

Explanatory note on the updated ENCORE knowledge base outlining business dependencies and impacts on nature

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ENCORE (Exploring Natural Capital Opportunities, Risks and Exposure) is a free, online tool that helps organisations explore their exposure to nature-related risk and take the first steps to understand their dependencies and impacts on nature. It allows users to scope and identify priorities for further analysis. ENCORE is a key tool, referenced by leading corporate frameworks and standards, such as the [Taskforce on Nature-related Financial Disclosures \(TNFD\)](#), the [Science Based Targets Network \(SBTN\)](#) and the [GRI Standards](#). It is also widely used in macroeconomic studies of nature-related risks.

The ENCORE tool was developed in 2018 by Global Canopy, UNEP FI and UNEP-WCMC, who together form the ENCORE Partnership, previously known as The Natural Capital Finance Alliance (NCFA). ENCORE Partnership maintains and continually improves the ENCORE tool. The update of the ENCORE knowledge base described in this note has been developed as part of the Horizon Europe project [“Strengthening Understanding and Strategies of Business to Assess and Integrate Nature \(SUSTAIN\)”](#). The organisations involved in the technical developments and quality assurance of the data were: UN Environment Programme World Conservation Monitoring Centre (UNEP-WCMC), the Capitals Coalition, the Netherlands Environmental Assessment Agency (PBL), the International Union for the Conservation of Nature (IUCN), IUCN Europe and Eidgenoessische Technische Hochschule Zürich (ETH Zürich). Other SUSTAIN project partners include Oxford Sustainable Finance Group, WBCSD, ShareAction and Fundación Biodiversidad.

The research conducted under the SUSTAIN project enabled updating and enhancing the ENCORE knowledge base. The improvements are in line with the evolving finance-business-nature nexus and associated user needs and feedback. The enhanced knowledge base is aimed primarily at businesses, financial institutions and regulatory bodies to support their screening of potential dependencies and impacts on biodiversity and ecosystem services. As before, ENCORE covers a broad range of sectors and economic activities at the global level. The data have been updated by drawing on the latest scientific research and grey literature.

This explanatory note outlines the components of the updated ENCORE knowledge base and how they can support users in understanding their dependencies and impacts. A more detailed methodological document will be made available in the second half of 2024.

Acronyms

CICES - Common International Classification of Ecosystem Services

DPSIR - Driver-Pressure-State-Impact-Response framework

EE-MRIO - Environmentally-Extended Multi-Regional Input-Output database

ENCORE - Exploring Natural Capital Opportunities, Risks and Exposure

ETH Zürich - Eidgenoessische Technische Hochschule Zürich

FAQ - Frequently asked questions

GET - IUCN Global Ecosystem Typology

GHG - Greenhouse gas

GICS® - Global Industry Classification Standard

IPBES - Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services

ISIC - UN's International Standard Industrial Classification for All Economic Activities (ISIC)

IUCN - International Union for the Conservation of Nature

NACE - European Classification of Economic Activities

N/A - Not Applicable

ND - No Data

NCFA - Natural Capital Finance Alliance

NWFP - Non-wood forest products

PBL - Planbureau voor de Leefomgeving / Netherlands Environmental Assessment Agency

SBTN - Science Based Targets Network

SEEA EA - System of Environmental Economic Accounting – Ecosystem Accounting

SUSTAIN - Strengthening Understanding and Strategies of Business to Assess and Integrate Nature

SUSTAIN WP1 - Work package 1

TNFD - Taskforce on Nature-related Financial Disclosures

UNEP FI - UN Environment Programme Finance Initiative

UNEP-WCMC - UN Environment Programme World Conservation Monitoring Centre

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1. General overview of the changes

The ENCORE knowledge base is the information that underpins the ENCORE tool. It contains two 'pathways', one focused on dependencies and the other on impacts, which are interconnected by the interrelation of the components. Both pathways were reviewed and improved during this process. The structure of the previous iteration of the knowledge base is outlined in Figure 1, whereas Figure 2 outlines the structure of the updated knowledge base.

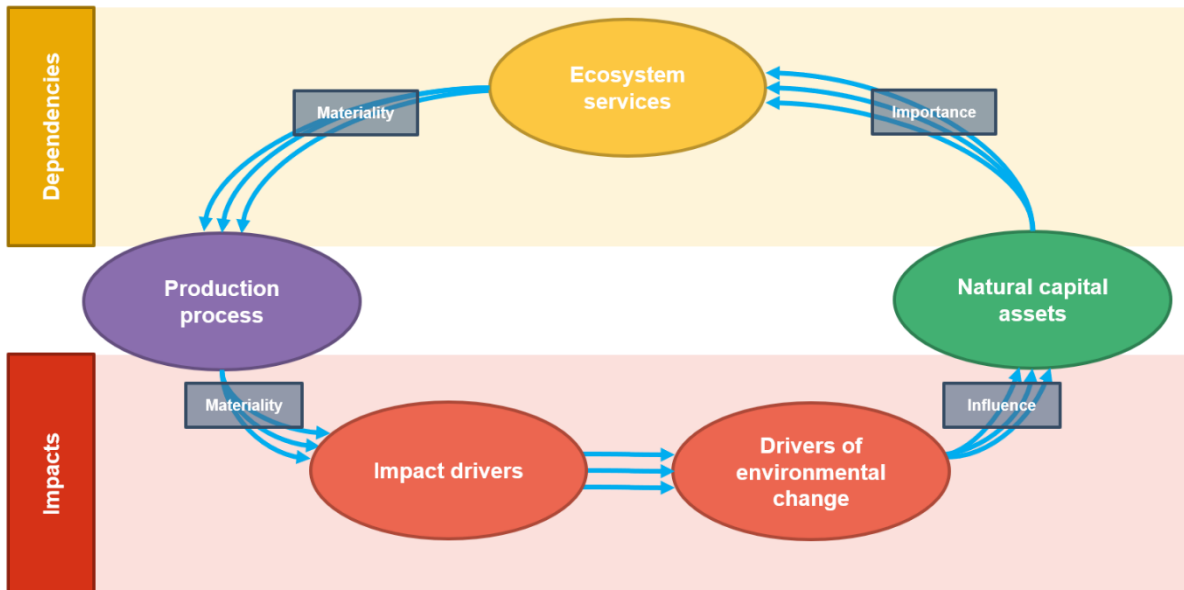


Figure 1: Structure of the 2018-2023 version of the ENCORE knowledge base

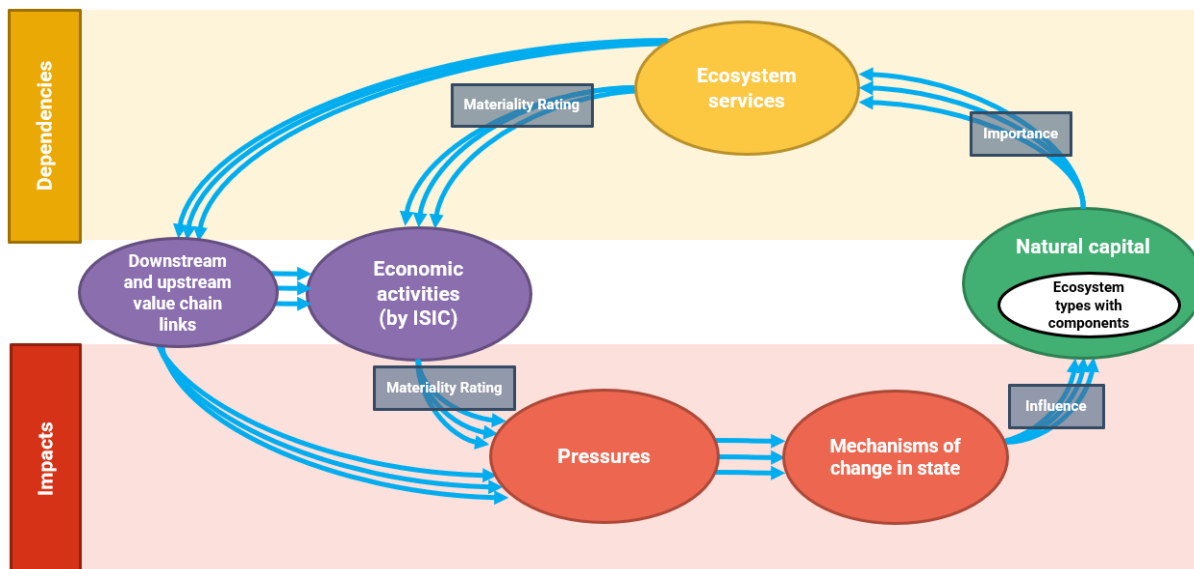


Figure 2: Structure of the updated ENCORE knowledge base.

The updated ENCORE knowledge base includes the seven key improvements summarized in Table 1 below.

Table 1. Summary of the changes between the 2018-2023 version of the ENCORE knowledge base and the updated knowledge base.

	2018-2023 version of the ENCORE knowledge base	Updated ENCORE knowledge base
1	GICS® Industry Classification	ISIC Industry Classification
2	Ecosystem services from CICES	Ecosystem services from SEEA-EA Level 1 (including cultural ecosystem services)
3	Impact drivers Drivers of environmental change	Pressures Mechanisms of change in state

4	No biome-specific information	Natural capital divided into ecosystem types (biomes) and ecosystem components
5	Qualitative links drawing on literature available in 2018	All qualitative links in the knowledge base have been updated using latest scientific research and grey literature
6	All materiality ratings based on qualitative assessment only, with limited comparability of ratings across sectors	Comparability of materiality ratings across sectors, some pressures materiality ratings draw on quantitative indicators to the extent possible
7	Direct potential dependencies and impacts only	Inclusion of downstream and upstream value chain links

2. Seven improvements included in the update

2.1 Industry classification

The first improvement involves replacing the [Global Industry Classification Standard \(GICS®\)](#) and a custom list of ENCORE production processes with the UN's [International Standard Industrial Classification for All Economic Activities \(ISIC\)](#). The previous version of the ENCORE knowledge base offered 92 production processes within 152 GICS® sub-industries, while the updated version provides dependencies and impacts for 271 economic activities based on ISIC groups and classes (levels 3 and 4).

What it means for users:

This update allows users to more easily find the economic activities in which they are interested. The list of production processes used in the 2018-2023 version of the knowledge base was not always clear as it was developed for the purposes of ENCORE only and did not draw on a standardized industry classification.

ISIC is a comprehensive, globally recognized classification and is the parent classification for many regional and local industry classifications. Conversion (crosswalk) tables from ISIC to most other industry classifications are publicly available. A crosswalk table from GICS^(R) to ISIC is provided for ENCORE users as part of the downloadable materials.

The increased number of economic activities under the new industry classification also provides additional granularity on potential dependencies and impacts.

2.2 Ecosystem services

The categorization of ecosystem services used in ENCORE has been updated. The new list is based on categorization of ecosystem services used in the UN [System of Environmental-Economic Accounting Ecosystem Accounting](#) (SEEA EA). It can be seen in Table 2 below along with the definitions for each ecosystem service. The previous version of the ENCORE

knowledge base used ecosystem services categories based on the [Common International Classification of Ecosystem Services](#) (CICES). A crosswalk between SEEA EA and CICES is available [here](#).

Please note that ecosystem services marked with a ‘*’ are not separately defined in the SEEA EA. They were retained from the previous version of the ENCORE knowledge base for consistency and in SEEA EA fall under “other provisioning ecosystem services” or “other regulatory and maintenance ecosystem services”. Their definitions have remained the same as in the previous version of the ENCORE knowledge base.

What it means for users:

The SEEA EA categorization of ecosystem services is better suited for applications in business and finance context. SEEA EA categorization of ecosystem services is also used by the TNFD framework and other corporate frameworks.

Furthermore, this improvement includes the addition of four cultural ecosystem services, which were not included in the previous version of the knowledge base:

1. Recreation-related services
2. Visual amenity services
3. Education, scientific and research services
4. Spiritual, artistic and symbolic services

Table 2: List of ecosystem services used in the updated ENCORE knowledge base based on SEEA EA. Mapping of dependencies of different economic activities was done using SEEA EA Level 1 (e.g. biomass provisioning services, genetic material services etc.). SEEA EA Level 2 is included in the table because some of the SEEA EA Level 1 ecosystem services are defined based on which Level 2 ecosystem services are included within them.

Ecosystem services (based on SEEA EA)		
Level 1 (Used for dependency links)	Level 2	Definition
Provisioning services		
Biomass provisioning services	Crop provisioning services	Crop provisioning services are the ecosystem contributions to the growth of cultivated plants that are harvested by economic units for various uses including food and fibre production, fodder and energy. This is a final ecosystem service.
	Grazed biomass provisioning services	Grazed biomass provisioning services are the ecosystem contributions to the growth of grazed biomass that is an input to the growth of cultivated livestock. This service excludes the ecosystem contributions to the growth of crops used to produce fodder for livestock (e.g., hay, soybean meal). These contributions are included under crop provisioning services. This is a final ecosystem service but may be intermediate to livestock provisioning services.
	Livestock provisioning services	Livestock provisioning services are the ecosystem contributions to the growth of cultivated livestock and livestock products (e.g., meat, milk, eggs, wool, leather), that are used by economic units for various uses, primarily food production. This is a final ecosystem service. No distinct livestock provisioning services to be recorded if grazed biomass provisioning services are recorded as a final ecosystem service.
	Aquaculture provisioning services	Aquaculture provisioning services are the ecosystem contributions to the growth of animals and plants (e.g. fish, shellfish, seaweed) in aquaculture facilities that are harvested by economic units for various uses. This is a final ecosystem service.
	Wood provisioning services	Wood provisioning services are the ecosystem contributions to the growth of trees and other woody biomass in both cultivated (plantation) and uncultivated production contexts that are harvested by economic units for various uses including timber production and energy. This service excludes contributions to non-wood forest products. This is a final ecosystem service.
	Wild fish and other natural aquatic products provisioning services	Wild fish and other natural aquatic biomass provisioning services are the ecosystem contributions to the growth of fish and other aquatic biomass that are captured in uncultivated production contexts by economic units for various uses, primarily food production. This is a final ecosystem service.
	Wild animals, plants and other biomass provisioning services	Wild animals, plants and other biomass provisioning services are the ecosystem contributions to the growth of wild animals, plants and other biomass that are captured and harvested in uncultivated production contexts by economic units for various uses. The scope includes non-wood forest products (NWFP) and services related to hunting, trapping and bio-prospecting activities; but excludes wild fish and other natural aquatic biomass (included in previous class). This is a final ecosystem service.
Genetic material services		Genetic material services are the ecosystem contributions from all biota (including seed, spore or gamete production) that are used by economic units, for example (i) to develop new animal and plant breeds; (ii) in gene synthesis; or (iii) in product development directly using genetic material. This is most commonly recorded as an intermediate service to biomass provisioning.
Water supply		Water supply services reflect the combined ecosystem contributions of water flow regulation, water purification, and other ecosystem services to the supply of water of appropriate quality to users for various uses including household consumption. This is a final ecosystem service.
Other provisioning services - Animal-based energy*		Physical labour is provided by domesticated or commercial species, including oxen, horses, donkeys, goats and elephants. These can be grouped as draught animals, pack animals and mounts.
Regulating and maintenance services		
Global climate regulation services		Global climate regulation services are the ecosystem contributions to the regulation of the chemical composition of the atmosphere and oceans that affect global climate through the accumulation and retention of carbon and other GHG (e.g., methane) in ecosystems and the ability of ecosystems to remove (sequester) carbon from the atmosphere. This is a final ecosystem service.

Rainfall pattern regulation services (at sub-continental scale)		Rainfall pattern regulation services are the ecosystem contributions of vegetation, in particular forests, in maintaining rainfall patterns through evapotranspiration at the sub-continental scale. Forests and other vegetation recycle moisture back to the atmosphere where it is available for the generation of rainfall. Rainfall in interior parts of continents fully depends upon this recycling. This may be a final or intermediate service.
Local (micro and meso) climate regulation services		Local climate regulation services are the ecosystem contributions to the regulation of ambient atmospheric conditions (including micro and mesoscale climates) through the presence of vegetation that improves the living conditions for people and supports economic production. Examples include the evaporative cooling provided by urban trees ('green space'), the role of urban water bodies ('blue space') and the contribution of trees in providing shade for humans and livestock. This may be a final or intermediate service.
Air filtration services		Air filtration services are the ecosystem contributions to the filtering of air-borne pollutants through the deposition, uptake, fixing and storage of pollutants by ecosystem components, particularly plants, that mitigates the harmful effects of the pollutants. This is most commonly a final ecosystem service.
Soil quality regulation services		Soil quality regulation services are the ecosystem contributions to the decomposition of organic and inorganic materials and to the fertility and characteristics of soils, e.g., for input to biomass production. This is most commonly recorded as an intermediate service.
Soil and sediment retention services	Soil erosion control services	Soil erosion control services are the ecosystem contributions, particularly the stabilising effects of vegetation, that reduce the loss of soil (and sediment) and support use of the environment (e.g., agricultural activity, water supply). This is may be recorded as a final or intermediate service.
	Landslide mitigation	Landslide mitigation services are the ecosystem contributions, particularly the stabilising effects of vegetation, that mitigates or prevents potential damage to human health and safety and damaging effects to buildings and infrastructure that arise from the mass movement (wasting) of soil, rock and snow. This is a final ecosystem service.
Solid waste remediation		Solid waste remediation services are the ecosystem contributions to the transformation of organic or inorganic substances, through the action of micro-organisms, algae, plants and animals that mitigates their harmful effects. This may be recorded as a final or intermediate service.
Water purification services (water quality amelioration)	Retention and breakdown of nutrients	Water purification services are the ecosystem contributions to the restoration and maintenance of the chemical condition of surface water and groundwater bodies through the breakdown or removal of nutrients and other pollutants by ecosystem components that mitigate the harmful effects of the pollutants on human use or health. This may be recorded as a final or intermediate ecosystem service.
	Retention and breakdown of other pollutants	
Water flow regulation services	Baseline flow maintenance services	Water regulation services are the ecosystem contributions to the regulation of river flows and groundwater and lake water tables. They are derived from the ability of ecosystems to absorb and store water, and gradually release water during dry seasons or periods through evapotranspiration and hence secure a regular flow of water. This may be recorded as a final or intermediate ecosystem service.
	Peak flow mitigation services	Water regulation services are the ecosystem contributions to the regulation of river flows and groundwater and lake water tables. They are derived from the ability of ecosystems to absorb and store water, and hence mitigate the effects of flood and other extreme water-related events. Peak flow mitigation services will be supplied together with river flood mitigation services in providing the benefit of flood protection. This is a final ecosystem service.
Flood mitigation services	Coastal protection services	Coastal protection services are the ecosystem contributions of linear elements in the seascape, for instance coral reefs, sand banks, dunes or mangrove ecosystems along the shore, in protecting the shore and thus mitigating the impacts of tidal surges or storms on local communities. This is a final ecosystem service.
	River flood mitigation services	River flood mitigation services are the ecosystem contributions of riparian vegetation which provides structure and a physical barrier to high water levels and thus mitigates the impacts of floods on local communities. River flood mitigation services will be supplied together with peak flow mitigation services in providing the benefit of flood protection. This is a final ecosystem service.
Storm mitigation services		Storm mitigation services are the ecosystem contributions of vegetation including linear elements, in mitigating the impacts of wind, sand and other storms (other than water related events) on local communities. This is a final ecosystem service.
Noise attenuation services		Noise attenuation services are the ecosystem contributions to the reduction in the impact of noise on people that mitigates its harmful or stressful effects. This is most commonly a final ecosystem service.
Pollination services		Pollination services are the ecosystem contributions by wild pollinators to the fertilization of crops that maintains or increases the abundance and/or diversity of other species that economic units use or enjoy. This may be recorded as a final or intermediate service.

Biological control services	Pest control services	Biological control services are the ecosystem contributions to the reduction in the incidence of species that may prevent or reduce the effects of pests on biomass production processes or other economic and human activity. This may be recorded as a final or intermediate service.
	Disease control services	Disease control services are the ecosystem contributions to the reduction in the incidence of species that may prevent or reduce the effects of species on human health. This is most commonly a final ecosystem service.
Nursery population and habitat maintenance services		Nursery population and habitat maintenance services are the ecosystem contributions necessary for sustaining populations of species that economic units ultimately use or enjoy either through the maintenance of habitats (e.g., for nurseries or migration) or the protection of natural gene pools. This service is an intermediate service and may input to a number of different final ecosystem services including biomass provision and recreation-related services.
Other regulating and maintenance service - Dilution by atmosphere and ecosystems*		Water, both fresh and saline, and the atmosphere can dilute the gases, fluids and solid waste produced by human activity.
Other regulating and maintenance service - Mediation of sensory impacts (other than noise)*		Vegetation is the main (natural) barrier used to reduce light pollution and other sensory impacts, limiting the impact it can have on human health and the environment.
Cultural services		
Recreation-related services		Recreation-related services are the ecosystem contributions, in particular through the biophysical characteristics and qualities of ecosystems, that enable people to use and enjoy the environment through direct, in-situ, physical and experiential interactions with the environment. This includes services to both locals and non-locals (i.e. visitors, including tourists). Recreation-related services may also be supplied to those undertaking recreational fishing and hunting. This is a final ecosystem service.
Visual amenity services		Visual amenity services are the ecosystem contributions to local living conditions, in particular through the biophysical characteristics and qualities of ecosystems that provide sensory benefits, especially visual. This service combines with other ecosystem services, including recreation-related services and noise attenuation services to underpin amenity values. This is a final ecosystem service.
Education, scientific and research services		Education, scientific and research services are the ecosystem contributions, in particular through the biophysical characteristics and qualities of ecosystems, that enable people to use the environment through intellectual interactions with the environment. This is a final ecosystem service.
Spiritual, artistic and symbolic services		Spiritual artistic and symbolic services are the ecosystem contributions, in particular through the biophysical characteristics and qualities of ecosystems, that are recognised by people for their cultural, historical, aesthetic, sacred or religious significance. These services may underpin people's cultural identity and may inspire people to express themselves through various artistic media. This is a final ecosystem service.

Source: United Nations et al. (2021). System of Environmental-Economic Accounting— Ecosystem Accounting (SEEA EA). White cover publication, pre-edited text subject to official editing. Available at: <https://seea.un.org/ecosystem-accounting>.

Note: Ecosystem services marked with * are not separately defined in the SEEA-EA. They were retained from the previous version of the ENCORE knowledge base for consistency. Their definitions are based on the Common International Classification of Ecosystem Services (CICES). Available at: <https://cices.eu/>

2.3 Impact pathway

As part of the improvements, the definition and structure of the impact pathway were reviewed and updated. In the 2018-2023 version of the ENCORE knowledge base, the impact pathway was split into "impact drivers" and "drivers of environmental change". In the updated ENCORE knowledge base, the components are renamed to "pressures" and "mechanisms of change in state", in line with the [Driver-Pressure-State-Impact-Response \(DPSIR\) framework](#).

The definition of *pressures* is adapted from the [IPBES definition](#), and in line with the DPSIR framework, which refers to "the use of a measurable quantity of a natural resource or release of measurable quantity of substances (emissions), physical and biological agents, the use of resources and the use of land. The pressures exerted by society are transported and transformed in a variety of natural processes to manifest themselves in changes in environmental conditions". Examples of pressures include Area of land use, GHG emissions, Emissions of toxic pollutants to water and soil. Other initiatives, such as TNFD and the Capitals Coalition use the term "impact driver".

Mechanisms of change in state refer to processes that cause changes in the state of ecosystems and their components (natural capital), which are influenced by pressures. Examples include Flooding, Sea surface temperature, Fires, Land use change, etc.

The contents of the lists of *pressures* and *mechanisms of change in state* were revised to ensure different potential impact pathways are captured and to reduce overlap between the two lists. For example, in the previous version of the ENCORE knowledge base an economic activity could be linked to *Soil pollutants* as an impact driver, and *pollution* as a driver of environmental change. In the updated knowledge base, the pressure caused by the economic activity would be *Emissions of toxic pollutants to water and soil*, and the mechanism of change in state would be *Pollutants concentration change*, which in turn would affect ecosystem components such as *Soils and sediments* or *Structural and biotic integrity*.

The updated ENCORE knowledge base contains descriptive links between pressures and ecosystem components, via mechanisms of change, supported by up-to-date citations. This new addition provides links for complete impact pathways from pressures through to components, rather than separately between pressures and mechanisms, and mechanisms and components.

This change also responds to the confusion expressed by some users caused by two different sets of 'drivers' (impact drivers and drivers of environmental change) in the previous version of the ENCORE knowledge base. The two distinct components of the impact pathway were kept to provide clarity and capture more detail. As illustrated in the example in Table 3 below, one pressure can exacerbate multiple mechanisms of change in state.

Table 3: Example illustrating how one pressure can exacerbate multiple mechanisms of change in state.

Pressure	Mechanism of change in state linked to the pressure
Area of freshwater use	Change in species composition
	Changes in species population size
	Diseases
	Droughts
	Flooding
	Land /freshwater/ seabed area modification
	Pollutants concentration change
Weather conditions	

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What it means for users:

This update provides users with improved clarity on the structure of the impact pathway. The two components of the impact pathway are more clearly defined and differentiated. The two-step impact pathway shows that one pressure can exacerbate multiple different mechanisms of change in state and, as a result, lead to multiple impacts.

2.4 Ecosystem types and components

As illustrated in Figure 2, the dependency and impact pathways in the ENCORE knowledge base are connected to natural capital. The updated knowledge base now includes added granularity. Natural capital is separated into different *ecosystem types* and *ecosystem components* (the latter were previously called *natural capital assets*).

The 15 ecosystem types are based on the biomes included in the [IUCN Global Ecosystem Typology 2.0](#) (see Table 4 below for an overview of how the IUCN GET 2.0 biomes were adapted for the purposes of ENCORE). Together with eight ecosystem components, the ecosystem types (see Table 5) provide more detail on habitats and species.

Table 4: List of ecosystem types used in the updated ENCORE knowledge base, compared to biomes and list of biomes used in the IUCN GET list and TNFD list of biomes.

IUCN Global Ecosystem Typology (GET) 2.0 Biomes (Level 2)			TNFD List of biomes	ENCORE ecosystem types
T1	Tropical-subtropical forests	T1	Tropical-subtropical forests	Tropical-subtropical and Temperate-boreal forests and woodlands
T2	Temperate-boreal forests & woodlands	T2	Temperate-boreal forests & woodlands	
T3	Shrublands & shrubby woodlands	T3	Shrublands & shrubby woodlands	Shrublands & shrubby woodlands, Savannas and grasslands
T4	Savannas and grasslands	T4	Savannas and grasslands	
T5	Deserts and semi-deserts	T5	Deserts and semi-deserts	Desert and Semi-deserts
T6	Polar-alpine	T6	Polar-alpine	Polar-alpine
T7	Intensive land-use systems	T7	Intensive land-use systems	Intensive Land Use Systems – Croplands, pastures and plantations
				Intensive Land Use Systems - Urban and industrial ecosystems
S1	Subterranean lithic systems	S1	Subterranean cave and rock systems	Subterranean ecosystems (including Subterranean lithic systems, Subterranean freshwaters, Anthropogenic subterranean freshwaters and Subterranean tidal systems)
		S2	Artificial subterranean spaces	
SF1	Subterranean freshwaters	SF1	Subterranean freshwaters	

SF2	Anthropogenic subterranean freshwaters	SF2	Artificial subterranean freshwaters	
SM1	Subterranean tidal systems	SM1	Subterranean tidal	
TF1	Palustrine wetlands	TF1	Vegetated wetlands	Palustrine wetlands
F1	Rivers and streams	F1	Rivers and streams	Artificial fresh waters, Lakes, Rivers and streams
F2	Lakes	F2	Lakes	
F3	Artificial fresh waters	F3	Artificial wetlands	
FM1	Semi-confined transitional waters	FM1	Coastal inlets and lagoons	Semi-confined transitional waters
M1	Marine shelves	M1	Marine shelf	Marine shelves
M2	Pelagic ocean waters	M2	Open ocean waters	Pelagic ocean waters and Deep Sea floors
M3	Deep sea floors	M3	Deep sea floors	
M4	Anthropogenic marine systems	M4	Artificial marine systems	Anthropogenic marine systems
MT1	Shoreline systems	MT1	Shoreline systems	Shoreline systems (including Anthropogenic shorelines) and supralittoral coastal systems
MT2	Supralittoral coastal systems	MT2	Maritime vegetation	
MT3	Anthropogenic shorelines	MT3	Artificial shorelines	
MFT1	Brackish tidal systems	MFT1	Brackish tidal systems	Brackish tidal systems
	Total = 24		Total = 25	Total = 15

Source: IUCN (2020). IUCN Global Ecosystem Typology 2.0. Available at <https://portals.iucn.org/library/sites/library/files/documents/2020-037-En.pdf>

TNFD (2023). Recommendations of the Taskforce on Nature-related Financial Disclosure framework. Available at: https://tnfd.global/wp-content/uploads/2023/08/Recommendations_of_the_Taskforce_on_Nature-related_Financial_Disclosures_September_2023.pdf?v=1695118661

As for the updated list of ecosystem components, they are shown in the table below.

Table 5: List of ecosystem components used in the updated ENCORE knowledge base

ENCORE ecosystem components
Atmosphere
Land geomorphology
Minerals
Ocean geomorphology
Soils and sediments
Water
Species populations
Structural and biotic composition
Total = 8

Assessments of the relevance between ecosystem types and ecosystem components in the provision of ecosystem services have also been added, with importance ratings of 1 (relevant) or 0 (not relevant) for provision of that service by a given ecosystem component in a given ecosystem type. This new information provides a useful structure and it is recognized that it will need further refinement in future. This could, for example, take the form of more granular importance ratings for the relationships between ecosystem components and ecosystem service within different ecosystem types, beyond the binary rating system currently applied.

What it means for users:

This update will allow users to explore what ecosystem components might be related to their dependencies and pressure in different types of ecosystems. It also provide more detailed information on the role of species and habitats.

2.5 Dependency and pressure links

As part of the updates, the SUSTAIN project reviewed and updated the links between 271 economic activities from ISIC and 25 ecosystem services from SEEA EA. This forms ENCORE's qualitative dependency database. Similarly, the team reviewed how the economic activities exert pressures on nature. This forms ENCORE's qualitative pressure database. These links and descriptions only show the ecosystem services on which given economic activities **directly depend** and the pressures these economic activities **directly exert**. Indirect dependencies and pressures on nature are captured through value chain links (see section 2.7).

All qualitative links in the knowledge base have been updated and improved to reflect increased granularity and to incorporate latest scientific research, as well as grey literature (such as high-profile reports, industry association publications, company sustainability reports, organisations' websites). In response to user feedback, there is now a clear distinction between instances where there is no link (N/A – Not Applicable) between an economic activity and an ecosystem service (e.g. nuclear power production and animal-based energy), and where there it is expected that there is a link but there is insufficient data or references to determine the link (ND – No Data). In the previous version of the ENCORE knowledge base, both cases were marked as N/A.

The qualitative links have undergone several stages of quality assurance by experts both from organizations involved in SUSTAIN WP1 (UNEP-WCMC, IUCN, PBL, Capitals Coalition and ETH Zürich). They were also reviewed by a group of industry experts from business and finance coordinated by WBCSD and ShareAction.

What it means for users:

This update allows users to get access to more up-to-date information on potential dependencies and pressures, based on the latest scientific and grey literature. The qualitative links between economic activities, their dependencies and their pressures are more granular and the descriptions of the qualitative links are more tailored to the specific economic activities.

2.6 Materiality ratings

Materiality ratings methodology has been improved to enable comparison of the ratings across economic activities and sectors. While in the 2018-2023 version of the ENCORE knowledge base all materiality ratings were based on qualitative assessment only, the materiality ratings in the updated knowledge base draw on quantitative environmental data where possible.

Materiality ratings in ENCORE aim to provide users with an indication of the significance of the *potential* nature-related dependencies and pressures identified for their economic activities. For the purposes of the ENCORE knowledge base, the term “material” is interpreted as synonymous to significant or important to consider in the decision-making process. This is in line with the definition of the term in the Natural Capital Protocol. In other contexts, “materiality” of dependencies and impacts may be defined through the requirements of investors or other stakeholders that a company may be reporting to, or it may be defined based on fiduciary or regulatory requirements. For the avoidance of doubt, these dimensions were not considered in the development of the ENCORE materiality ratings.

Similar to the previous version, the updated ENCORE materiality ratings use the rating scale of Very High (VH), High (H), Medium (M), Low (L) and Very Low (VL). It is important to note that the ratings indicate materiality of dependencies and pressures at the global level. These ratings should only serve to inform initial screening, which should be followed by spatially explicit and company-specific assessments to understand the actual dependencies and pressures of the given company.

Where there was sufficient data available, the materiality ratings now draw on quantitative environmental indicators, primarily from the Environmentally-Extended Multi-Regional Input-Output (EE-MRIO) database developed by ETH Zürich based on EXIOBASE version 3.6. Where no suitable quantitative data were available in the EE-MRIO or other sources, qualitative assessments have been carried out to complement or substitute the quantitative data. Each materiality rating is therefore based on a set of quantitative or qualitative indicators. In some cases, we followed a blended approach with a combination of quantitative and a qualitative assessment of pressures and dependencies. As a result, there are three types of methodologies that were used to assess materiality in the updated ENCORE knowledge base:

1. Dependency materiality ratings
 - a. Using qualitative assessment only – 16 ratings
 - b. Using a blended (mixed methods) methodology – 9 ratings
 - c. Using quantitative data only – 0 ratings
2. Pressure materiality ratings

- a. Using quantitative data only – 7 ratings
- b. Using a blended (mixed methods) methodology – 6 ratings
- c. Using qualitative assessment only – 0 ratings

An overview of which dependency materiality ratings were developed using a quantitative, qualitative and blended methodology can be found in Table 6 below. An overview of which pressure materiality ratings were developed using a quantitative approach and which ones were developed using a blended approach can be found in Table 7 below.

Table 6: Overview of methodologies used for different dependency materiality ratings included in the updated ENCORE knowledge base

Dependency materiality ratings that were assessed using a qualitative methodology
Genetic material services
Other provisioning services - Animal-based energy*
Global climate regulation services
Rainfall pattern regulation services (at sub-continental scale)
Local (micro and meso) climate regulation services
Air filtration services
Soil and sediment retention services
Solid waste remediation
Water purification services
Flood mitigation services
Storm mitigation services
Noise attenuation services
Biological control services
Nursery population and habitat maintenance services
Other regulating and maintenance service - Dilution by atmosphere and ecosystems
Other regulating and maintenance service - Mediation of sensory impacts (other than noise)
Recreation-related services
Visual amenity services
Education, scientific and research services
Spiritual, artistic and symbolic services
Dependency materiality ratings that were assessed using a blended methodology (combination of quantitative and qualitative assessment)
Biomass provisioning services
Water supply
Soil quality regulation services
Water flow regulation services
Pollination services

Table 7: Overview of methodologies used for different pressure materiality ratings included in the updated ENCORE knowledge base

Pressure materiality ratings that were assessed using a quantitative methodology
Emissions of GHGs
Emissions of non-GHG air pollutants
Other biotic resource extraction (e.g. fish, timber)
Other abiotic resource extraction
Generation and release of solid waste

Area of land use
Volume of water use
Pressure materiality ratings that were assessed using a qualitative methodology
Disturbances (e.g. noise, light)
Area of freshwater use
Area of seabed use
Emissions of toxic pollutants to water and soil
Emissions of nutrient pollutants to water and soil
Introduction of invasive species

2.6.1 Qualitative assessment methodology

All qualitative assessments that fed into qualitative or blended materiality ratings were conducted using the Delphi consensus building method. This approach was also used to assign materiality ratings in the 2018-2023 version of ENCORE. It involved the following steps:

1. Each combination of economic activity – ecosystem service or economic activity – pressure was assessed against specified questions. Qualitative materiality ratings used two questions (see Box 1 and 2 below) and blended materiality ratings typically used one qualitative question, which would be combined with a score determined based on quantitative data.
2. Two researchers independently assessed each combination of economic activity with ecosystem service or pressure, assigning a score from 1 to 3 depending on the response. Each researcher was from a different partner organization involved in SUSTAIN WP1: UNEP-WCMC, IUCN, Capitals Coalition, PBL and ETH Zurich.
3. An automated formula was used to compare the mismatches in ratings assigned by the two researchers. Where the qualitative approach was used for several questions, the mismatches would be checked at the level of the resulting ratings, not for each score feeding into the rating.
4. All identified mismatches were discussed in a meeting with the two researchers present, to determine what the final score or materiality rating should be.
5. All qualitative and blended materiality ratings went through a quality assurance process within UNEP-WCMC, where additional technical experts reviewed the ratings. The ratings were also shared for review by a group of industry experts from business and finance convened by WBCSD and ShareAction.

Box 1: Questions used to guide the qualitative assessment of dependency materiality ratings

The dependency materiality ratings are intended to reflect the *magnitude of the reliance* of an economic activity on the given ecosystem service. In other words, how affected would an economic activity be if the ecosystem stops providing the ecosystem service or benefit, or the provision of these were disrupted.

The assessment of the magnitude of the reliance was broken down into the following two questions, each focusing on a different determinant of the level of reliance:

Question 1: How significant is the loss of functionality in the economic activity if the ecosystem service is disrupted?

- **Limited loss of functionality:** The economic activity can continue as is or with minor modifications.
- **Moderate loss of functionality:** The economic activity can continue only with important modifications (e.g., slower production or use of substitutes).
- **Severe loss of functionality:** Disruption in the service provision prevents the economic activity.

Question 2: What is the financial cost to the economic activity of adapting to the disruption of the ecosystem service?

- **Low financial cost:** Adaptation to the disruption of the ecosystem services will represent a minor cost to an average company engaging in the economic activity, which will not significantly affect the financial position of the company in the long run.
- **Moderate financial cost:** Adaptation to the disruption in the ecosystem service will represent a relatively significant cost to an average company engaging in the economic activity, but the cost would not affect the financial viability of the economic activity for the company.
- **Severe financial cost:** Adaptation to the disruption in the ecosystem service will have a significant effect on the financial viability of the economic activity for an average company engaging in the economic activity.

The responses to the questions above were assigned a score of 1-3 as follows:

Score	Functionality loss	Financial cost
1	Limited loss of functionality	Low financial cost
2	Moderate loss of functionality	Moderate financial cost
3	Severe loss of functionality	Severe financial cost

The scores assigned based on the two questions were summed and a total score from 2 to 6 obtained. This total score was then translated into grades on the VL-VH rating scale as follows:

Sum of scores	Materiality rating
2	VL
3	L
4	M
5	H
6	VH

Box 3: Questions used to guide the qualitative assessment of pressure materiality ratings

Pressure materiality ratings are intended to reflect the *magnitude of the pressure* exerted by the economic activity (e.g. volume of pollutants emitted, area size used).

To enable comparability of the pressure materiality ratings across sectors and economic activities, the ratings drawing on quantitative data were assigned based on per 1 EUR of output values (e.g. volume of pollutants emitted per 1 EUR of output, not the total volume of pollutants emitted by the economic activity in a year). This accounts for the fact that economic activities and sectors in ISIC (or other industry classifications) are not defined to be equivalent in size.

Our approach to qualitative assessment of pressure materiality ratings was designed to mirror the methodology used for the quantitative pressure materiality ratings. The assessment of the pressure materiality was broken down into the following two questions:

Question 1: What is the size of the economic activity's total financial output per year?

- **Low output**
- **Medium output**
- **High output**

To reduce human error, the response to this question was determined automatically based on the total output value from EE-MRIO. The output value is the total sales or production output of the sector in million Euros. The three levels (Low, Medium, High) were calculated by taking the total output values for all EXIOBASE activities and splitting them into three intervals.

Question 2: What is the typical magnitude of the pressure created by the economic activity in a year?

- **High magnitude:** The pressure caused by this economic activity is severe.
- **Medium magnitude:** The pressure caused by this economic activity is relatively significant.
- **Low magnitude:** The pressure caused by this economic activity is minor.

The responses to the questions above were assigned scores of 1-3 as follows:

Score	Size of financial output of the economic activity	Typical pressure magnitude
1	High output	Low magnitude
2	Medium output	Medium magnitude
3	Low output	High magnitude

Unlike for the qualitative dependency materiality ratings where the two questions were given equal weight in determining the final materiality rating, for the pressure materiality ratings the magnitude question was given a greater weight than the size of the economic activity.

The weighted approach was tested on pressures for which quantitative data was available, to compare whether the qualitative methodology is likely to yield similar ratings. Based on this testing, the weighting of 3:1 was found to be most closely aligned with the quantitative approach, meaning the magnitude of the pressure was given three times more weight than the size of the economic activity.

After applying the 3:1 ratio to the scores, the total score from 4 to 12 is obtained. The lowest score is 4 and the highest one is 12. The total score is then translated into grades on the VL-VH rating scale as follows:

Total score	Materiality rating
4	VL
5	L
6	L
7	M
8	M
9	H
10	H
11	VH
12	VH

2.6.2 Materiality ratings for the cultural ecosystem services

The materiality rating of Very High (VH) was assigned to all cultural ecosystem services (*Recreation-related services; Visual amenity services; Education, scientific and research services; and Spiritual, artistic and symbolic services*) across all economic activities that were identified as depending on them. Our review of existing literature on the relationship between specific economic activities and cultural ecosystem services has shown that further consolidation in the scientific community is needed to establish a recognised approach for how the materiality of the dependencies on these ecosystem services for specific economic activities should be assessed. ENCORE users are encouraged to prioritise the cultural ecosystem services as potentially likely highly material as they have complex societal and economic implications.

2.6.3 Quantitative materiality ratings

For the ratings using a fully quantitative methodology, the materiality ratings were assigned based on a set of quantitative indicators from EE-MRIO or other sources. For example, the materiality rating for the pressure of Volume of water use was assigned based on a set of water withdrawal and water consumption indicators from EE-MRIO. Another example is the materiality rating for the pressure of Area of land use, which in addition to EE-MRIO also uses area use data from several global studies of land use footprint of different economic sectors and activities.

The materiality ratings were assigned based on the per 1 EUR of output values (e.g. volume of GHGs emitted per 1 EUR of output produced by the economic activity). Any economic activities with values that are more than three standard deviations above from the mean were identified as outliers and assigned a Very High materiality rating. Any economic activities with values that are more than three standard deviations below the mean were identified as outliers and assigned a Very Low materiality rating. The remaining values were split into the five grades on the rating scale (Very Low, Low, Medium, High, Very High) using a natural breaks method. Mean was calculated as the average value of the economic activities included in the calculations (i.e. economic activities linked to the dependency or pressure in question in the qualitative desk review).

More detailed overview of the methodologies used to assign the quantitative materiality ratings will be made available in the second half of 2024.

2.6.4 Blended materiality ratings

There are five dependency materiality ratings using a blended methodology, which combines quantitative indicators from EE-MRIO or other sources with qualitative assessment. They include Biomass provisioning services, *Water supply*, Soil quality regulation, *Water flow regulation* and *Pollination services*. For these dependency materiality ratings, there were quantitative indicators that enabled assessing how significant would be the loss of functionality for the economic activity if the ecosystem service is disrupted (e.g. data on the amount of biomass or volume of water used by an economic activity per 1 EUR of output). Qualitative assessment was used to assess additional aspects (e.g. what would be the financial cost to the economic activity if it needed to replace the ecosystem service).

More detailed overview of the methodologies used to assign the blended materiality ratings will be made available in the second half of 2024.

What it means for users:

ENCORE materiality ratings can be used to screen dependencies and pressures that are likely to be significant before conducting a more detailed assessment. The improvements to the materiality ratings methodologies included in these updates enable use of the ratings for comparisons of materiality of a certain potential dependency or pressure across economic activities and sectors. Where possible, the materiality ratings now draw on quantitative environmental data. Where suitable quantitative environmental data was not available, a robust qualitative assessment methodology was used. In addition to increased comparability and reliability, the level of granularity in the ratings has increased too. Materiality ratings are now available for 271 economic activities at ISIC Level 3 or 4.

2.7 Value chain links

This is a new functionality of the ENCORE knowledge base that directly responds to user feedback. The updated ENCORE knowledge base contains a list of key

upstream and downstream value chain links (two tiers upstream and two tiers downstream) for all 271 economic activities for which dependencies and impacts have been identified and materiality ratings assigned.

Table 8: Terminology used for the value chain links and extent of coverage.

Upstream	N-2	Second upstream tier. Supplies to N-1.
	N-1	First upstream tier. Supplies to N.
Direct	N	Direct economic activity
Downstream	N+1	First downstream tier. Consumes output from N.
	N+2	Second downstream tier. Consumes output from N+1.

Data on value chain links is based on the Environmentally-Extended Multi-Regional Input-Output database (EE-MRIO) developed by ETH Zürich, which is based on EXIOBASE (version 3.6). The links within the input-output database reflect the trade flows between different sub-sectors. Note that what is shown as an important link in terms of the trade flows may differ from what would be considered to be an important link based on the commodity or product life cycle.

The EE-MRIO data was converted to ISIC using an EXIOBASE-NACE-ISIC crosswalk (which is also available with the data files, see Section 9 below). While the direct operations economic activities are captured in the ENCORE knowledge base using ISIC Level 3 or 4, upstream and downstream links are shown using ISIC Level 2. This is because Level 2 of ISIC provides the best match with the EXIOBASE classification.

The value chain links are provided for two tiers upstream and two tiers downstream from the direct operations. Adding more tiers would risk showing a large proportion of the economy in the value chain of each economic activity, rendering the information too complex to use.

To make the database more manageable, the ENCORE knowledge base shows only key value chain links, not all value chain links. Only the top five links are included for each tier (i.e., for one direct economic activity, up to five N-1 links and up to 25 N-2 links are shown). These top five links were selected based on their value added as provided in the EE-MRIO.

What it means for users:

ENCORE users will be able to see the key upstream and downstream value chain links associated with an economic activity in question. This will allow them to start exploring dependencies and pressures are associated with activities. For many companies, the most material dependencies and impacts are found in their value chain and not in direct operations.

The focus on top five value chain links enables presenting the information in a user-friendly format. It will be useful for companies beginning to assess nature-related dependencies and impacts in their value chains.

Companies with more advanced analytical capacities will be able to apply the EXIOBASE-ISIC crosswalk developed for the purposes of the updated ENCORE knowledge base and the full input-output data from EE-MRIO or EXIOBASE to map all value chain links that are likely to be included in their value chain.

3. Crosswalk tables

Along with other materials, the following crosswalks are provided to help users align data between the previous and updated versions of the ENCORE knowledge base, and between ENCORE and other tools and frameworks:

- GICS® + ENCORE's bespoke production processes to ISIC industry classification.
- Ecosystem services from 2018-2023 version of the ENCORE knowledge base (based on CICES v4.3) to ecosystem services categorization used in the updated ENCORE knowledge base (based on SEEA EA).
- List of impact drivers used in the 2018-2023 version of the ENCORE knowledge base to list of pressures used in the updated ENCORE knowledge base.
- EXIOBASE to NACE to ISIC crosswalk developed for the purposes of the updated ENCORE knowledge base by merging existing EXIOBASE to NACE and NACE to ISIC crosswalks.

All the crosswalk tables are available for download from the [Methodology & Downloads](#) tab of the website. Please note that you will need to be logged in to access the download link. Creating an account on the ENCORE website is free.

4. Other notes

Do you have any questions that were not answered in this note? Please check our FAQ document (also available on the Methodology & Downloads tab).

5. Limitations

As any similar tool or methodology, the updated ENCORE knowledge base and the methodology behind it have some limitations. Some of these could be addressed through future research and development of ENCORE, others are inherent to this type of a screening tool.

Qualitative links between economic activities and ecosystem services, and economic activities and pressures

The links between economic activities and ecosystem services and between economic activities and pressures documented in the updated ENCORE knowledge base are high-level, global links. Therefore, where there is a dependency or a pressure link recorded for an economic activity, it does not mean that all firms engaging in that activity have that dependency or exert that pressure. ENCORE is designed as a screening tool showing potential dependencies and impacts. All users are encouraged to delve deeper and assess their actual dependencies and impacts on nature, taking into consideration the context of their company and characteristics of locations where they have direct operations or value chain links.

Value chain links

As described in Section 8 above, the value chain links shown in the updated ENCORE knowledge base are taken from the EE-MRIO based on EXIOBASE. They do not show all value chain links that an economic activity has, only the key links based on the value added data in the EE-MRIO database. Since the data only shows two tiers upstream and two tiers downstream, the data may not reach the point of extraction or primary production. For example, for direct economic activity *Wholesale of food, beverages and tobacco, the activity of Growing of fibre crops will not appear in the N-1 or N-2 value chain links provided by the ENCORE knowledge base because it is more than two steps removed.* Extending the value chain links coverage for key sectors will be one of the areas for potential future research and development of the ENCORE tool. In the meantime, users are encouraged to add or extend value chain links in their own assessments as relevant.

Fossil fuels

In the updated ENCORE knowledge base, stocks of fossil fuels (e.g., coal, gas, oil) are not considered as part of natural capital's stock of abiotic resources. Economic activities dependencies and impacts on the stocks of coal, gas, oil and other fossil fuels are therefore not captured in the qualitative links or materiality ratings.

Materiality ratings

The updated ENCORE knowledge base allows users to compare materiality ratings for a given dependency or pressure across multiple economic sectors and activities. However, the ratings are not designed to enable comparisons across different ecosystem services or pressures.

As an example, users of the updated ENCORE knowledge base will be able to say that the economic activity *Growing of rice* tends to use more water than the economic activity *Manufacture of plastics* per 1 EUR of output. However, users seeing that the economic activity *Growing of rice* has VH materiality rating for the pressure of Volume of water use and VL materiality rating for the pressure of introducing invasive species, will not be able to say how much more material the water use is for the *Growing of rice* economic activity compared to the pressure of introducing invasive species. This reflects the recognition that there is no consistent hierarchy between pressures or ecosystem services – while some pressures or ecosystem services may appear more important to address in certain contexts or locations, in other cases the relative priority between them may be completely different. ENCORE users are encouraged to consider this limitation when interpreting the materiality ratings.

Where quantitative indicators were used, the calculations of materiality ratings were done using values per 1 EUR of output. This enabled comparability of the materiality across sectors and economic activities. In ISIC, similarly to other industry classifications, economic activities are not defined to be consistent in size (neither size of the turnover nor number of companies included). Since the per 1 EUR of output values were used, some economic activities with the same absolute quantities of pressures exerted may be assigned different materiality ratings. For some ecosystems and pressures that are linked to a small number of economic activities, not all materiality rating scale grades are represented. For example, in the ecosystem service of *Other provisioning services - Animal-based energy*, there are no economic activities that have a High or Very High materiality rating.

The materiality ratings indicate typical level of materiality at global level. The actual materiality of dependencies and impacts is likely to vary significantly based on the specific context, company and location that is assessed.

Water supply ecosystem service

The SEEA EA definition of the *water supply* ecosystem service states that the service "reflects the combined ecosystem contributions of water flow regulation, water purification, and other ecosystem services to the supply of water of appropriate quality to users for various uses including household consumption" ([SEEA EA, 2021](#)). When interpreting the dependency data and ratings from ENCORE, we encourage users to consider that *water supply* represents a final ecosystem service that combines other water-related ecosystem services also captured in ENCORE. As these ecosystem services are designed to overlap in the SEEA EA categorisation, users should consider excluding the *water supply* ecosystem service from their analyses where this may cause duplication.

When describing an economic activity's dependency on the *water supply* ecosystem service, we encourage users to refer to ecosystems as "providing the ecosystem service of regulating water quantity" or "providing the water quantity regulation ecosystem service". The wording "water provision" or "ecosystems supply water" are occasionally used as a shorthand but these statements are not scientifically correct and could be misleading. Ecosystems do not generate, produce, or provide water, they support the regulation of quality and quantity of water throughout the water cycle.

Dependency on water supply, water purification and water flow regulation ecosystem services

Following a precautionary approach, in this knowledge base, an economic activity is described as dependent on the *water supply*, *water purification* and *water flow regulation* ecosystem services both if the activity extracts water from the ecosystem itself and if the activity uses piped water (e.g., provided through municipal means). Scientific and grey literature reviewed for the purposes of determining the dependency links do not always differentiate between an economic activity's consumption of water that it directly extracted or that has been supplied to it. The data from the EE-MRIO database that was used to calculate the dependency materiality ratings for water-related ecosystem services also does not differentiate between water that has been directly extracted by the economic activity and water that has been supplied to it.

Location specificity

The knowledge base was not developed using location-specific information. All users are encouraged to integrate, apply and adapt the broad information gathered here for their own individual use case. Shifting supply chains to a different country to manage impacts on natural capital assets is also not captured in this framework, but these mitigation efforts could be captured in individual risk assessments by financial institutions or businesses.

Data coverage

Possible data sources are collected and curated in a wide variety of languages worldwide. As such, it is unlikely that all available data sources have been identified.

Data currency

The data sources identified in the updated ENCORE knowledge base represent the best available data at the time the research was conducted (2023-2024). However, websites providing access to data sources may not be accessible indefinitely and more up-to-date datasets may become available.

Technical skills

Many of the spatial data sources identified within the inventories may require technical skills or Geographical Information Systems knowledge to use.

Industry classification coverage

The ENCORE knowledge base on natural capital dependencies and impacts currently uses a list of economic activities drawn from the UN's International Standard Industrial Classification of All Economic Activities (ISIC). It is recognised that many financial institutions and businesses use other classification systems. ENCORE now provides crosswalks for ISIC to some other classifications (e.g., NACE and GICS®). However, it is recognized that it does not yet support all major industry classifications.

Opportunities

The ENCORE knowledge base currently provides information on dependencies and impacts associated with different economic activities. However, it does not yet cover opportunities related to companies' interactions with nature.