecommunication Services industry entities provide a range of services from wireless and wireline telecommunications to cable and satellite services. The wireless services segment provides direct communication through radio-based cellular networks and operates and maintains the associated switching and transmission facilities. The wireline segment provides local and long-distance voice communication via the Public Switched Telephone Network. Wireline carriers also offer voice over internet protocol (VoIP) telephone, television and broadband internet services over an expanding network of fibre optic cables. Cable providers distribute television programming from cable networks to subscribers. They typically also provide consumers with video services, highspeed internet service and VoIP. Traditionally, these services are bundled into packages that charge subscribers a single payment. Satellite entities distribute TV programming through broadcasting satellites orbiting the earth or through ground stations. Entities serve customers primarily in their domestic markets, although some entities operate in more than one country.

### **Internet Media & Services**

The Internet Media & Services industry consists of two main segments. Entities in the Internet Media segment provide search engines and internet advertising channels, online gaming and online communities such as social networks. They also provide content, which is usually easily searchable, such as educational, medical, health, sports or news content. Entities in the internet-based services segment sell services, mainly through the internet. The industry generates revenue primarily from online advertising, usually on free content, with other revenue coming from subscription fees, content sales or the sale of user information to third parties.

**From SASB Standards (2024) Sustainable Industry Classification System (SICS®)**

## Annex 2: List of environmental quality standards for pollutants

Organisations in the semiconductors, hardware and electronics and datacentres industries should refer to the lists of standards below that are contained in relevant regional and national regulations, including existing international conventions for relevant pollutants.

**Table 13: Selected examples of environmental regulations for pollutants**

List	Type of source
<a href="#">Restriction of Hazardous Substances in Electrical and Electronic Equipment (RoHS)</a>	Regulation
<a href="#">EU REACH Regulation</a>	Regulation
<a href="#">IEC 62474 Material declaration for products of and for the electrotechnical industry</a>	Technical standards
<a href="#">The e-Stewards Standard</a>	Technical standards
<a href="#">TSCA Toxic Substances Control Act</a>	Regulation
<a href="#">Proposition 65</a>	Regulation
<a href="#">R2v3 Standard</a>	Technical standards
<a href="#">PFAS</a>	Emerging contaminants
<a href="#">EU Battery Directive</a>	Regulation
<a href="#">Chemicals Used in the Electronics Industry</a>	Academic literature
<a href="#">OECD Emission scenario document for chemicals used in the electronics industry</a>	Scientific and policy guidance

## Annex 3: Glossary

Sector-specific concepts and definitions are defined in this section. The [TNFD glossary](#) will be updated to include these concepts once the technology and communications sector guidance is finalised, based on market consultation and feedback. Readers are recommended to visit the TNFD glossary for other terms used throughout the document.

Concept	Definitions
<p><b>Electronic waste or e-waste</b></p>	<p>Electronic waste or e-waste, also known as Waste Electrical and Electronic Equipment (WEEE) or e-scrap, depending on regional or regulatory context, refers to electrical and electronic equipment (EEE) that has reached its end of life and is discarded by the holder with no intention of re-use. E-waste includes all components, sub-assemblies and consumables that are part of the equipment at the time it becomes waste. It encompasses a broad range of household and business products that operate using electrical currents, electromagnetic fields or battery power.</p> <p>E-waste can be classified under the Basel Convention as hazardous or non-hazardous waste, depending on whether it contains hazardous constituents listed in Annex I and exhibits hazardous characteristics described in Annex III.</p> <p>Adapted from The Global e-waste Statistics Partnership and The Basel convention (Annex I and III) sources: <a href="#">What is e-Waste</a> / <a href="#">Overview</a></p>
<p><b>Battery waste</b></p>	<p>Battery waste refers to any battery or battery-containing substance or object that the holder discards, intends to discard, or is required to discard.</p> <p>Under the Basel Convention, waste batteries can be classified and listed as hazardous or non-hazardous depending on their composition and characteristics, as set out in Annex VIII and Annex II. Specifically, Annex VIII lists waste batteries that are considered hazardous, including waste lead-acid batteries and unsorted waste batteries containing hazardous substances.</p> <p>Adapted from <a href="#">GRI Standards Glossary</a> and United Nations Environment Programme (1989) Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal.</p>

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