
**Sustainability in buildings and civil
engineering works — Sustainability
indicators —**

**Part 2:
Framework for the development of
indicators for civil engineering works**

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 59, *Buildings and civil engineering works*, Subcommittee SC 17, *Sustainability in buildings and civil engineering works*.

This first edition cancels and replaces ISO/TS 21929-2:2015, which has been technically revised.

The main changes are as follows:

- new indicators are provided;
- core and additional indicators and some specific indicators for different typologies of CEW are listed in [Annex A](#);
- the relationship between the indicators and United Nations SDGs (Sustainable Development Goals) is addressed.

A list of all parts in the ISO 21928 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document describes and provides guidelines for the development of sustainability indicators related to civil engineering works and defines the aspects and impacts of civil engineering works to consider when developing systems of sustainability indicators.

These guidelines form a basis for the suite of ISO/TC 59/SC 17 standards intended to address specific issues and aspects of sustainability relevant to civil engineering works. The issue of sustainable development is broad and of global concern and, as such, involves all communities and stakeholders. Both current and future needs define the extent to which economic, environmental and social aspects are considered in a sustainable development process.

The built environment (buildings and civil engineering works) is a key element in determining quality of life and contributes to cultural identity and heritage. As such, it is an important factor in the appreciation of the quality of the environment in which people live and work.

The built environment is highly important for sustainable development because:

- it is a key sector in national economies;
- it has a significant impact on poverty reduction through the provision of improved basic economic and social services within the built environment;
- it is one of the single largest industrial sectors and, while providing value and employment, it uses considerable resources and contributes to the transformation of areas, with consequential impacts on economic and social conditions and the environment;
- it represents a significant share of the economic assets of individuals, organizations and nations, providing societies with their physical and functional environment;
- it has considerable opportunity to show improvement relative to its economic, environmental and social impacts.

While the challenge of sustainable development is global, the strategies for addressing sustainability in civil engineering works are essentially local and differ in context and content from region to region. These strategies reflect the context, the preconditions and the priorities and needs, not only in the built environment, but also in the social environment. This social environment includes social equity, cultural issues, traditions, heritage issues, human health and comfort, social infrastructure and safe and healthy environments.

In addition, these strategies can include poverty reduction, job creation, access to safe, affordable and healthy shelter, and loss of livelihoods. These aspects are closely related to the United Nations Sustainable Development Goals (SDG). For this reason, in [Annex D](#), the relation of the provided indicators to these SDG is shown.

This document defines a framework for the development of sustainability indicators for civil engineering works based on the premise that civil engineering works contribute to improving the economic, social and environmental aspects at local, regional and global levels with minimum adverse impact. This document follows the general principles presented in ISO 15392.

Indicators are figures or other qualitative or descriptive measures that enable information on a complex phenomenon, such as, environmental impact, to be simplified into a form that is relatively easy to use and understand.

The four main functions of indicators are quantification, simplification, communication and decision making. Changes in a civil engineering works over time and the development of changes in relation to stated objectives and targets should be monitored with the help of indicators.

When developing and selecting indicators, the starting point is the identification of the main users and user needs. Sustainability indicators for civil engineering works are needed in decision-making by several stakeholders, such as:

- public bodies and policy makers;
- investors, owners and promoters;
- planners, developers and designers;
- governmental and non-governmental organizations (considering interest groups both at national and at local level);
- manufacturers of products;
- contractors;
- operators and maintainers;
- users and other stakeholders who are given service by the infrastructure; and
- local residents.

An example of utilization of indicators for decision support in the selection of alternatives is provided in [Annex E](#).

Sustainability indicators, as well as sets and systems of indicators, for the specification, assessment and representation of the contribution of a civil engineering works to sustainable development can be used in many ways. For example, among others, their application can support the following:

- design and decision-making process(es) during the planning and design stage of a civil engineering works (e.g. incorporation in the design of sustainable material, technologies, processes and other components);
- development and application of assessment methods and certification systems;
- specification and verification of environmental and social requirements in the context of procurement;
- indicating the civil engineering performance (e.g. marketing);
- measuring, monitoring or evaluating the performance and achievement of sustainability objectives over the different life cycle stages of the civil engineering works;
- identifying critical trends, both positive and negative, in the development and operation of civil engineering works;
- accepting responsibility for impacts on the environment and the society;
- representation of activities and results in the context of responsibility towards the economy, environment and society (e.g. sustainable development reporting).

NOTE The monitoring and evaluation of objectives can contribute to the continual improvement related to a specific or group of civil engineering works.

Aspects and impacts are the basis of the framework for the development of sustainability indicators for assessing the sustainability performance of new or existing civil engineering works, related to their design, construction, operation, maintenance, refurbishment and end-of-life. The indicators developed from these sets of aspects and impacts provide measures to express how the performance of a civil engineering works contributes to sustainability and sustainable development. The indicators developed based on these sets represent aspects of civil engineering works that potentially impact on issues of concern related to sustainability and sustainable development.

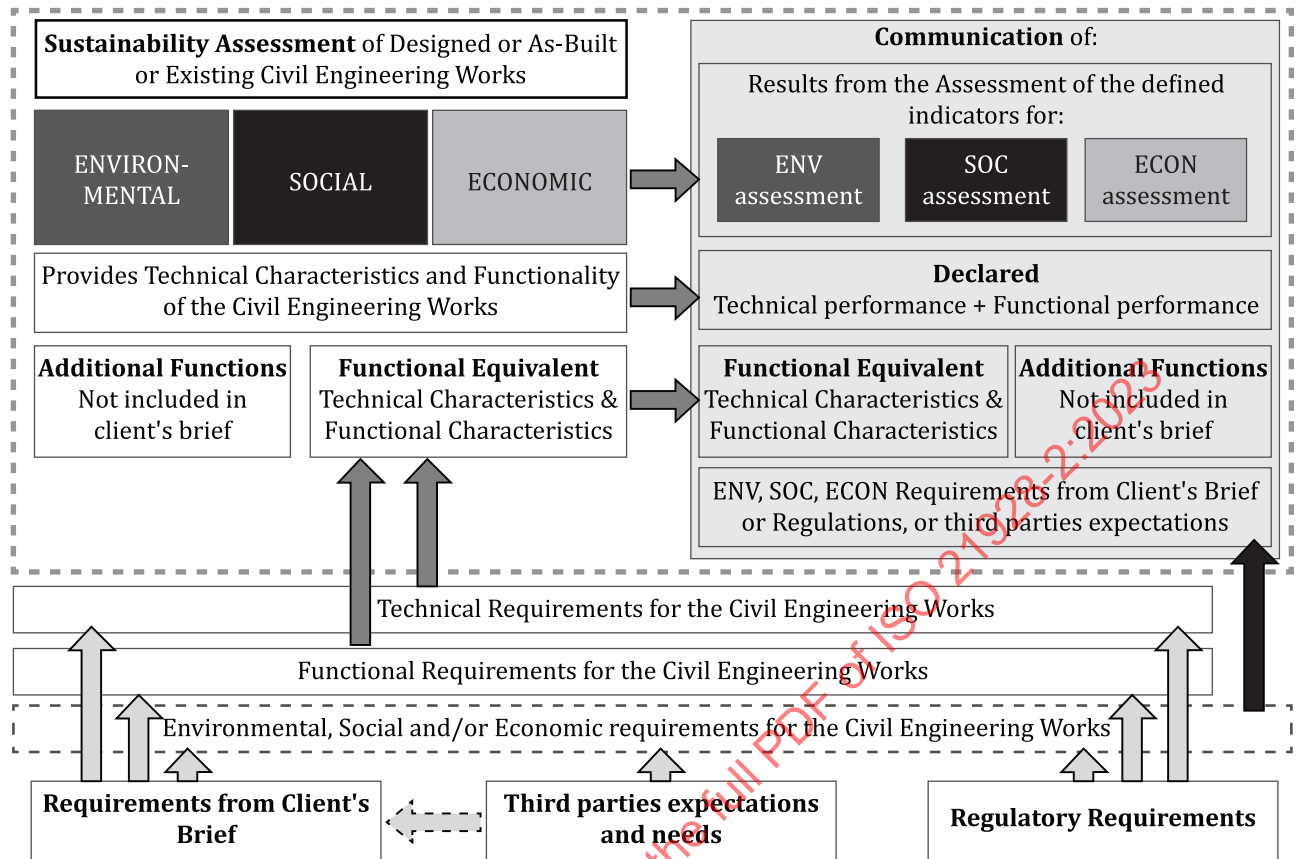
The object of consideration in this document is a civil engineering works, a part of the civil engineering works or a combination of several civil engineering works.

This document is one in a suite of International standards dealing with sustainability in buildings and civil engineering works, which includes ISO 15392, ISO 21929-1, ISO 21930, ISO 21931-1, ISO 21931-2, along with the terminology of sustainability in buildings and civil engineering works defined by ISO/TR 21932. The relationship among these International standards is shown in [Figure 1](#).

ISO/TC 59/SC 17	Environmental aspects	Social aspects	Economic aspects	Technical aspects	Functional aspects
Principles	ISO 15392 General principles				
	ISO/TS 12720 Guidelines on the application of ISO 15392				
	ISO/TR 21932 A review of terminology				
Buildings (Parts 1) + Civil engineering works, CEW (Parts 2)	ISO 21929-1 Framework for the development of indicators – Part 1: Buildings				
	ISO 21928-2 Framework for the development of indicators – Part 2: CEW				
	ISO 21931-1 Framework for methods of assessment of the environmental, social and economic performance of construction works as a basis for sustainability assessment – Part 1: Buildings				
	ISO 21931-2 Framework for methods of assessment of the environmental, social and economic performance of construction works as a basis for sustainability assessment – Part 2: Civil engineering works				
	ISO 20887 Design for disassembly and adaptability – Principles, requirements and guidance				
	ISO 16745-1+2 Carbon metric of an existing building during use stage – Part 1: Calculation, reporting, communication – Part 2: Verification				
	ISO 21678 Indicators and benchmarks – Principles, requirements and guidelines				
Products	ISO 22057 Data templates for the use of environmental product declarations (EPDs) for construction products in building information modelling (BIM)				
	ISO 21930 Core rules for environmental product declarations of construction products and services				

Figure 1 — Suite of related international standards for sustainability in buildings and civil engineering works

[Figure 2](#) illustrates how the assessment of the environmental, economic and social performances fits within the concept of the sustainability assessment of a civil engineering works.



NOTE The outer box with the thick dotted line represents the area within the scope of this document.

Figure 2 — Concept of sustainability assessment of civil engineering works

Indicators related to technical and functional performance are beyond the scope of this document. Technical and functional characteristics are taken into account here by reference to the functional equivalent, which also forms a basis for comparison of the results.

This document supports the development of indicators as a basis for quantification of the contribution of the assessed civil engineering works to sustainable construction and sustainable development.

Third parties' expectations and needs include those from societal, NGOs and local communities.

Environmental, social and/or economic requirements for the civil engineering works (based on the client's brief, as part of third parties' expectations and needs or imposed by regulation) are taken into account. Thus, they are part of the communication and included in the report. However, they are not assessed.

This document adapts general sustainability principles for civil engineering works and follows the principles set out in ISO 15392 and, where appropriate, is intended to be used in conjunction with, and following the principles set out in, ISO 26000, ISO 14040 and the family of International Standards that includes ISO 14020, ISO 14021, ISO 14024 and ISO 14025. Where deviation occurs, this document goes beyond the requirements of these standards.

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Sustainability in buildings and civil engineering works — Sustainability indicators —

Part 2: Framework for the development of indicators for civil engineering works

1 Scope

This document establishes a set of common aspects and impacts for all typologies of civil engineering works, and identifies core sets of environmental, social and economic aspects and impacts for each typology of civil engineering works defined.

The common core set of aspects and impacts described in this document are applicable to all types of civil engineering works. In addition, this document describes specific core sets of aspects and impacts for different typologies of civil engineering works (industrial process infrastructures; linear infrastructures; dams and other fluvial works; maritime works; public spaces; and other civil engineering works not contained in the previous typologies).

Further, the document gives rules for establishing a system of indicators and describes how to use sustainability indicators regarding civil engineering works.

This document does not provide guidelines for the weighting of indicators or the aggregation of assessment results.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 1996-2:2017, *Acoustics — Description, measurement and assessment of environmental noise — Part 2: Determination of sound pressure levels*

ISO 2631 (all parts), *Mechanical vibration and shock — Evaluation of human exposure to whole-body vibration*

ISO 14020, *Environmental statements and programmes for products — Principles and general requirements*

ISO 14040, *Environmental management — Life cycle assessment — Principles and framework*

ISO 15392:2019, *Sustainability in buildings and civil engineering works — General principles*

ISO 15686-1:2011, *Buildings and constructed assets — Service life planning — Part 1: General principles and framework*

ISO 15686-2, *Buildings and constructed assets — Service life planning — Part 2: Service life prediction procedures*

ISO 15686-5:2017, *Buildings and constructed assets — Service life planning — Part 5: Life-cycle costing*

ISO 15686-7, *Buildings and constructed assets — Service life planning — Part 7: Performance evaluation for feedback of service life data from practice*

ISO 15686-8, *Buildings and constructed assets — Service-life planning — Part 8: Reference service life and service-life estimation*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

3.1 airport

area containing an airfield and facilities for handling passengers and cargo

[SOURCE: ISO 6707-1:2020, 3.1.3.12]

3.2 area of influence

area or combination of areas surrounding a *civil engineering works* (3.6) that can be affected with changes to their economic, environmental or social conditions by the civil engineering works' operations throughout its *life cycle* (3.23)

Note 1 to entry: The area of influence is variable and dependent on the civil engineering works project, its location and its life cycle stage. As an overall approach, the area of influence is usually limited to the civil engineering works itself and its immediate surroundings and neighbourhoods.

3.3 avoided emissions

emissions that are not produced (are avoided) as a result of the implementation of voluntary initiatives or good practices

3.4 built environment

collection of man-made or induced physical objects located in an area or region

Note 1 to entry: When treated as a whole, the built environment typically is taken to include buildings, external works (landscaped areas), *infrastructure* (3.20) and other construction works within the area under consideration.

[SOURCE: ISO 21929-1:2011, 3.7, modified — Note 2 to entry has been removed.]

3.5 civil engineering work

work of constructing *civil engineering works* (3.6)

[SOURCE: ISO 6707-1:2020, 3.5.1.3]

3.6 civil engineering works

construction works comprising a *structure* (3.40), such as a *dam* (3.9), bridge, *road* (3.35), *rail-transit* (3.30), runway, utilities, *pipeline* (3.28), or *sewerage system* (3.38), or the result of operations such as dredging, *earthwork* (3.11), geotechnical processes, but excluding a building and its associated site works

[SOURCE: ISO 6707-1:2020, 3.1.1.2]

3.7**system boundary**

set of criteria specifying which unit processes are part of the specific analysis of a *civil engineering works* (3.6)

[SOURCE: ISO 14044:2006, 3.32 modified — Reference to “a product system” has been replaced by “the specific analysis of a civil engineering works”; note 1 to entry has been removed.]

3.8**construction work**

activity of forming a *civil engineering works* (3.6)

[SOURCE: ISO 6707-1:2020, 3.5.1.1, modified — The alternative term “construction, US” and note 1 to entry have been removed; “activities” has been changed to “activity”; “construction works” has been changed to “a civil engineering works”.]

3.9**dam**

barrier constructed to retain water to raise its level, form a reservoir, or reduce or prevent flooding

[SOURCE: ISO 6707-1:2020, 3.1.2.22]

3.10**dock**

partially enclosed or sheltered area of water where vessels may be moored or docked, used for shipping

3.11**earthwork**

work of excavating, or the raising or sloping of ground

[SOURCE: ISO 6707-1:2020, 3.5.1.6, modified — The alternative terms “excavation” and “work, US” have been removed.]

3.12**economic aspect**

characteristic of *civil engineering works* (3.6), part of works, processes or services related to their *life cycle* (3.23), that can cause change to economic conditions

[SOURCE: ISO 15392:2019, 3.12, modified — “construction works” has been replaced by “civil engineering works”.]

3.13**energy efficiency**

measure of energy use against a baseline

EXAMPLE An energy efficient lamp which produces the same amount of light as a conventional lamp but uses up to 75 % less energy to do so.

3.14**environmental aspect**

characteristic of *civil engineering works* (3.6), part of works, processes or services related to their *life cycle* (3.23), that can cause change to environment

[SOURCE: ISO 15392:2019, 3.13, modified — “construction works” has been replaced by “civil engineering works”.]

3.15

external costs

costs associated with an asset that are not necessarily reflected in the transaction costs between provider and consumer and that, collectively, are referred to as externalities

Note 1 to entry: These costs may include business staffing, productivity and user costs; these can be taken into account in a *life-cycle cost* (3.24) analysis but are to be explicitly identified.

[SOURCE: ISO 15686-5:2017, 3.1.6]

3.16

impact

the result of a change or existing condition that may be adverse or beneficial

[SOURCE: ISO 15392:2019, 3.17]

3.17

impact category

class representing an economic, environmental or social issue(s) of concern (areas of protection) to which analysis (assessment) results may be assigned

Note 1 to entry: Issues of concern can involve either *impacts* (3.16) or aspects related to the economy, the environment or the society.

[SOURCE: ISO 21929-1:2011, 3.15, modified — Note 2 to entry has been removed.]

3.18

indicator

quantitative, qualitative or descriptive measure representative of one or more *impact categories* (3.17)

Note 1 to entry: Periodic evaluation and monitoring using indicators can show direction of any *impact* (3.16).

[SOURCE: ISO 21929-1:2011, 3.16, modified — Note 2 to entry has been removed.]

3.19

indirect indicator

indicator (3.18) that does not express the subject of interest directly or only expresses it in a proxy way

3.20

infrastructure

civil engineering works (3.6), part of the civil engineering works or combination of several civil engineering works

Note 1 to entry: In this document, the term "infrastructure" is sometimes used as a synonym for civil engineering works.

Note 2 to entry: Use of the preferred term, infrastructure, is derived from the definition of civil engineering works in ISO 15392.

3.21

stakeholder

interested party

person or organization that can affect, be affected by, or perceive itself to be affected by a decision or activity

EXAMPLE Customers, communities, suppliers, regulators, non-governmental organizations, investors and employees.

[SOURCE: ISO 21931-1:2022, 3.5.6]

3.22**issue of concern**

aspect(s) of the economy, the environment or the society that can be impacted by *civil engineering works* (3.6), goods or services

EXAMPLE Asset value, cultural heritage, resources, human health and comfort, social infrastructure.

[SOURCE: ISO 15392:2019, 3.3 — The preferred term to designate this concept has been changed from ‘areas of concern’ to ‘issue of concern’ and the admitted terms removed. “Construction works” has been replaced by “civil engineering works”.]

3.23**life cycle**

all consecutive and interlinked stages in the life of the object under consideration

Note 1 to entry: For consideration of environmental impacts and *environmental aspects* (3.14), the life cycle comprises all stages, from raw material acquisition or generation of natural resources to end-of-life.

Note 2 to entry: For consideration of economic impacts and *economic aspects* (3.12), in terms of costs, the life cycle comprises all stages from construction to decommissioning. A *period of analysis* (3.27) can be chosen to be different from the life cycle, see ISO 15686-5.

[SOURCE: ISO 15392:2019, 3.19]

3.24**life-cycle cost**

cost of an asset or its parts throughout its *life cycle* (3.23), while fulfilling its *performance* (3.26) requirements

[SOURCE: ISO 15686-1:2011, 3.11, modified — The abbreviated term “LCC” has been removed.]

3.25**linear infrastructure**

civil engineering works (3.6) characterized by its length, that transfers persons, materials or energy from one specific point to an end point

Note 1 to entry: It includes civil engineering works such as *roads* (3.35), *rail-transits* (3.30), bridges, *pipelines* (3.28) or channels.

3.26**performance**

observed (or predicted) behaviour of a *civil engineering works* (3.6), construction product or construction service in fulfilling (to fulfil) required functions or intended use conditions

Note 1 to entry: Performance in this context pertains to functional and technical requirements in use.

[SOURCE: ISO 15392:2019, 3.20, modified — “construction works” has been replaced by “civil engineering works”.]

3.27**period of analysis**

period of time over which *life-cycle costs* (3.24) or *whole-life costs* (3.44) are analysed

Note 1 to entry: The period of analysis is determined by the client.

[SOURCE: ISO 15686-5:2017, 3.3.6]

3.28**pipeline**

long continuous line of pipes, including ancillary equipment, used for transporting liquids or gases

[SOURCE: ISO 6707-1:2020, 3.1.2.30]

3.29

primary energy resource

energy resource that has not been subjected to any conversion or transformation process

[SOURCE: ISO 6707-3:2022, 3.6.22, modified — The word “energy” has replaced by “energy resource”.]

3.30

rail-transit

national or regional transport system for guided passage of wheeled vehicles on rails

[SOURCE: ISO 6707-1:2020, 3.1.3.3, modified — The term has been changed from “railway” or “railroad, US” to “rail-transit”.]

3.31

recovery

waste (3.43) treatment operation that serves a purpose in replacing other resources or prepares waste for such a use

3.32

recycling

recovery (3.31) operation by which waste (3.43) materials are reprocessed into products, materials or substances

Note 1 to entry: This can be done by “upcycling or high-level-recycling or recycling in closed cycles” or “low-level-recycling or downcycling in open cycles”.

3.33

resilience

ability to resist, adapt to, or quickly recover from a potentially disruptive event, whether natural or manmade in order to maintain or restore the intended service

3.34

re-use

operation by which products or components previously used are used again, without reprocessing, as products, materials or substances

3.35

road

way mainly for vehicles

[SOURCE: ISO 6707-1:2020, 3.1.3.1]

3.36

secondary energy source

energy source recovered from a previous use or from waste (3.43) which substitutes primary energy sources

3.37

set of indicators

non-structured list of indicators (3.18)

[SOURCE: ISO 21929-1:2011, 3.30]

3.38

sewerage system

system of sewers and ancillary works that conveys the contents to a sewage treatment works or another place of disposal

[SOURCE: ISO 6707-1:2020, 3.3.4.40, modified — The alternative term “sewage system, US” has been removed.]

3.39**social aspect**

characteristic of *civil engineering works* (3.6), part of works, processes or services related to their *life cycle* (3.23) that can cause change to society or quality of life

[SOURCE: ISO 15392:2019, 3.14, modified — “construction works” has been replaced by “civil engineering works”.]

3.40**structure**

civil engineering works (3.6) having an organized combination of connected parts designed to provide some measure of rigidity

3.41**sustainability indicator**

indicator (3.18) related to economic, environmental, or social impacts

[SOURCE: ISO 21929-1:2011, 3.33]

3.42**system of indicators**

structured list of *indicators* (3.18)

[SOURCE: ISO 21929-1:2011, 3.34]

3.43**waste**

substances or objects that the original holder has disposed of or intends to or is required to dispose of

Note 1 to entry: In this document, this concept is not confined to hazardous waste.

Note 2 to entry: Adapted from the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (22 March 1989). Article 2 Definitions, Item 1. The wording has been simplified and the reference to national law as the basis for any requirements has been removed.

[SOURCE: ISO 21929-1:2011, 3.37]

3.44**whole-life cost**

all significant and relevant initial and future costs and benefits of an asset, throughout its *life cycle* (3.23), while fulfilling the *performance* (3.26) requirements

[SOURCE: ISO 15686-5:2017, 3.1.14, modified — The abbreviated term “WLC” has been removed.]

3.45**whole-life costing**

methodology for systematic economic consideration of all *whole-life costs* (3.44) and benefits over a *period of analysis* (3.27), as defined in the agreed scope

Note 1 to entry: The projected costs or benefits may include *external costs* (3.15) (including, for example, finance, business costs, income from land sale, user costs).

Note 2 to entry: Whole-life costing can address a period of analysis that covers the entire *life cycle* (3.23) or (a) selected stage(s) or periods of interest thereof.

[SOURCE: ISO 15686-5:2017, 3.1.15, modified — Note 3 to entry has been removed.]

4 General rules for sustainability indicators development and its framework

4.1 General

There are several issues that shall be considered when expressing or describing an assessment of the contribution which a civil engineering works has on achieving sustainability and sustainable development with the help of indicators.

Indicators are quantitative, qualitative or descriptive measures representative of one or more impact categories or classes of economic, environmental or social issues of concern, to which analysis (assessment) results may be assigned. An indicator is intended to be relevant and representative of a wider, more complex issue, which it helps to illustrate. The use of indicators reduces the complexity of an issue that is to be assessed and allows the assessment of issues that in themselves are not measurable.

When assessing or setting targets for the contribution of a civil engineering works to sustainability, the use of other sustainability indicators may be relevant depending on the specific circumstances of the civil engineering typology and location. Indicators can address economic, environmental and social impacts directly as well as issues that have indirect consequences on such impacts. In some cases, the indicators address more than just a single aspect of sustainability.

NOTE For instance, the hypothetical indicator “reused excavation material”, that can be developed under the aspect “use of material resources” can be used to measure the surplus of excavated material that is reused or recycled on site, instead of taken to landfill. This indicator can address economic, social and environmental impacts, as detailed below.

- Economic impacts: The higher the excavated surplus material is reused on site, instead of being taken to landfill, the less will be the filling material that the project needs to purchase for its construction. The reuse of material on site also decreases the transport of raw material to the site and the transport of surplus construction materials to landfill, and it consequently reduces the fuel consumption. All these effects have an important economic impact for the project.
- Environmental impacts: On the one hand, the reduction of borrow pits by reusing the surplus materials on site, minimises the consumption of soil resources and the dust generation. On the other hand, the reduction of waste taken to landfill reduces the need of space for this activity and consequently minimises the environmental impact on natural habitats. As well, the reduction of transport reduces the emissions to air and, in the long term, the depletion of non-renewable sources like fuel. These examples show the environmental impacts that can be addressed through the potential indicator.
- Social impacts: The reuse of excavated materials on site reduces the space needed for landfills. This avoids landscape modification and territory segregation. The excavated materials can be reused for land levelling; which increases the useful surface area that can be for instance beneficial for agriculture uses. These are examples of social impacts, which can be addressed through the potential indicator.

There are some technical design specifications that can affect the civil engineering works and its sustainability. For example, selecting one- or two-layer porous pavements instead of dense asphalt in the design stage of a road can be used to reduce tyre road noise. This may avoid or reduce the need to take corrective measures for noise abatement, such as noise barriers or sound insulation in the use stage, and may affect the values of several indicators of economic, environmental or social impact when comparing it to other alternatives.

Guidelines on the selection of materials, products and systems can be given as practical recommendations, aiming to favour a certain type of technical measure. Practical recommendations depend in any case on geographical and technological circumstances. The degree of implementation of these measures, which are either defined as a design alternative or adopted as a preventive measure or good practice, can be used as an indicator to assess the sustainability of the civil engineering works.

4.2 Life cycle approach

The character, quality and availability of relevant information are all dependent on the life cycle stage of the civil engineering works. This document applies the life cycle stages as defined in the ISO 21931 series. In the life cycle of a civil engineering works, the following stages should be considered.

- Product stage: covers the period from “cradle” (extraction of natural resources) to the factory “gate” (before the products are transported to the site). It includes:
 - natural resources extraction and/or harvesting;
 - transport;
 - manufacturing and all upstream processes from cradle to gate.

Design and procurement are included in the construction process stage. When considering activities such as site investigation or archaeological studies, which are undertaken during planning, procurement or design stages, their impact shall be considered in the construction process stage.

- Construction process stage: covers the transportation of products to the site and the period between the point of time when construction work starts and the point when the civil engineering works is “ready” to be used or to give its service to the related community. It includes:
 - on site extraction;
 - transportation to and on the site;
 - construction of the civil engineering works.

NOTE 1 The pre-construction stage can be considered within the construction process stage: non-physical processes before construction, preliminary studies, tests, acquisition of land/site and design.

- Use stage: covers the period in which the civil engineering works is used or gives its service to the related community. It includes:
 - use;
 - operation and management;
 - maintenance and repair;
 - replacement;
 - refurbishment.
- End of life stage: covers the stages that occur during the end-of-life process. It includes:
 - decommissioning, deconstruction and demolition;
 - transport;
 - processing for reuse, recovery and/or recycling of construction materials;
 - disposal of construction material;
 - relandscaping.

NOTE 2 Impacts and benefits during and beyond end of life stage (reuse, recovery and recycling, as well as exported utilities) can be expressed as additional information.

Beyond the system boundary of the assessment two parts should be considered: the potential resources for future use including reused products, recycled materials and energy recovery, and the benefits and loads of exported energy or other utilities.

In the different life stages of a civil engineering works, the indicators may need to be considered differently. Indicators addressing the same issues may, therefore, initially relate to values predicted at the planning and design stage, while during the construction or use stage, indicators addressing that same issue of concern may be based on measurements or inquiries.

NOTE 3 For example, the sources of the data needed for the quantification of material supply change over time depending on the life stage of the civil engineering works, since during the design stage and at the beginning of the works, most of these data are predictions obtained from the construction project, literature, estimates or experts' views, whereas during the construction and use stage the quantity of materials used can be calculated with solid data, gathered from self-records, measurements, invoices, accounting systems or delivery notes.

Figure 3 illustrates the organization of the different stages in the life cycle of a civil engineering works, which should be considered in the assessment.

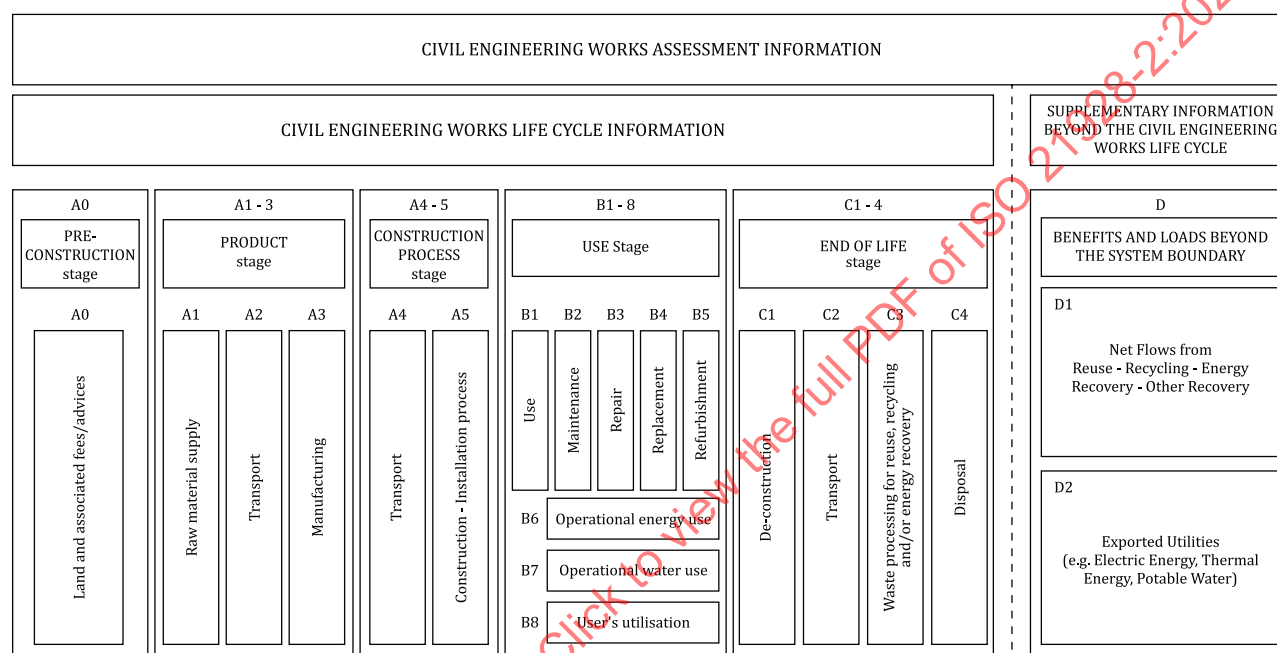


Figure 3 — Display of modular information for the different stages of civil engineering works' assessment

4.3 Area of influence

Civil engineering works affect a specific area throughout its life cycle; this spatial area over which the civil engineering works has significant economic, environmental or social influence is called "area of influence". Since the area of influence is variable and dependent on several factors, such as the civil engineering work typology, its location, the affected sustainability indicators and the life cycle specific stage, determining the area of influence is an important step when performing a sustainability assessment of civil engineering works.

For determining the area of influence of a civil engineering works, it is necessary to define the beginning and end of this area. Given that the area of influence is not always limited to the civil engineering works itself or some set distance from this area, the area of influence shall be defined for every typology of

civil engineering works and for each of the dimensions of sustainability: environmental, social and economic.

NOTE 1 For example, the area of influence related to land use, in general, is localized and restricted to the civil engineering works itself and immediate surroundings, whereas the area of influence related to releases of pollutants to a water body can be limited to a single river or stream, but can extend many miles downstream. Additionally, the spatial boundaries of the construction process stage normally include the civil engineering works area and immediate surroundings, and the socioeconomic regions supplying workers, whereas the spatial boundaries of the use stage include the civil engineering works itself and surroundings, the areas affected by emissions and effluents of the civil engineering works' use and the socioeconomic regions supplying workers.

NOTE 2 The definition of the spatial boundaries is a part of the system boundary definition.

Indicators have a relationship to both the concerns of the stakeholders and the overall assessment goal. The selection of the relevant set of indicators shall reflect the concerns of stakeholders and the proper representation of the assessment goal.

4.4 Civil engineering works typologies

The development and use of indicators require the classification of civil engineering works in different typologies, such as:

- industrial process infrastructures;

EXAMPLE 1 Waste disposal, sewerage, nuclear plants, cars factories, quarries, water treatment systems.

- linear infrastructures (including above and below ground);

EXAMPLE 2 Roads, pipelines, rail-transits, electrical transmission lines under the sea, runways, bridges.

- dams and other fluvial works;

EXAMPLE 3 Dams, locks, cofferdams, dredging, aquifer recharge.

- maritime works;

EXAMPLE 4 Electrical transmission lines under the sea, harbours, dredging, breakwater, wharves.

- public spaces.

EXAMPLE 5 Parks, airports, stadiums, railway stations, earthworks, landfill, public realm works.

Civil engineering works can be considered within one or more typologies. Consideration shall be given to all appropriate indicators for the identified typologies.

EXAMPLE 6 Canals can be considered as a linear infrastructure as well as a fluvial works.

In the case of a civil engineering works that does not fit very well into any of the five typologies defined, either because it is different or because it is a combination of several, the typologies that best fit the one under consideration shall be selected, and the indicators of all those selected shall be considered.

NOTE This includes some multifunctional and cross-typology infrastructures.

4.5 General principles and relationship to other relevant standards

4.5.1 General principles and procedures

In addition to the requirements of this document, the principles and procedures set out in ISO 15392, ISO 14040 and the ISO 14020 family of standards shall apply. The principles set out in ISO 26000 should also be taken into consideration, where appropriate. Where this document provides more specific requirements than these standards, such specific requirements shall be followed.

ISO 15392 presents six objectives for applying the concept of sustainability to buildings and civil engineering works and at the same time promoting sustainable development. These are:

- improvement of the construction sector and the built environment;
- reduction of adverse impacts while improving value, where impacts as well as value may be judged against any combination of the three primary aspects of sustainability;
- stimulation of a proactive approach;
- stimulation of innovation;
- decoupling of economic growth from increasing adverse impacts on the environment and/or society;
- reconciliation of contradictory interests or requirements arising from short-term and long-term planning or decision.

4.5.2 ISO 15392 — General principles of sustainability in building construction

ISO 15392 lists nine general principles applied to reach the objectives for applying the concept of sustainability to civil engineering works. These general principles are:

- continual improvement;
- equity;
- global thinking and local action;
- holistic approach;
- involvement of stakeholders;
- long term consideration and resilience;
- responsibility;
- risk management;
- transparency.

Sustainability indicators provide a means for taking into consideration the different principles related to sustainability and aid in the implementation of these principles.

4.5.3 ISO 14000 — Management systems standards

The ISO 14000 family of standards are intended to address the implementation of environmental management systems within organizations to help them manage the environmental impacts of their operations. Regarding the ISO 14020 family of standards, the overall goal related to environmental declarations and claims is to encourage the demand for, and supply of, those products (goods and services) that cause less stress on the environment, through communication of verifiable and accurate information that is not misleading, thereby stimulating the potential for market-driven continuous environmental improvement. ISO 14040 on life cycle assessment (LCA) provides one of several environmental management techniques (e.g. risk assessment, environmental performance evaluation, environmental auditing, and environmental impact assessment) and might not be the most appropriate technique to use in all situations. LCA typically does not address the economic or social aspects of a product, but the life cycle approach and methodologies described in ISO 14040 can be applied to these other aspects.

4.5.4 ISO 26000 — Social responsibility standard

ISO 26000 presents guidance on social responsibility relative to organizations and is intended to assist organizations in contributing to sustainable development. It describes seven high-level underlying

general principles related to social responsibility that an organization should respect and address, which includes:

- accountability;
- transparency;
- ethical behaviour;
- respect for stakeholder interests;
- respect for the rule of law;
- respect for international norms of behaviour;
- respect for human rights.

It also identifies lower-level principles specific to several core subjects (issues), such as, the environment, consumer issues and community development.

In assessing the contribution of civil engineering works projects to sustainable development, how and when these different standards and their principles apply vary and depend on the issue of concern under consideration. It also depends on the goods and services (products) used, and the different activities and decisions that the various stakeholders use or undertake, during the life cycle of the building.

NOTE 1 ISO/TS 12720 provides guidelines on the application of the general principles described in ISO 15392.

NOTE 2 The purpose of any sustainability assessment of a building is influenced by the specific scenario and different stakeholders involved. ISO 21931-1:2022, Annex B, provides guidance on the intended use, life cycle consideration and the application and/or purpose of assessments of the environmental performance of buildings.

4.6 Requirements for the development of indicators

The development of indicators for the specification and assessment of the contribution of a given civil engineering works to sustainability and sustainable development requires knowledge about the key issues of concern, the dimensions and complex interdependencies of sustainability in general and how these are applied to civil engineering works.

Indicators shall be:

- relevant: able to accomplish the goal of the intended use of the stakeholders;
- simple: presenting information in an easily understandable way to the different users of indicators;
- valid: objective, verifiable and reproducible and based on available and affordable standardized data and methodologies, whenever possible;
- informative: imparting knowledge and reflecting information which can have an influence or effect;
- sensitive and responsive: detecting changes in the system;
- reliable: giving the same result on successive trials (measurements under the same circumstances).

Information about an indicator shall include the following:

- nomenclature;
- a definition, comprising a general description and the underlying definitions and concepts, including a formula or expression when possible;
- unit of measurement (where applicable).

In addition, the indicator should also contain the following:

- method of measurement, including the status of the methodology against recognized standards;
- potential impact on one or more issues of concern, classifying these issues under environmental, economic and social aspects;
- data required to calculate the indicator, including data availability, reliability, accuracy, data sources and limitations of the data;
- organisations and/or responsible people involved in the development of the indicator;
- justification, describing the necessity of including this indicator in the core set and giving references and recognized standards related to the indicator, plus additional reading and sources of information;
- main aspects of the indicator, pointing out the themes to which it is related and those on which it can have a significant influence, including its relationship and links to other indicators.

The set of indicators shall be developed such that double counting is avoided. However, if an indicator is relevant to more than one dimension of sustainability and accounted for accordingly; this should not be regarded as double counting but represents a multi-effect approach.

4.7 Framework of sustainability indicators

4.7.1 General

A sustainability indicator is a quantitative or qualitative measure related to economic, environmental or social aspects. Generally, indicators have numerical values. However, in cases where relevant indicators cannot be measured with quantitative data then qualitative descriptions shall be used.

EXAMPLE A qualitative description can be that improved transportation would lead to economic development.

A sustainability indicator shall be linked to at least one of the three dimensions of sustainability. When developed, a set of indicators shall include the aspects and impacts described in this document.

When some aspects are not considered or are excluded from consideration, the reasons for such omission or exclusion shall be clearly explained and justified.

The sustainability indicators shall be organized within the three dimensions of sustainability, depending on the topic where they fit best. This does not mean that the indicators should be considered exclusively within only one dimension; on the contrary, they can have effects on economic, environmental and social issues of concern.

NOTE 1 For instance, the hypothetical indicator that can be developed under the name “Land take” (total area of land required for the civil engineering works), categorised in the aspect “Land use changes”, has an obvious influence on the environmental conditions, since it affects the use of natural resources, and the surrounding biodiversity and ecosystem. However, it has also economic and social linkages; because the act of taking land for a civil engineering development has a direct cost for the investors and promoters, it can affect the economic value of the nearby properties, it can lead to relocation of communities that lived in this land or to relocation of economic activities or it can change the cultural heritage either damaging it or rising its value through protection measures.

There are two types of sustainability indicators: direct indicators, which refer directly to the subject of interest they have been developed; indirect indicators, the development of which may be necessary, because the subject of interest cannot be measured directly or for ease of use. When used, indirect indicators shall have an evident connection with the subject of interest.

NOTE 2 Water quality can be expressed through different water quality factors. For example, the extent of eutrophication can be reflected either directly, through measures of the phosphate and nitrate contents of the water, or indirectly, through the amount of fertilizers, measured in terms of N or P, consumed in the nearby areas.

All life cycle stages of a civil engineering works shall be considered in the development of the indicators and their measurement (calculation) methods. When some stages are not considered or are excluded from consideration, the reasons for such omission or exclusion shall be clearly explained and justified.

NOTE 3 For example, when indicating the environmental performance of existing infrastructures, it can be justified to exclude the impacts from the original construction process stage.

The indicators addressing the issues of concern over the entire life cycle shall, as a minimum, maintain the distinction of:

- product stage (including materials extraction, transport and manufacturing);
- construction process stage;
- use stage;
- end-of-life stage.

The assessment of the economic impact of civil engineering works should, whenever possible, be based on a whole-life costing approach, and therefore consider all costs occurring in the life cycle of the civil engineering works. For consideration of economic impacts and economic aspects, in terms of costs, the life cycle comprises all stages from product stage to end-of-life stage.

This document provides a set of aspects and impacts common to all the typologies of civil engineering works, but there are also some specific aspects and impacts defined as core for each one of the typologies.

The core set of aspects and impacts are those for which indicators shall always be developed, at least. Depending on the case, specificities, location, etc., some other indicators based on aspects and impacts not included in the core set of aspects and impacts shall be developed.

Aspects and impacts as defined in [Annex A](#) shall be considered.

4.7.2 Issues for the development of environmental indicators

Environmental indicators relate to the environmental aspects of civil engineering works and to related impacts. When developing a system of environmental indicators of civil engineering works, the following environmental impacts and aspects shall be taken into consideration:

- water management;
- energy management;
- material management;
- waste management;
- emissions to environment (air, water and soil);
- noise, vibrations and light impacts (emission and obstruction);
- landscape changes;
- ecosystem health;
- land use changes.

NOTE The use of methods that support the consideration of environmental aspects, such as:

- service life assessment methods;
- environmental assessment methods;
- energy-efficiency assessment methods; and

- procurement and commissioning methods;

can demonstrate the rigour with which environmental issues have been considered within the design process. This can be used as a qualitative additional indicator.

4.7.3 Issues for the development of social indicators

Social indicators relate to the social aspects of civil engineering works and to related impacts.

The following social aspects shall be considered for developing a system of social indicators of civil engineering works.

- Accessibility: access to nature and access to basic services, i.e. users shall be able to access the service the civil engineering works is providing (water or energy supply, mobility services, etc.). That means that the infrastructure shall be functional and easy to use. However, there are some assets in civil engineering works that need to be inaccessible, to avoid incidents.
- Adaptability.
- Population system: changes in the number and distribution of inhabitants living in the areas of influence of the civil engineering works. The civil engineering works can either attract people to live in an area because of the associated improvements and value increase or make people leave their living areas to settle in other regions. A resettlement happens, for instance, when a location is flooded to build a dam.
- Job creation: working population in the areas of influence of the civil engineering works and their composition, considering different target groups like local, minorities or women employees.
- Cultural heritage elements: aesthetic or cultural concerns, such as preserving historical or archaeological sites, value of nearby properties.
- Stakeholder involvement, including education, training and literacy.
- Human rights.
- Risks and resilience: robustness and resilience of the infrastructure, i.e. durability, resistance to adverse conditions (climate change, natural disasters like fire or earthquakes, terrorism, etc.); retaining function, i.e. in case of disaster or after a terror action carried out against a civil engineering works, it shall have mechanisms to restore its function and value in a short period, so that normality in society is re-established. The redundancy of structural safety is directly related to the resilience of a structure. Infrastructure effects on users' health and safety: the further away from populated areas a gas pipeline is located, the fewer will be the effects on the health of the people who live in the surrounding area, in the case of a gas leak the greater the distance to a railway track, the less the vibrations will be felt by nearby residents; if a road is designed with stricter outline parameters in order to avoid its wandering through a natural protected area, the number of accidents may increase.
- Health and comfort: health and safety of population affected, including construction workers.
- Impacts on the neighbourhood.
- Maintenance and maintainability.
- Sourcing of materials and services.
- Social equity.

Also, process-related issues can be used to indicate the social aspects of new construction or refurbishment.

NOTE Some examples of process-related subject matters that can be used to indicate the social impact of construction process include:

- co-operation with the people who are benefiting from the infrastructure services and the nearby residents;
- consideration of users' needs in the design and construction process;
- ability to support social cohesion in the process, by considering the different social groups of users and their special needs or by making use of local labour.

4.7.4 Issues for the development of economic indicators

Economic indicators relate to the economic aspects of civil engineering works and to related impacts.

The following issues shall be considered when developing a system of economic indicators of civil engineering works:

- life-cycle costs;
- direct costs, such as cost of water and energy supply, cost of material acquisition, cost of preventive measures, cost of waste management;
- direct benefits, such as operating income from a toll road or financial benefits received from the government;
- external costs;
- indirect economic effects: for instance, the monetary value loss or increase of the areas influenced by the civil engineering works, due to noise levels, air pollution, landscape changes, tourism better access, installation of solar panels or integration of local businesses;
- effects on local economy: for instance, the selected infrastructure alternative can boost tourism in one area, since its communications or supplies are more efficient, or it can cause rural areas to depopulate, making these social groups more vulnerable;
- sustainable funding;
- social internal rate of return.

5 Set of aspects and impacts

5.1 General

The development of indicators for the specification and assessment of the contribution of a given civil engineering works to sustainability and sustainable development requires knowledge about the issues of concern, the dimensions and complex interdependencies of sustainability in general, and how these are applied to civil engineering works.

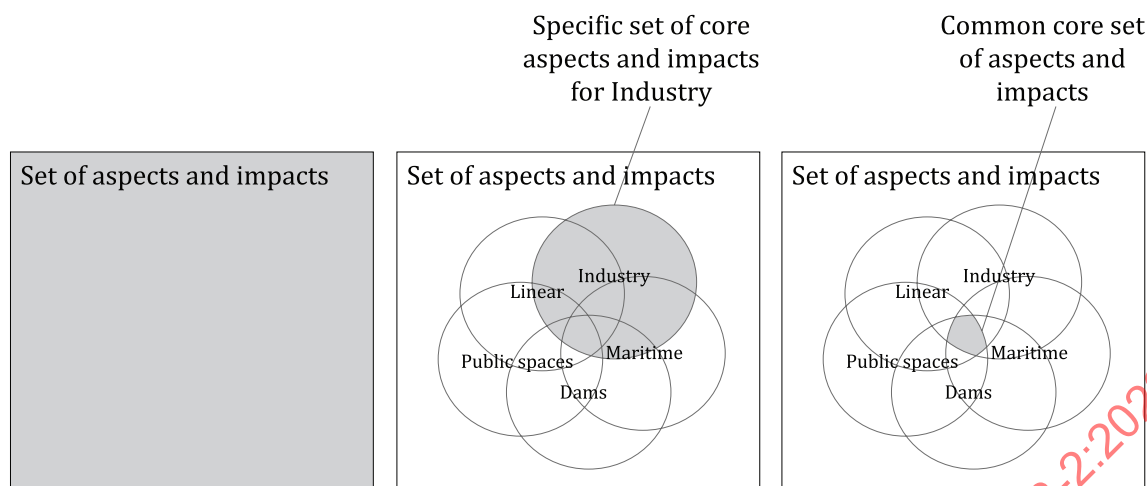


Figure 4 — Core sets of aspects and impacts

This document establishes a set of aspects and impacts as well as its relation to the three dimensions of sustainability (environmental, economic and social). These aspects and impacts should be taken as the basis for the development of indicators for assessing the sustainability performance of civil engineering works. It also provides a core set of aspects and impacts within the whole set that shall be developed when assessing the sustainable performance of a civil engineering works (see [Figure 4](#)). When developed, the sustainability indicators should be:

- essential from the viewpoint of assessing the contribution of a civil engineering works to sustainability and sustainable development;
- relevant for both new and existing civil engineering works.

Indicators shall represent the aspects of a civil engineering works that have a potential impact on issues of concern. The issues of concern relevant to a civil engineering works should be categorised in the following three dimensions of sustainability:

- environmental protection of climate stability, natural resources and ecosystems;
- economic costs and value creation;
- social issues of health and wellness, safety, quality of life, population and community and cultural heritage.

The sustainability indicators shall be developed considering the influence of the issues of concern and the aspects and impacts listed in [4.7.2](#) to [4.7.4](#).

5.2 Description of environmental aspects and impacts

5.2.1 General

[5.2.2](#) to [5.2.10](#) describe the aspects and impacts which shall be considered for developing a system of indicators for assessing the environmental pillar of sustainability performance of new or existing civil engineering works. When some of them are not considered or are excluded from consideration, the reasons for such omission or exclusion shall be clearly explained and justified.

5.2.2 Water management

The water used in civil engineering works can be provided from the following sources: surface water (including water from wetlands, rivers, lakes and oceans), groundwater, rainwater, municipal water supplies or wastewater. Indicators used to assess freshwater consumption should include quantity

(such as the total peak annual or average annual consumption of consumptive and non-consumptive fresh water), as well as quality (such as decrease of water quality).

For this category, the following aspects are considered:

- Consumptive use of fresh water.

Indicator: the amount of water used by the civil engineering works during construction and to perform and to maintain its functions, as well as the end of life, and not returned to the same water catchment area.

This indicator does not cover the relevant indicators, impacts and aspects obtained from the environmental product declaration (EPD).

The value shall be expressed in m^3 according to the relevant scenario(s).

- Non-consumptive use of fresh water.

Indicator: the amount of water used by the civil engineering works during construction and to perform and to maintain its function(s), as well as at the end of life, and returned to the same water catchment area with similar quality.

- Water scarcity.

Indicator: deprivation potential (deprivation-weighted water consumption) (m^3 world eq. deprived).

The value shall be expressed in m^3 according to the relevant scenario(s).

NOTE The values for this indicator come from the asset level.

EXAMPLE 1 Decrease of water in m^3 released from a dam to produce electricity.

- Water flooding.

Indicator: effectiveness of measures adopted against excess flows (number of days with excess flows over the acceptable limit).

- Decrease of water quality (physical and chemical characteristics) as a result of its use by the civil engineering works.

Water quality shall be measured throughout specific parameters depending on local context.

The following parameters shall be measured or calculated:

- dissolved oxygen;
- total suspended solids;
- pH;
- biochemical oxygen demand;
- turbidity.

Some others may also be required depending on the local context, such as temperature, total faecal coliforms, phosphates, nitrates, heavy metals.

In case of significant temperature variation, information shall be given. The information on water withdrawal may be obtained from water meters, water bills or calculations derived from other available water data.

Depending on the typology of the civil engineering works, changes in the water regime due to the construction work should also be measured. This could include changes from fluvial system

to lacustrine system in dams (in terms of volume), changes in the mean volumes of river water (in terms of volume), changes in the water table level (in terms of volume and depth) or length of flow affected by diversions. The information sources could be previous published studies or direct measure campaigns.

Calculation of the decrease of water quality (physical and chemical characteristics) as a result of its use by the civil engineering works shall be done by calculating the volume of freshwater that is required to obtain similar physicochemical characteristics to the original (such as to assimilate the load of pollutants based on natural background concentrations and existing ambient water quality standards). It shall be expressed in m^3 .

EXAMPLE 2 The theoretical amount of water in m^3 required to dilute the total quantity of runoff water collected by the drainage system of a highway to achieve water applicable quality standards.

In case of significant temperature variation, information should be given.

5.2.3 Energy management

The use of energy resources refers to the total energy required by the civil engineering works. This aspect is measured by indicators related to the use of energy, specifying direct and indirect sources of energy or renewable and non-renewable energy sources. The energy aspects and impacts which are used for defining the indicators are classified in four areas as follows:

a) Energy sources

- Total non-renewable primary energy resources (primary energy and primary energy resources used as raw materials) (MJ, net calorific value).
- Total renewable primary energy resources (primary energy and primary energy resources used as raw materials) (MJ, net calorific value).
- Non-renewable secondary energy sources (such as electricity, heating and cooling, steam, nuclear energy or other forms of imported energy) (MJ, net calorific value); and
- Renewable secondary energy sources (such as solar, wind, geothermal, hydro energy, and biomass based intermediate energy) (MJ, net calorific value).

Measurement (calculation) in the design stage is generally accomplished by evaluating the energy flows during the entire life cycle, whereas measurement in the construction and use stages is normally accomplished by evaluating the energy flows caused by the different activities, normally through energy suppliers' invoices.

The total energy consumed by the civil engineering works during construction can be reported separately but shall be considered in the whole life cycle approach.

- Depletion of abiotic resources – fossil fuels.

Indicator: abiotic depletion potential (ADP-fossil fuels) for fossil resources (MJ, net calorific value)

b) Demand side management (DSM)

- reduction of peak energy capacity requirements via DSM (MW);
- reduction of over-all consumption via DSM (MWh);
- flexibility of consumption via DSM (able to shift to off peak periods).

NOTE 1 Flexibility of consumption is the ability to modify demand behaviour to reduce the required energy system capacity.

c) Energy efficiency: ratio between useful energy output over total energy input.

NOTE 2 Efficiency addresses input-output efficiencies but also can include energy quality such as flexibility, power factors and thermal grades. Flexibility of the energy system is the extent to which it can modify energy production in response to need.

- d) Generation and storage: on-site energy generation/recovery, co-generation, energy storage contributions (MW).

5.2.4 Material management

Indicators related to the consumption of raw materials should be developed as they relate to depletion of natural resources. The consumption of such resources can result from the production of building products, as well as the construction, use and subsequent deconstruction of the civil engineering works. Resource use indicators include purchases of materials and sub-assemblies (inputs), stock variation, and waste generation (outputs). If appropriate, indicators related to the consumption of recycled resources in the construction work should be developed, due to the potential to minimise the depletion of natural resources.

The use or reuse of material resources, either virgin or recycled, shall be described in a disaggregated form. Whilst the use or recycled resources is one potential indicator, it is equally important to consider recyclability, that is, the extent to which materials in civil engineering works can be reused, recycled or recovered at end-of-life.

NOTE 1 Some reference material types used in civil engineering works are concrete, bituminous products (asphalt), aggregates, soil or steel.

Resource depletion may include an abiotic resource depletion approach which encompasses both the use of non-renewable and renewable abiotic resources. The indicator for abiotic resource depletion potential is a measure of the decrease in availability of said resource compared to a reference resource.

Toxic substances should also be considered, and indicators related to it, developed.

NOTE 2 The preferred method to develop these indicators is based upon the work of authoritative governmental bodies and a consensus process.

Indicators concerning environmentally sustainably managed materials should also be developed.

A material inventory shall be completed disaggregating them into detailed material types, such as concrete, bituminous products (asphalt), aggregates, soil or steel.

Origin, source, place of extraction, production, and transport of material is also important and shall be described. Reused materials shall account for both materials originating on site and off site, if any. Virgin materials may also have its origin in the work site, in the nearby or far away from its end point of use.

Indicators related to the total amount of materials are used as they relate to depletion of natural resources. The use of material resources, either virgin or recycled, shall be described in a disaggregated form within these categories:

- virgin material (kg);
- recycled material (kg);
- recyclable material (kg);
- non-recyclable material (kg);
- reused material (kg).

NOTE 3 Recycled material origin can be “upcycling or high-level-recycling or recycling in closed cycles” or “low-level-recycling or downcycling in open cycles”.

The amount of materials in each material category originating on site and reused on site shall also be described.

EXAMPLE On site material reclaim. The amount of bulk materials reclaimed in the construction site (within the civil engineering works bounds). Valuation can be expressed in m³; e.g. amount of excavated materials used as embankment in the same road; e.g. amount of on-site recycled asphalt reused for the new pavement.

NOTE 4 Some categories of materials to be considered are:

- metal materials;
- non-metallic mineral materials;
- fossil energy materials (e.g. plastics, bituminous products);
- biomass-based materials;
- non-fossil resources (ADP-elements (abiotic depletion potential) kg Sb eq.).

5.2.5 Waste management

An indicator which measures the production of the total amount of hazardous and/or non-hazardous wastes generated by the civil engineering works as a result of using materials resources should be included. The generation of such waste can result from the production of construction products, as well as construction, use and subsequent deconstruction of the civil engineering works. The total amount of waste includes all wastes (hazardous and non-hazardous) to disposal, as well as the materials for reuse, for recycling or for energy recovery off site.

- hazardous waste disposed (kg);
- non-hazardous waste disposed (kg);
- radioactive waste disposed (kg);
- components for re-use (kg);
- materials for recycling (kg);
- materials for energy recovery (not being waste incineration) (kg);
- exported energy (MJ for each energy carrier).

5.2.6 Emissions to environment (air, water and soil)

5.2.6.1 General

The indicators developed under this aspect should reflect the total emissions to local environment and their effects on air, soil and water, by describing the changes to, climate, human health and ecosystem quality.

5.2.6.2 Emissions to air

Indicators related to emissions to air should provide information on the total emissions of different gases and particles that have a potential impact on climate change or environmental pollution. These emissions can be calculated from accounting data and defaults and from direct emissions measurements or can be estimated using published emission factors.

Although each project shall decide which emissions to air it will measure and report per its local context, infrastructure typology and boundaries; significant emissions to air to measure include: NO_x, SO_x, CO, NH₃, persistent organic pollutants (POP), volatile organic compounds (VOC), hazardous air pollutants (HAP), stack and fugitive emissions and other standard categories of air emissions identified in regulations.

Ozone depletion should also be calculated and reported. It will be studied the disappearance of stratospheric ozone and the potential formation of tropospheric ozone (due to the reaction of VOCs, NO_x in the presence of strong insolation).

Particularly important for some civil engineering works are the dust (particulate) emissions. An indicator should be established reflecting the calculation, simulation, or measurements of the annual particulate matter emissions. The information can be drawn from direct emissions measurements, calculated from accounting data and defaults, or estimated using published emission factors. Control methods for industrial sources include the use of dust collectors, such as cyclones or bag filters, and total or partial enclosure of potential dust sources, such as conveyors, where the measurements can be realized.

NOTE 1 There are two general types of dust measurements: dust deposition and total suspended particulate. The chosen methods are related to the scale and significance of the environmental effects and sensitivity of the receiving environment. In some cases, dust monitoring is not appropriate, given the scale and significance of the predicted effects. For such small-scale sources, concentrating on good practice dust management measures is likely to be more beneficial.

- Construction works contribute to PM (particulates), through the following pathways.

NOTE 2 In this context, PM refers to the direct loads to the workers and the neighbourhood. Global impact is calculated in the environmental assessment.

- Construction process.

EXAMPLE 1 Diesel trucks used for transport from and to the construction site; milling and drilling in concrete; using glass or stone wool insulation.

- Operational energy use during the use phase.

EXAMPLE 2 PM generated by the burning of fossil fuels for power generation, oil fired boilers, coal fires, woodstoves and diesel driven engines/generators.

- User's utilization.

EXAMPLE 3 PM generated by cars using a motorway.

- Demolition works and transport during the EoL phase.

EXAMPLE 4 Crushing on demolition sites and waste incineration.

The greenhouse gases (GHG) emissions should be measured and reported separately due to their potential to impact climate stability.

NOTE 3 The main GHG emissions are: carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydro fluorocarbons (HFCs-a group of several compounds), per fluorocarbons (PFCs-a group of several compounds) and sulphur hexafluoride (SF₆). To help delineate direct and indirect emission sources, ISO 14064-1 provides a methodology.

NOTE 4 To calculate the amount of GHG emissions per source, some of the following methodologies are indicated as an example:

- direct measurement (e.g. continuous online analysers);
- calculation based on site specific data (e.g. for fuel composition analysis);
- calculation based on default data;
- estimations.

As an addition to the GHG emissions, an indicator which measures the avoided GHG emissions, according to ISO 14064-1 or equivalent, should be developed.

NOTE 5 Avoided emissions are those emissions that are not produced (are avoided) by using non-emitting technologies, by implementing good practices or by capturing and sequestering emissions from an emitting source. Avoided emissions are calculated from a baseline that describes what the GHG emissions would have been without the implementation of these measures.

If the emissions reductions are mandatory (derived from regulations or trading systems at international or national levels) they shall be quantified separately from the voluntary emissions reductions.

The pollution caused by emissions of acidifying gases should also be considered and indicators should be developed.

Source and frequency of any potential odours caused by the civil engineering works in any stage of its life cycle should be considered and, if needed, indicators could be developed.

— Ozone depletion.

Indicator – Depletion potential of the stratospheric ozone layer, ODP (kg CFC 11 eq.).

— Global warming total.

Indicator – Global warming potential, GWP (kg CO₂ eq.).

— GWP from fossil carbon emissions and removals.

Indicator – GWP fossil (kg CO₂ eq.).

— GWP from biogenic carbon emissions and removals.

Indicator – GWP biogenic (kg CO₂ eq.).

— GWP from land use and land use transformation emissions and removals.

Indicator – GWP land use and land use transformation (kg CO₂ eq.).

— Photochemical ozone creation.

Indicator – Formation potential of tropospheric ozone, POCP (kg Ethene eq.).

Indicators related to emissions to air may provide information on the description of air quality on a given area during a defined period and quantify the amount of area affected.

5.2.6.3 Emissions to water

Indicators related to emissions to water should provide information on the water quality, the water regime and the water table level, both qualitatively and quantitatively.

To determine the water quality, a common practice is to use a general water quality index, based on known and easily measurable parameters (such as dissolved oxygen, total suspended solids, pH, biochemical oxygen demand, total faecal coliforms, turbidity, phosphates, and nitrates). For that, management actions shall avoid the accidental spillage of any polluting substances (e.g. materials which may cause pollution shall not be stored near the water environment, qualified personnel are nominated as being responsible for the supervision of the filling of oil storage tanks). The necessary information can be drawn from water meters, in-situ analysis, laboratory tests, parameters' limits established in the wastewater discharge authorisation, calculations derived from other available water data, local or national water-related administrations sources, or research studies data.

— Eutrophication aquatic freshwater.

Indicator – Fraction of nutrients reaching freshwater end compartment, Eutrophication potential, EP freshwater (kg PO₄ eq.).

- Eutrophication aquatic marine.

Indicator – Fraction of nutrients reaching freshwater end compartment, Eutrophication potential, EP marine (kg N eq.).

- Eco-toxicity (freshwater).

Indicator – Potential comparative toxic unit for ecosystems (CTUe).

The assessment of the category should cover whether management actions have been taken to avoid the accidental spillage of any water polluting substances (e.g. materials which may cause pollution shall not be stored near the water environment, qualified personnel are nominated as being responsible for the supervision of the filling of oil storage tanks).

5.2.6.4 Emissions to soil

5.2.6.4.1 General

Indicators related to emissions to soil should provide information on the description of soil quality on a given area during a defined period and quantify the amount of area affected.

NOTE 1 Soil quality refers to the capacity of a soil to function within its ecosystem and land use boundaries, to sustain biological productivity, to maintain environmental quality, and promote plant and animal health and to preserve its geotechnical characteristic. It can be determined based on the following measurable parameters, which can be drawn from direct observation, photographic interpretation, in-situ analysing methods or laboratory tests:

- visual parameters: exposures of subsoil, change in soil colour, pounding, runoff, plant response, weed species or deposition;
- physical parameters: measurements of topsoil depth, bulk density, porosity, aggregate stability, texture, crusting, and compaction;
- chemical parameters: measurements of pH, salinity, organic matter, phosphorus concentrations, cation-exchange capacity, nutrient cycling, and concentrations of elements that may be potential contaminants (heavy metals, radioactive compounds, etc.) or those that are needed for plant growth and development;
- biological parameters: measurements of micro and macro-organisms, their activity, or by-products.

Indicators should provide information about the amount of contaminated land (per applicable legal designations) and remediated land, since it may affect soil quality, water quality, human health or other environmental or ecological receptors.

When toxic substances appear in the life cycle of the project, they shall be listed. Depending on the previous quality of the soil, the pollution can be less or more harmful. Based on this level of harmfulness information, scenarios shall be developed in the consideration of the risk that these substances present. Decontamination of the asset shall be one of the end-of-life or refurbishment scenarios.

NOTE 2 Contamination can occur as a result of civil engineering work activities, can have occurred as a result of prior use or activities by an unrelated entity or can also be of natural origin. In cases where contamination has occurred as a result of prior activities, promoters and construction companies frequently conduct assessment, risk management and/or remediation activities, which make the land suitable for existing or new purposes and uses.

The indicators to be used are:

- Soil quality.

Indicator – Potential soil quality index (dimensionless).

- Eutrophication terrestrial.

Indicator – Accumulated exceedance, eutrophication potential, EP terrestrial (mol N eq.).

— Biogenic carbon.

Indicator – Biogenic carbon (C) contained in bio-based materials used in the product system under study and remaining in landfill after 100 years since deposition (kg C).

5.2.6.4.2 Acidification for soil and water (acidification potential, AP)

This indicator measures the potential impact on the acidification of land and water resources. The indicator's value is estimated with the help of EPD or the life cycle assessment of the civil engineering works by assessing the total magnitude(s) of those emissions to soil or water that potentially affect acidification and by expressing the result in terms of SO₂ equivalent.

In addition to the measurement of the acidification potential, it is also important to take into account the measures that are implemented in the different civil engineering works stages in order to prevent or minimise acidifying emissions, such as the purchase of machinery with BADT (best available demonstrated technology) or equipment replacement, when needed.

NOTE The sulphur dioxide present in the environment is emitted from natural as well as from anthropogenic sources. Civil engineering works can emit this pollutant, especially on the basis of the energy use, when the sources of energy are fossil fuels and when there is no efficient de-sulfurization. One of the main consequences of the emission of this substance into the environment is acidification of soil and water resources.

— Acidification.

Indicator – Accumulated exceedance, acidification potential AP (mol H⁺ eq.).

EXAMPLE Estimated emissions of SO₂ in kg (m) is calculated multiplying the activity rate, tonnes of asphalt produced (A) multiplied by the emission factor, kg of SO₂ per tonne of asphalt produced (EF) and multiplied by, 1 minus the overall emission reduction efficiency (ER/100).

5.2.7 Noise, vibrations and light impacts

The noise, vibrations and light impacts on the biosphere caused by the civil engineering works or experienced by users are represented by indicators based on calculations, simulations or measurements. Some potential data sources can be acoustic studies, environmental impact assessment, noise maps, noise legislation with local allowed noise levels or competent administration's studies, light studies or models, etc.

Regarding the environmental performance of the civil engineering works, the indicator describes disturbance on ecologically important groups of species from the civil engineering works.

— Disturbance because of noise, vibrations and light impacts on ecological species.

Indicator – Area (m²) of ecologically disturbed habitat.

The social impact of the civil engineering works performance is described in [5.3](#).

5.2.8 Landscape changes

The indicators included in this aspect should represent and evaluate the changes in the aesthetic effects of the landscape, townscape and cityscape due to the civil engineering works. Some data sources for developing this information can be maps, plans and photographs of the surrounding area, field survey, videos, photomontages aided by computer-generated models, quantifiable data, annotations, information about distinctive landscape components, landscape features (topography, geology, drainage and vegetation) and visual receptors, local plans and planning documents from the planning authority.

Although the magnitude of the visual impact still proves to be a subjective assessment to a large degree, the created indicator should be as technical and objective as possible.

Visibility, visual intrusion of the infrastructure and the obstruction it can produce, and overshadowing should also be considered and, if needed, indicators should be developed.

- Permanent occupied land area (m²).

Land surface occupied by the asset or that can't be used for anything different from the asset itself.

EXAMPLE 1 The land occupied by a rail-transit with two lanes includes the surface physically occupied by the railway itself, and the space in between. It also includes the service area in which no different activities from railway (maintenance, security, etc.) is allowed.

EXAMPLE 2 The land occupied by a dam includes the dam itself and the surface occupied by the reservoir.

It shall be expressed in m².

- Temporary land occupation.

Land surface occupied by the temporary works for construction, maintenance, demolition, etc., in addition to the asset itself.

It shall be expressed in m² per month.

5.2.9 Ecosystem health

5.2.9.1 General

The indicators developed under this aspect provide information about the changes in ecosystem processes and services in the areas of influence of the civil engineering works.

NOTE 1 The main ecosystem service categories are:

- regulating services: regulation of biophysical conditions, biotic environment or against hazards; for example, air quality regulation, climate regulation, moderation of extreme events, erosion prevention, maintenance of soil fertility or biological control;
- provisioning services: provision of food and beverages, raw materials, energy, medical resources, genetic resources or ornamental resources;
- cultural services: spiritual or aesthetical value, recreation and tourism;
- supporting services: existence of biodiversity at the level of species, genes, ecosystems and landscapes.

To provide information on the availability and use of ecosystem services, clear, consistent, comparable and quantified ecological change indicators should be developed.

Some specific indicators related to ecosystem health that shall be considered are the biodiversity change of an area and the ecological connectivity that may have been eased or impeded through the civil engineering works.

5.2.9.2 Ecosystem services changes

The biodiversity of species, genes, ecosystems or landscapes can be measured by different indicators such as:

- number of animal and vegetal species located in the system boundaries;
- types of landscape which are partially affected by the infrastructure;
- change of the number and extension of the habitat areas affected by the civil engineering works.

To create an accurate and reliable indicator, factors as the magnitude (number of species or size of ecosystem areas), the connectivity and the quality of the affected habitats and species, the extinction

risk of the species, the conservation status or the protection status of the specie or ecosystem shall be considered.

It can also be interesting to develop indicators for measuring some ecosystem services which are made available for the civil engineering works' area of influence. This may include:

- the protection from avalanches, rock falls and debris fall through vegetation on steep slopes;
- the carbon sequestration;
- the natural supply of ground and surface water usable as drinking and process water;
- the yield of wild animals and fish for commercial use;
- the renewable energy sources;
- the natural supply of pollination and biological pest control; among others.

The information may be obtained from the competent local administrations, published literature, environmental impact assessment, previous field study reports and site's records regarding the affected species.

5.2.9.3 Biodiversity change

The indicators developed under this aspect shall provide information about the changes in biodiversity and shall be reported as areas, in m² and biodiversity before and after, expressing:

- protected areas affected and if the impact is positive or negative according to the scientific based methodology regulated or recommended by the relevant authorities, within the system boundaries and the area of influence;
- non-protected areas with biodiversity quality changes.

5.2.9.4 Ecological connectivity (landscape connectivity)

This aspect expresses the degree to which civil engineering works facilitates or impedes the movement through the landscape for flora and fauna.

- Indicator: length of the barrier effect.
- Indicator: number of natural corridors crossed.
- Indicator: measures applied to avoid the barrier effect.

EXAMPLE Average distance between passages for wildlife in a road crossing a protected area.

5.2.10 Land use changes

Land use changes inside the project boundaries for the civil engineering works development. During the life cycle of the civil engineering works, land use changes should be taken into account. For instance, there is a temporary need of auxiliary areas in the construction process stage, whereas these areas are no longer needed in the use stage.

For the development of indicators, the previous use of the land should also be considered, including the following.

- Non-previously developed land: natural and semi-natural land, which has never been developed for any artificial use (known as greenfield land). It may include agricultural land (arable land and permanent crops; pastures and mixed farmlands), forest and woodland and other (open spaces with little vegetation, wetlands, water bodies). Some of these areas can be also protected areas, which are established by its Governments and various organisations. If this is the case, the proportion of

protected areas used for the civil engineering works should also be used as an indicator, since that has a potential impact on the related biodiversity and ecosystems.

- Previously developed land: land that has been previously developed (this should include brownfield land). This land may be available for development and includes previously developed land now vacant, vacant buildings, remediated land, derelict land and buildings, previously developed land or buildings currently in use and allocated in local plan or with planning permission and previously developed land or buildings currently in use with redevelopment potential but no planning allocation or permission.

Indicators for changes in land uses and land's economic value should also be developed.

NOTE The indicator developed with the consideration of the previous land use measures the avoidance of consuming of greenfield areas through the reuse of brownfield and derelict areas, refurbishment, using infill sites and re-development of existing built environment.

Indicator: Surface of land that changes its previous use because of the civil engineering works (because the land is occupied by it or because of its influence). It is expressed in m².

5.3 Description of social aspects and impacts

5.3.1 General

[5.3.2](#) to [5.3.15](#) describe the aspects and impacts which shall be considered for developing a system of indicators for assessing the social pillar of sustainability performance of new or existing civil engineering works. When some of them are not considered or are excluded from consideration, the reasons for such omission or exclusion shall be clearly explained and justified.

5.3.2 Accessibility

Accessibility considers the ability of all users and stewards (e.g. operators and maintainers) of the infrastructure to access the services provided by civil engineering works, as well as access to nature, and the effect on the ability of people to continue to access the existing services.

Accessibility assesses the provisions included in the civil engineering works to facilitate access to and use of its facilities and services (e.g. electrical systems – switches, circuit breakers, access of passengers to a ship in a harbour, payment systems on toll bridges and motorways, etc., where relevant) as much for users as for employees.

Accessibility for people with additional needs (e.g. wheelchair users, the blind and partially sighted, the hearing impaired, and those with other types of physical, mental or cognitive impairment/conditions, parents with children in pushchairs, elderly people) whether as employees, users or for the general public (where appropriate) shall be considered and measures describing how this has been achieved shall be part of the assessment. This shall only be excluded when justified, for example, as not required by regulations or the client's brief.

NOTE 1 Legislation, standards and guidelines exist related to accessible design can be consulted when designing the civil engineering works, so that measures to ensure the accessibility for people with additional needs are taken into account in the project. In addition, it is presupposed that national and/or local laws that set the minimum requirements and the guidelines for designing urban spaces that met the criteria of universal accessibility are considered.

When planning and designing a civil engineering works, it is important to ensure that access is available to as many different relevant users as possible. Users considered in this clause are those different from the main intended users of the civil engineering works according to the client's brief.

When designing the civil engineering works, appropriate measures shall be planned in order to ensure a safe access for relevant users to the facility and its nearby and related infrastructure and in order to avoid possible obstructions. However, there are some assets in civil engineering works that need to be inaccessible, in order to avoid accidents.

Access to the services provided by civil engineering works shall include the consideration of different issues such as:

- user's affordability (toll charges, electricity charges, price of water, equity of financial mechanisms, etc.);
- service level (including, for example, reliability, punctuality, distances, quality of the water provided, electricity assurance, frequency).

Connectivity is used to assess the ability to transit across and around the infrastructure. Civil engineering works are usually large projects that imply land take, temporarily as well as permanently. Obstruction or hindering of access to nature and recreational areas, to existing and proposed routes for pedestrians, cyclists and other relevant users, or to other nearby populations can occur.

Connectivity is often measured in "travel time". If "source" and "target" are defined in an appropriate way, this indicator can also be used to assess fragmentation of settlements caused by new infrastructures. It shall be defined for all participants in public space (including pedestrians) and all relevant functional relations.

NOTE 2 'Source' and 'Target' can be urban centres, significant local facilities and/or places of interest that might be directly affected by the development of the civil engineering works.

The indicators included in this aspect relate also to the changes of people's opportunity to access a good quality natural environment, due to the construction of the civil engineering works.

A civil engineering works can either improve or worsen the ease of access to natural green areas, since it can have influence on the natural environment's quality or size and on the distance from population centres to nature.

Access to nature should be measured by indicators which report the extent of accessible natural green space or the percent of population with access to green space within the civil engineering works area of influence.

Potential sources of information used for the indicators could be geographic information systems (GIS) datasets of competent environmental local administrations, national or regional databases, published inventories of accessible green areas, published maps of soil land cover types or previous field studies reports and site's records.

For this category, the following aspects shall be considered when relevant:

- Inclusive access.

Indicator: provisions included in the civil engineering works to facilitate access to people with disabilities (such as provision of appropriate tactile, visual and audio wayfinding systems; the number and proportion of allocated car-parking for users with additional needs relative to the total number of parking places provided: the number of kerb ramps to facilitate the use of asset).

Indicator: user's affordability such as toll charges, electricity charges, price of water or equity of financial mechanisms.

- Access to basic supplies provided by the civil engineering works.

Indicator: service level including reliability, punctuality, distances, quality of the water provided, electricity assurance and frequency.

Indicator: changes of people's opportunity to access a good quality natural environment, including access to natural green areas (extent of accessible natural green space or the percent of population with access to green space within the civil engineering works area of influence).

Indicator: net change in the utility supply (measured by comparing the number of inhabitants that have access to each relevant basic supply before and after the construction of the civil engineering works).

Any changes in the costs for inhabitants or municipalities of this basic supplies shall be taken into account in the economic assessment.

- Connectivity.

Indicator: the 'travel time' from a defined "source" to a defined "target".

Indicator: fragmentation of settlements.

Indicator: design features incorporated that enable transit for all relevant users (such as % pedestrian over/under passes) including points allowing safe and easy access around or across the civil engineering works, with appropriate signage.

These indicators shall be reported (as appropriate) in modules A5 and B1.

5.3.3 Adaptability

The adaptability considers the characteristics of the civil engineering works that allow it to be modified to make it suitable for potential future needs or alternative or complementary uses (e.g. enlarging a motorway or creation of a new access, new terminal for an airport).

To measure the adaptability, indicators which describe redundancy in load-bearing capacity, accessibility/demountability, reconfiguration and, in general, flexibility, should be developed.

For the assessment of adaptability, the civil engineering works' ability to accommodate shall be considered:

- technical changes;
- change of use;
- complementary uses;
- external events.

EXAMPLE For pipes and cables (or prestressing/anchoring tendons) adaptability can relate to the provision of space for additional pipes and cables required for a change of use and provisions for possible future equipment (e.g. lifts).

The scenario for adaptation shall specify what potential adaptations are to be taken into account in the assessment of the civil engineering works, if relevant. The assessment shall report how the object of assessment may be adapted according to the aspects listed above.

NOTE Adaptability can also offer advantages in economic and environmental performance, which are assessed as part of the initial assessment of economic performance and assessment of environmental performance, and which can be reassessed at the time of a change in the technical and functional requirements.

For the aspect "adaptability of the civil engineering works", the following indicator can be considered: number of measures of the civil engineering works to accommodate technical changes, change of use, complementary uses and external events.

The following are examples that can be cited for measures to provide for an increased adaptability:

- ease of demolition/demountability of the civil engineering works including construction elements, pipes, cables etc.;
- redundancy in load-bearing capacity;
- provision of space for additional lanes, terminals, pipes or cables required for expansion;
- over dimension of the civil engineering works to allow the growth of the external facilities;
- provision for future change of use (a railway converted into highway or cycleway);

— alternative or complementary uses during the expected service life of the civil engineering works.

This list of examples is not intended to be exhaustive.

The results of these indicators shall be reported in module B1.

NOTE 2 For further information on design for disassembly and adaptability, see ISO 20887.

5.3.4 Population system

The indicators included in this aspect should evaluate the changes in the way the land is used, due to the civil engineering works. These changes can lead either to a revaluation or to a depreciation of the land's economic value, which consequently affects the population living in the areas of influence of the civil engineering works.

Indicator: number, or if unavailable an informed estimate, of people resettled directly or indirectly because of the civil engineering works. Resettlement is either physical or economic.

The civil engineering works can either attract people to live in an area because of the associated improvements and value increase or make people leave their living areas to settle in other regions. Consequently, other indicators related to the changes in the territorial relation system of the civil engineering works' areas of influence should be developed.

There can also be changes in the population centre distribution (e.g. disappearance of population centre due to the flooded area needed when building a dam, creation of new population centre or resettlement from the population in another centre).

Some changes in the number of inhabitants living in the areas of influence of the civil engineering works may occur (the civil engineering works can either attract people to live in an area because of the associated improvements and value increase or make people leave their living areas to settle in other regions. A resettlement happens, for instance, when a location is flooded in order to build a dam) and indicators on that issue should be developed.

NOTE 1 Civil engineering works can result in the displacement and resettlement of people. Whether voluntary or involuntary, potential impacts can include changes of productive land, changes of employment and income, changes of housing, changes of access to common resources and public services, and social fragmentation or integration.

- Involuntary resettlement refers both to physical displacement (relocation or changes of shelter) and to economic displacement (changes of assets or access to assets that leads to changes of income sources or means of livelihood as a result of project related land acquisition). Land acquisition includes both outright purchases and/or expropriation of property and purchases of access rights such as rights of way. Resettlement is considered involuntary when affected individuals or communities do not have the right to refuse land acquisition that results in their displacement.
- Voluntary resettlement refers both to physical displacement (relocation or changes of shelter) and to economic displacement (changes of assets or access to assets that leads to changes of income sources or means of livelihood as a result of project related land acquisition). Resettlement is considered voluntary when affected individuals or communities have the right to refuse land acquisition that results in their displacement.

The data can be obtained from time series, statistics, aerial photographs, land use maps, databases with interpretations of urban extent, transportation routes, water features and other important land uses, social surveys, land and properties market or local and national administrations.

5.3.5 Job creation

The short and long-term employment effects as a result of a civil engineering works should be demonstrated by indicators such as the proportion of workers, suppliers or subcontractors employed directly or indirectly by the civil engineering works, the type and number of jobs influenced as a result of a better or worst access, etc.

It includes the provision of employment by the civil engineering works and considers employment structure: working population in the areas of influence of the civil engineering works and their composition (taking into account different target groups like local, minorities or women employees).

The data can be obtained from sample surveys and statistics of the employed and unemployed population of a certain area, carried out by the local or national labour administration.

When addressing job creation, the following indicators shall be considered:

- number of people to be employed;
- type of employees (local or not local);
- number of local disadvantaged people to be employed.

Scope and criteria used in the assessment shall be reported.

Local people are defined as permanent residents of the relevant territory.

These indicators shall be reported (as appropriate) in the pre-construction stage (module A0), the construction process stage (modules A4-A5), the use stage (modules B1-B8) and the end of life stage (C1-C4).

It can be differentiated the high, medium and low skilled jobs, and the long- and short-term jobs created.

The local disadvantaged people may include but are not limited to:

- women;
- people at risk of social exclusion, in particular young people of working age in difficult situations;
- persons with disabilities;
- unemployed jobseekers, in particular those who are long term unemployed in the local community;
- people detained in prison near the civil engineering work.

5.3.6 Cultural heritage

This aspect should include indicators that report the number and value of cultural heritage elements affected due to the civil engineering works. Both the level of effect from the civil engineering works on the cultural or historic element, and its protection category should be considered.

On this matter, cultural heritage elements should be classified according to its social and political significance, scientific significance, historical significance, education and economic significance or aesthetic significance.

NOTE At the Convention Concerning the Protection of the World Cultural and Natural Heritage, cultural heritage is defined to include the following:

- monuments: architectural works, works of monumental sculpture and painting, elements or structures of an archaeological nature, inscriptions, cave dwellings and combinations of features, which are of outstanding universal value from the point of view of history, art or science;
- groups of buildings: groups of separate or connected buildings which, because of their architecture, their homogeneity or their place in the landscape, are of outstanding universal value from the point of view of history, art or science;
- sites: works of man or the combined works of nature and man, and areas including archaeological sites which are of outstanding universal value from the historical, aesthetic, ethnological or anthropological point of view.

Created values and effects of the civil engineering works on cultural heritage elements and aesthetic or cultural concerns, such as preserving historical or archaeological sites, value of nearby properties, safety and public health, should be considered as indicators.

Indicator: number and value of cultural heritage elements affected due to the civil engineering works.

5.3.7 Stakeholders' involvement

This aspect should include indicators that reflect the engagement and participation of relevant stakeholders, individuals and communities in the decision-making process and their levels of satisfaction with the civil engineering works. It also includes education, training and literacy of the relevant stakeholders.

Users' acceptance of the infrastructure and satisfaction with the civil engineering works should also be considered and indicators related to it should be developed.

NOTE Social acceptance can be focused in three main areas, depending on the considered users: public acceptance (the assessment of the levels of public support), community acceptance (the identification and understanding of the dimensions underlying the social controversy at the local level) and stakeholder's acceptance (social acceptance by key stakeholders and policy makers).

The following issues should be addressed.

a) Involvement of end users and consideration of their needs

- identification, characterization, and involvement of the future end users and their needs;
- identification of the demographic features and other characteristics of the end users;
- identification of the end users' needs, desires, values and requirements;
- when and how the end users are involved;
- identification of the end users' needs related to education, training and literacy.

Indicator: consideration of end user's involvement and their needs (yes or no).

b) Involvement of stakeholders other than end users

- identification of other key stakeholders [e.g. the neighbours, local authorities, local associations, professionals (service providers and operators)], their level of importance, influence, and their role;
- when and how the other stakeholders are involved;
- identification of the end users' needs related to education, training and literacy.

Indicator: consideration of stakeholders (other than end users) involvement and their needs (yes or no).

c) Management and resolution of contradictions or conflicts among the opinions of the stakeholders

Indicator: Existence of a procedure for management and resolution of contradictions or conflicts (yes or no).

d) Satisfaction of users and other affected parties

- how and when the satisfaction of the users is determined and assessed (e.g. predicted result of surveys on visual comfort and/or post use evaluation);
- how and when the satisfaction of the other stakeholders will be determined and assessed.

Indicator: degree of satisfaction of affected parties.

e) Improvement actions and lessons learned for future projects

Indicator: number of documented lessons learned.

The management process for collecting and evaluating the information should be consistent with, and support the assumptions and scenarios used in, the assessment.

5.3.8 Human rights

To measure the effects of civil engineering works on human rights, applied indicators should be consistent with the spirit and intent of the United Nations Universal Declaration of Human Rights; the International Labour Organization (ILO) Declaration on Fundamental Principles and Rights at Work, where applicable to business; and other applicable international principles, including the Voluntary Principles on Security and Human Rights.

NOTE 1 The Universal Declaration of Human Rights (UDHR) was drafted by representatives with different legal and cultural backgrounds from all regions of the world, the Declaration was proclaimed by the United Nations General Assembly in Paris on 10 December 1948 (General Assembly resolution 217 A) as a common standard of achievements for all peoples and all nations. It sets out fundamental human rights to be universally protected and it has been translated into over 500 languages.

NOTE 2 Adopted in 1998, the ILO Declaration on Fundamental Principles and Rights at Work Declaration commits Member States to respect and promote principles and rights in four categories, whether or not they have ratified the relevant Conventions. These categories are freedom of association and the effective recognition of the right to collective bargaining, the elimination of forced or compulsory labour, the abolition of child labour and the elimination of discrimination in respect of employment and occupation.

NOTE 3 The Voluntary Principles (VPs) on Security and Human Rights documents provide guidance to companies in developing practices that maintain the safety and security of their operations while respecting the human rights of those who come into contact with security forces related to those operations. The VPs include provisions defining the following expectations:

- companies regularly engage with host governments and local communities regarding security issues and practices;
- security forces act in a manner consistent with UN Principles on the Use of Force and Firearms by Law Enforcement Officials and the UN Code of Conduct for Law Enforcement Officials, including that any use of force needs to be proportional to the related threat;
- companies have mechanisms for the reporting and investigation of allegations of improper actions by private security forces hired by the company;
- companies have mechanisms to report alleged abuses by public security forces in their area of operation, and to encourage and monitor progress of investigations.

Indicator: number of failures to comply with relevant standards or declarations of human rights.

5.3.9 Resilience

5.3.9.1 General

Resilience is considered as it relates to safety and security of a civil engineering works, as well as adaptation to climate change. Indicators should describe if risks are assessed and what probability of occurrence is given on a specific location. To measure the resilience of a civil engineering works, indicators shall be developed which describe the ability to resist, adapt to, or quickly recover from a potentially disruptive event, whether natural or manmade, in order to maintain or restore the intended service.

In regard to safety and security, safety and condition indexes are useful indicators.

Several indicators related to adaptation to climate change shall be developed.

For the addressing of resilience, the following aspects shall be considered:

- structural stability;
- ability to resist, adapt to, or quickly recover from consequences of climate change;
- ability to resist, adapt to, or quickly recover from accidental actions (e.g. earthquakes, explosions, fire and traffic accidents);
- personal safety and security against intruders and vandalism;
- provisions to resist, adapt to, or quickly recover from interruptions of supply of utilities.

NOTE Minimum requirements for loads resulting from wind, snow, earthquake and explosions are usually specified in national design codes and regulations.

Measurement in the design phase is accomplished with the help of expert assessment and/or simulation of the structural design. Measurement in the in-use stage should take place with the help of expert assessment and/or simulation.

5.3.9.2 Structural stability

Stability against loading expresses the ability of the civil engineering works to provide a safe and resistant structure that has a potential impact on the safety for the users of the civil engineering works and also on the ability to maintain or quickly recover the operability of the asset.

Indicator: safety indexes.

NOTE Safety indexes can vary depending on the civil engineering works typology. Some examples of these indexes are as follows.

- Dam safety index: generally measures the risk of breakage of the dam derived from an incorrect design or construction. Each dam is associated to a risk category, depending on the population and main services affected as well as the material and environmental damages caused by the breakage.
- Road safety index: generally measures the probability of accident in certain areas, taking into account parameters, such as number of curves or number of slope changes.
- Harbour safety index: usually measures the probability of the sea water to rise above the dock and to break it totally or partially, considering parameters, such as risk of life losses, population affected or value of the material losses.

5.3.9.3 Consequences of climate change

5.3.9.3.1 General

The aspects relating to climate change are the resistance (strength, deflection, stability) against loadings exceeding the currently regulated impact levels. These may arise from increased intensity and frequency of e.g. strong winds, snow, rain, flooding, solar radiation intensity, cold or hot temperatures, etc.

All the relevant parameters shall be assessed for the required service life and/or the reference study period of the civil engineering works. They should account for projected changes in conditions based on proper climate change models applicable to the geographic region in question. The model used shall be reported together with the upper and lower limit values for the parameters as predicted by the model.

NOTE The assessment includes the effects of climate change, taking into account any adverse or beneficial change in projected peak values for weather-loadings (rain, wind, snow, solar radiation) specified in scenarios.

The effects caused by climate change can vary dependent on the location of the project. Therefore, a location-specific assessment shall be carried out.

Two different types of effects shall be included into the assessment:

- a) Risks resulting from hazards and extreme weather events:
 - the probability of occurrence of different events dependent on the intensity and the location;
 - the behaviour of a civil engineering work exposed to a determined set of extreme events.
- b) Future changes of impacts: altered conditions in the future, such as possible changes of wind and snow loads, the amount of rain and higher sea levels.

Infrastructures such as bridges and dams are often designed for service lives in excess of 100 years. It shall be considered that the design conditions used today may not be applicable in future. Therefore, possible altered conditions in the future should be included into the assessment.

For two types of future changes an analysis of the changes of impacts should take place.

- Changes of the probability of occurrence of extreme event and changes of their intensity. The results can be used as input parameters for an adapted consideration of risk explained above.
- Changes of “regular” loads used for the design such as higher wind, snow and rain loads.

Especially for the second aspect the adaptability of the civil engineering works is crucial. In the design phase possible strategies should be run through. Thereby, strategies addressing the possibility to perform structural changes, to enhance the load carrying capacity, to activate adaptive capabilities and to join and split system components should be addressed.

5.3.9.3.2 Consideration of risk

For the civil engineering works, an evaluation of the probability of occurrence for different intensity levels should be performed for the following types of events (hazards):

- rain;
- wind effects, sand and dust storms;
- hail;
- snow;
- flood;
- temperature variation;
- droughts;
- sea level, waves and coastal effects;
- glacier, geological impacts and changes to permafrost;
- wildfires.

NOTE See [Annex C](#) for a discussion on classification and evaluation of risks.

Indicators: measures adopted for each one of the climate aspects considered.

5.3.9.3.3 Aspects to consider

To consider the resilience of the civil engineering works to climate change, indicators for the following aspects shall be developed:

— Rain effects

This aspect relates to the capacity of the civil engineering works to resist, adapt to, or quickly recover from the effects of predicted peak rainfall for the region in question in terms of water tightness, load bearing capacity/water removal capacity.

Measures against rain effects may include, but are not limited to:

- increased capacity to discharge water (sufficient dimensions of ground drainage);
- increased clearance below bridges;
- reinforced foundations for pillars inside rivers.

— Wind effects, sand and dust storms

This aspect relates to the capacity of the civil engineering works to resist, adapt to, or quickly recover from the effects of predicted peak wind loads for the region in question.

Measures against higher wind loads may include, but are not limited to:

- increase structural resistance;
- prevention of the detachment of elements;
- improve aerodynamics (smoothness or shape) of the civil engineering works and the surrounding area;
- prevention of dust accumulation;
- protection of users and neighbours.

— Hail

This aspect relates to the capacity of the civil engineering works to resist, adapt to, or quickly recover from the effects of predicted hail.

Measures against hail may include, but are not limited to:

- increase surface resistance;
- prevention of the detachment of elements;
- protection measures for vulnerable parts;
- protection measures for people and other devices (cars, etc.).

— Snow and ice

This aspect relates to the capacity of the civil engineering works to resist, adapt to, or quickly recover from the effects of predicted peak snowfall and ice formation in terms of loading, water tightness, safety for the region in question. Extra consideration may be required in areas that currently have no snowfall but can in the future.

Measures against variations in snow and ice formation may include, but are not limited to:

- increased or adaptable structural resistance (safety factor);
- increased dimensions of drainage systems;

- features that enable the management of snow and ice on the civil engineering works;
- protection of users and neighbours.
- Flood

This aspect represents relates to the capacity of the civil engineering works to resist, adapt to, or quickly recover from the effects of predicted intensity and frequency of flooding.

Measures against flooding may include, but are not limited to:

- flood barriers (permanent or removable);
- adequacy of surface and storm water management (drainage and handling);
- provision of sacrificial flooding areas;
- ease of reinstatement after flooding;
- protection of users and neighbours.

NOTE Protection of users and neighbours' measures can include alert systems in case of floods or extreme events.

- Temperature variation

This aspect relates to the capacity of the civil engineering works to resist, adapt to, or quickly recover from the effects of long and short-term temperature variations, as well as changes in the temperature averages and extreme values.

Measures against temperature-stress may include, but are not limited to:

- preventing evaporation;
- vegetation;
- colour and reflectiveness of surfaces;
- consideration of thermal behaviour including that of expansion loops and materials selection (with criteria such as thermal expansion coefficient, ductility or brittleness);
- adaptive cooling or heating;
- protection of users and neighbours.

- Droughts

This aspect relates to the capacity of the civil engineering works to resist, adapt to, or quickly recover from the effects of droughts.

Measures against water scarcity may include, but are not limited to:

- dams;
- waterproofing;
- water recycling;
- measures to reduce water demand of the civil engineering works.

- Sea level, waves and coastal effects

This aspect relates to the capacity of the civil engineering works to resist, adapt to, or quickly recover from the effects of both extreme sea level and mean sea level raise, waves, storm surges, tsunamis and other coastal effects.

For those sea phenomena a broad range of measures can be considered, such as:

- elevated structures;
 - sea barriers;
 - drainage measures;
 - additional sea related protection measures (e.g. antichloride protection);
 - erosion protection techniques;
 - artificial reefs and breakwaters;
 - manage retreat;
 - protection of users and neighbours.
- Glacier, geological impacts and changes to permafrost

This aspect relates to the capacity of the civil engineering works to resist, adapt to, or quickly recover from the effects of glacier, geomorphological and geological impacts.

A broad range of measures can be considered against glacier, geomorphological and geological impacts such as:

- consideration of mass land movements in the design;
 - drainage to guide ice melts;
 - land slide protection;
 - snow sheds;
 - protection of users and neighbours.
- Wildfires

This aspect relates to the capacity of the civil engineering works to resist, adapt to, or quickly recover from the effects of wildfires.

A broad range of measures can be considered against wildfires such as:

- firebreaks;
- water reservoirs;
- protection of users and neighbours.

5.3.9.4 Incidental actions

The aspects relating to incidental actions assess a civil engineering works' resistance (protection/strength/deflection/stability/ safety) against incidental loads deriving from one-off events, e.g. earthquakes, explosions, fire and traffic impacts and their consequential effects (such as projectiles, toxic gases, breaking glass).

In general, the assessment of measures in this category represents performance above that required by regulation and should consider the country in which the assessment takes place. Depending on the location, design and the functional requirement of the civil engineering work, not all parameters are relevant.

The evaluation should use an ordinal scale with classes or a more comprehensive classification or calculation method if exists. The scale to be defined for intensity depends on its type. For example, for earthquakes the Richter magnitude scale is commonly used. Sources of data related to the location

specific exposition of the civil engineering works can be hazard maps, regional threat assessments, weather data, risk mapping projects, etc.

The civil engineering works shall be assessed for the aspects listed below.

— Mass movements

This aspect indicator represents the resistance of the civil engineering works against mass movements and their consequential effects which shall be considered if relevant.

Provisions for increased resistance to mass movements may be:

- catchment basins;
- retaining walls;
- slope stabilization.

— Earthquake resistance

This aspect indicator represents the resistance of the civil engineering works against earthquakes and their consequential effects, which shall be considered if relevant.

Examples of provisions for increased resistance to earthquakes may be:

- increased structural stability;
- installation of dampers or other comparable measures that ensure flexibility and shock resistance.

— Explosion resistance

This aspect indicator represents the resistance of the civil engineering works to explosions and their consequential effects.

Examples of provisions for increased resistance against explosions may be:

- increased structural stability;
- avoidance of explosive gases;
- provision of refuges.

— Fire performance for inside or outside events

This aspect indicator represents the performance of the civil engineering works in providing fire protection in the event of a fire and in restricting its consequential effects. The protection is considered in respect of people in and around the civil engineering works, of the surroundings, and of fire damage to the built asset (e.g. through the loss of the civil engineering works or parts of it for a period of time and/or displacement of employees).

Provisions for increased fire performance that are over and above the regulatory requirements, may result from considerations of property protection, interruption to the use of a civil engineering works and of adverse impacts on health from fire. Examples may include, but are not limited to:

- higher fire resistance classes or other measures included in the design to improve the load bearing capacity, integrity and/or insulation performance;
- improved access and facilities for fire fighters;
- improved design of the means of escape (including consideration of people with additional needs);

- installation and/or enhancement of fire detection and alarm systems using approved components and approved competent persons for the design, installation and maintenance;
- installation and/or enhancement of fire extinguishing systems using approved components and approved competent persons for the design, installation and maintenance;
- installation and/or enhancement of smoke control systems using approved components and approved competent persons for the design, installation and maintenance;
- optimisation of the size of smoke and fire compartments;
- using materials and products with a higher reaction to fire classification than required by prevailing regulations;
- use of fire engineering approaches to optimise the design of the construction works and fire protection systems;
- protection of vulnerable areas outside the civil engineering works (e.g. ensuring enough distance).

In addition to consideration of the above technical measures, an emergency action plan covering the regulatory requirements, as well as the above aspects where relevant, should be made available to facility managers, employees and communicated to visitors and other occupants as appropriate.

— Traffic incidents (collisions)

This aspect indicator represents the resistance of the civil engineering works against traffic incidents (i.e. collisions of vehicles with the civil engineering works) and their consequential effects, which shall be considered, if relevant.

Provisions for increased resistance to traffic incidents may include, but are not limited to:

- provision of physical barriers;
- strengthening of areas which may be at risk.

5.3.9.5 Personal safety and security against intruders and vandalism

This aspect addresses the capacity of the civil engineering works to resist forced access and deliberate damage as well as to satisfy the users need to feel safe and secure.

EXAMPLE Examples of provisions for increased safety and security against intruders and vandalism include:

- expert analysis and implementation of recommendation during the design stage;
- barriers and systems to act against deliberate intrusion:
 - high security perimeter barriers;
 - alarm and surveillance systems, preferably linked to the police or other approved agents;
 - well-illuminated pathways with clear lines of sight;
 - motion-sensitive illumination;
- resistance of the civil engineering works to protect against vandalism/arson:
 - graffiti-resistant surfaces;
 - secure waste-storage to minimize risks of vandalism/arson.

5.3.9.6 Security against interruptions of utility supply

The capacity of the civil engineering works to maintain its functions and services in case of interruptions of utility supply (e.g. water supply, energy, communications) shall be considered.

Provisions made for increased security against interruptions of utility supply may include, but are not limited to:

- the presence of back-up equipment for heating and power supply (e.g. generator, photovoltaics, uninterruptible power supply, supplementary chimney provisions for emergency heating systems);
- free and safe movement inside of the civil engineering works and evacuation protocols in case of need;
- measures to use services manually in case of interruption of power supply.

5.3.10 Health and comfort

This aspect should include indicators that measure the impacts caused by the civil engineering works on the health, comfort and well-being conditions of the population living in the areas of influence of the civil engineering works. It should also include indicators that describe the implementation and monitoring of prevention and/or mitigation measures to reduce the nuisance caused.

Issues such as time savings due to civil engineering works (e.g. shorter travel time, access to resources); characteristics of visual comfort (e.g. adequate lighting, colour of road surface); characteristics of water quality; health and safety of construction workers and probability of accidents (e.g. due to numerous curves on a road) should be considered and indicators related to them, developed.

Infrastructure effects on users' health and safety should also be taken into account and indicators developed. The further away from populated areas a gas pipeline is located, the fewer will be the effects on the health of the people who live in the surrounding area relative to gas leaks. The greater the distance to a railway track, the less the vibrations will be felt by nearby residents. If a road is designed with stricter outline parameters (e.g. narrower lanes, narrower verges, tighter radii in curves) in order to avoid wandering through a natural protected area, the number of accidents may increase.

Information concerning this subject can be obtained from surveys, research, complaints, and monitoring reports. The following aspects can be considered.

— Workers' health and comfort

This aspect includes the following indicators for the protection of the health and comfort of workers in the outdoor environment:

Indicator: provision (number and quality) of sanitary and rest facilities.

Indicator: protection of workers against the potential adverse effects of:

- solar radiation;
- extreme heat and/or cold;
- other radiation effects in the environment (e.g. radon in tunnelling);
- construction processes or working conditions.

Indicator: design of the civil engineering works in order to allow a more comfortable and safe construction and maintenance.

- number of lost days because of an occupational accident or disease;

— number of employees' accidents with sick leave.

— Characteristics of air quality

Air quality depends on a wide range of factors: e.g. the types, quantities of materials, and where they are situated in civil engineering works, number and types of vehicles (e.g. motor vehicles, trains, aircraft) using the asset, and typology.

For addressing air quality, the following indicators shall be considered:

Indicator: the concentration of recognised pollutants (such as Ozone, CO, NO_x and SO_x and particulates PM10 and PM2.5) that are regulated and/or stated in the client brief, considering the minimum and/or maximum threshold values of those concentrations; and

Indicator: measures to protect workers and users against the adverse effects of the above.

NOTE 1 The valuation can be by simulation (before construction) or monitoring (during construction, use and deconstruction).

— Acoustic characteristics

The aspect of acoustic characteristics depends on the sound level, reverberance period and sound attenuation. Both airborne and impact sound adds to the sound level. The acoustic performance shall take into account different types of use and sources of noise.

To address impacts on employees (including for construction workers during construction, maintenance repair replacement refurbishment and deconstruction) and/or the general public (where appropriate) the following indicators shall be considered:

Indicator: sound levels after insulation and other measures adopted against impact and sounds from the civil engineering works [dB(A)];

Indicator: sound levels after insulation from sounds from outside the civil engineering works and other measures adopted (e.g. from traffic, airplanes or adjacent civil engineering works) [dB(A)];

NOTE 2 Low frequency noise and vibrations can have a serious effect on the quality of life of those affected by them. Sources of low frequency noise are many and varied but are often industry related. Examples of possible sources are pumps, boilers, heavy industry, electrical installations, amplified music, wind farms, fans, ventilation plant, blasting, road, rail, sea and air traffic.

— Characteristics of visual comfort

For employees (including construction workers during maintenance repair replacement refurbishment and deconstruction) and/or the general public (where appropriate) aspects of visual comfort (the amount of daylight, the amount and quality of artificial light, protection against sunlight and the visual connection with the 'outside world' or with other parts of the civil engineering works) shall be considered.

To address aspects of visual comfort in the outdoor environment the following indicators shall be considered:

Indicator: the amount (coverage) and quality of artificial light for lighting (e.g. in tunnels, on station platforms, quaysides) and floodlighting (e.g. for car parks, sports facilities and outdoor activity centres).

Indicator: protection from glare for users.

— Additional impacts indicators

The following additional impact indicators may also be considered:

- Human toxicity, cancer effects

Indicator: potential comparative toxic unit for humans (CTUh)

- Human toxicity, non-cancer effects

Indicator: potential comparative toxic unit for humans (CTUh)

- Particulate matter emissions

Indicator: potential incidence of disease due to PM emissions (incidence of disease)

- Ionizing radiation, human health

Indicator: potential human exposure efficiency relative to U235 (kBq U235 eq.)

5.3.11 Impacts on the neighbourhood

5.3.11.1 General

For these category impacts on the neighbourhood, the following aspects shall be considered:

- visual impact;
- glare/overshadowing;
- noise;
- shocks and vibration;
- emissions to outdoor air, soil and water;
- changes of microclimate;
- other impacts on the neighbourhood.

5.3.11.2 Visual impact

Visual impacts include several different aspects, the following indicators shall be considered:

Indicator: visibility (“zone of visual influence” or “zone of visual intrusion”) – a GIS-based analysis counting the “number of points” from which an infrastructure can be seen.

Indicator: visual intrusion – a GIS-based analysis of all private areas that can be seen from an infrastructure.

Indicator: obstruction of viewpoints – a GIS-based analysis of situations where a desirable view is obstructed by an infrastructure.

5.3.11.3 Glare/Overshadowing

For addressing glare and overshadowing the following indicators shall be considered:

- Glare from artificial lights

Indicator: the projection and illuminance (lux) from the object of assessment at night and whether it is continuous or intermittent.

Indicator: the presence of (e.g. blinking, flashing, coloured) lighting causing irritation, loss of concentration, etc.

Indicator: Glare emitted during the civil engineering works use (e.g. lights coming from vehicles circulating in the opposite direction).

— Sun glare

Indicator: Glare emitted from a civil engineering works surface, e.g. caused by exterior materials with a high reflectivity.

Indicator: Glare from sudden transitions (e.g. way out from tunnels)

— Overshadowing

Indicator: overshadowing area with adverse effects on the neighbourhood (expressed in m²).

Indicator: overshadowing hours of shade on neighbours with adverse effects (expressed in hours).

NOTE There are different methods to estimate overshadowing which have been developed for analysis of the performance of photovoltaic modules. Some of these are based on 3D-visualisation models of the built environment (GIS-based).

For each of the above indicators the selected basis of design chosen shall be briefly stated together with reference to supporting documents.

5.3.11.4 Noise

Dependent on the type of civil engineering work noise and vibrations can cause massive effects on infrastructure users, the neighbourhood, communities and the public. Noise and vibrations can lead to disturbances of individuals exposed to sources like traffic or construction activities. Secondly, harmful effects (negative impacts on human health) can result if a long-term exposure arises.

For addressing noise impact on the neighbourhood, the following shall be considered:

- Indicator: emitted noise pressure level [measured in L_{eq} dB(A)].
- Indicator: peaks of noise [measured as L_{10} dB(A)] and their evolution during the service life term.
- Indicator: noise pressure levels at the receiver's side.

The measures shall be made in accordance with ISO 1996-2:2017, Annex B.

NOTE If not specified for sound-emitting appliances and devices, direct measurements can provide information on the sound pressure levels.

When the assessment is made on the basis of a design, the following aspects of the construction should be considered for their potential to contribute to control of noise emitted from the civil engineering works:

- internal sound insulation (on the source itself);
- acoustic characteristics of the materials or the design;
- external noise barriers.

For each of the above technical solutions the selected basis of design chosen shall be briefly stated together with reference to supporting documents.

5.3.11.5 Shocks and vibration

To address shocks and vibrations the following indicators shall be considered.

Indicator: shocks and vibrations emitted from the civil engineering works, evaluated in accordance with the ISO 2631 series.

Indicator: shocks and vibrations levels at the receiver's side.

5.3.11.6 Emissions to air, soil and water

Emissions of pollutants to air, soil and water are covered in the environmental assessment, however emissions from civil engineering works can have an impact directly on the neighbourhood.

To address emissions and the possible adverse impact on the neighbourhood, the following issues shall be considered:

- dust and smoke;
- odour;
- water;
- heat.

The report shall describe the source and frequency of any potential nuisance caused by the above.

The level of controllability of emissions shall be considered for each impact mentioned in the above report.

- Systems for controlling the emissions from the civil engineering works

Indicator: Is there a system for controlling the emissions from the civil engineering works? [yes/no].

If yes, the system shall be briefly stated together with reference to supporting documents.

a) Dust and smoke:

To address emissions of particulates, e.g. dust and smoke to outdoors the possible adverse impact of the following on the neighbourhood shall be described:

Indicator: levels of dust and measures against it.

Civil engineering works may contribute to PM through the following pathways:

NOTE 1 This indicator is for consideration of the direct loads on the neighbourhood. Global impact is calculated in the environmental assessment.

- Construction process

EXAMPLE 1 Diesel trucks used for transport from and to the construction site; milling and drilling in concrete; using glass or stone wool insulation.

- Operation and maintenance activities

EXAMPLE 2 PM generated by the burning of fossil fuels for power generation, oil fired boilers, coal fires, woodstoves and diesel driven engines/generators.

- User's utilization

EXAMPLE 3 PM generated by cars using a motorway.

- Demolition works and transport during the EoL stage.

Indicator: Levels of smoke and measures against it.

EXAMPLE 4 Smoke generated by the burning of fossil fuels for power generation, oil fired boilers, coal fires, woodstoves and diesel driven engines/generators.

b) Odours

Emissions of odours from a civil engineering works can have an impact directly on the neighbourhood.

NOTE 2 Emissions of pollutants to air, soil and water are covered in the environmental assessment.

The source and frequency of any potential nuisance caused by the above shall be described and the following shall be considered:

- Indicator: is there an emission of an odour? Yes/no.
- Indicator: number of persons impacted.
- Indicator: is there a system for controllability of the emission level on the Civil Engineering Works: Yes/no. (The system shall be briefly stated together with reference to supporting documents).

c) Water

Water pollution from a civil engineering works can have an impact directly on the neighbourhood. (e.g. water from outflows, pipes).

Any potential nuisance caused by the above shall be described and the following shall be considered:

- Indicator: is there any water discharge? Yes/no.
- Indicator: number of persons impacted.
- Indicator: is there a system for controllability of the discharge: Yes/no. (The system shall be briefly stated together with reference to supporting documents).

d) Heat

Heat outcome from a civil engineering works can have an impact directly on the neighbourhood. (e.g. exhaust from cooling towers, heat pumps).

Any potential nuisance caused by the heat shall be described and the following shall be considered:

- Indicator: is there any heat emission? Yes/no.
- Indicator: number of persons impacted.
- Indicator: is there a system for controllability of the heat emission: Yes/no. (The system shall be briefly stated together with reference to supporting documents).

5.3.11.7 Changes of microclimate

Civil engineering works may sometime influence and produce some effects on climate in the surroundings. These effects shall be described.

EXAMPLE Changes in the local wind regime because of the corridor created by a road; changes in the humidity because of the water stored in a reservoir; temperature increases because of the heating of the civil engineering works surface.

For this aspect, the indicators shall be:

- Indicator: impact on local temperature.
- Indicator: changes in rainfall.
- Indicator: changes in wind speed.

5.3.11.8 Other impacts on the neighbourhood

Loadings on the surroundings could also be related to the following aspects:

- Conflicting uses

Indicator: number of expected points of conflict between civil engineering works users (pedestrians, cyclists, car drivers, etc.) or users of public spaces (e.g. children, elderly people).

- Quality of space

NOTE A number of infrastructures can be considered as public spaces and their quality can be evaluated with methods from urban planning.

Indicator: space quality index according to a specific urban planning method.

The method used to calculate the space quality index shall be specified and clearly stated.

5.3.12 Maintenance and maintainability

This aspect assesses the consequences on users, neighbours and neighbourhoods of the maintenance activities (including planned repair, replacement and refurbishment) needed to retain the civil engineering works in a state in which it can perform its required functions or to restore its technical performance when a fault occurs. Maintainability is influenced by the quality of design, construction, the accessibility of the infrastructure structure and services, and the quality of the maintenance plan. Addressing maintainability shall take into account the frequency and duration of maintenance, and short, medium- and long-term effects of this on:

- Safety for users and neighbours during maintenance.

Indicator: quality level of safety measures (considering those measures that reduce risks or separate risks from neighbours beyond the legal requirements).

- The usability of the civil engineering works while maintenance tasks are being carried out, (e.g. as a ratio of expected maintenance duration causing disruption to days of normal use).

Indicator: average number of downtime hours during maintenance.

The assessment shall be based on the estimated service life as determined in accordance with specific rules of product standards and shall take into account rules and guidance given in ISO 15686-1, ISO 15686-2, ISO 15686-7 and ISO 15686-8, and relevant scenarios.

5.3.13 Safety/security

This indicator expresses the measures adopted in order to avoid injuries or to increase the security and safety of workers, users and neighbours.

For workers the indicator shall be:

Indicator: additional measures over the regulation that increase the personal safety and decreases the possibility of incidents.

EXAMPLE 1 Temporary safety barriers protecting the working area or use of chips in helmets to locate workers in a specific dangerous area.

For users, this indicator relates to the secure use of the infrastructure.

Indicator: additional measures over the regulation that increase the user's safety and decreases the possibility of incidents.

EXAMPLE 2 A better layout of a road, or a well-illuminated tunnel decreases the possibility of accidents.

5.3.14 Sourcing of materials and services

This aspect shall include indicators of the responsible sourcing and traceability of products and services.

For addressing sourcing of materials and services the following aspects shall be considered:

- Information concerning responsible sourcing of materials:

Indicator: compliance with the following standards, declarations, codes or specifications:

- a) materials' production:

- raw material origin (e.g. certification) from the point of extraction or harvest of the raw materials including processing and transport (trade routes);
- implementation of environmental management systems (e.g. according to ISO 14001 or equivalent).

- b) safety performance from start to finish of the materials' production:

- implementation of occupational health and safety management systems (e.g. according to ISO 45001 or equivalent).

- c) human rights – compliance with social responsibilities (e.g. ILO Declaration on fundamental principles and rights at work, ISO 26000 related to the human resources):

- legal situation of the company, employees, contractors and subcontracted personnel;
- social conditions applying to the workplace.

- d) traceability:

- management procedures ensuring the traceability of materials supplied and respective characteristics.

- e) quality management/control:

- implementation of quality management systems (e.g. according to ISO 9001 or equivalent) and factory production control.

- Sourcing of services:

Indicator: compliance with the following standards, declarations, codes or specifications:

- a) safety performance from start to finish of the service supplied:

- implementation of health and management systems (e.g. according to ISO 45001 or equivalent).

- b) compliance with social responsibilities (e.g. ILO conventions, ISO 26000 related to the human resources):

- legal situation of the organization providing the service, its employees, contractors and subcontractors;
- social conditions of the workplace and transportation to and from work as well as accommodation of workers.

- c) traceability;

- d) management procedures ensuring the traceability of the services supplied;

- e) quality management/control:
 - implementation of quality management systems (e.g. according to ISO 9001 or equivalent) and factory production control.
- f) environmental management/control:
 - implementation of environmental management systems (e.g. according to ISO 14001 or equivalent).

This may be demonstrated by third party certification schemes which meet the scope and issues defined, where they exist at a national/international level or through relevant information supplied by the manufacturer/supplier.

5.3.15 Social equity

This aspect assesses the consequences on social equity of new or existing civil engineering works. Addressing social equity shall take into account three important dimensions: the recipient -who gets something-; the item -what is distributed-; and the process -how the distribution is carried out-, and short, medium- and long-term effects of this influenced or caused by the civil engineering works.

Indicator: number of measures adopted in order to increase equity during life cycle.

NOTE Measures can relate to areas such as gender equality, poverty alleviation, access to training, equal pay for equal work, equal access of vulnerable people, including people with disabilities and indigenous peoples, to participate in decision-making, etc.

Indicator: percentage of most disadvantaged population with access to services provided by infrastructure.

EXAMPLE It can be expressed as disadvantaged population accessing the service divided by the total disadvantaged population. Or Disadvantaged population accessing the service divided by the total population accessing the service.

5.4 Description of economic aspects and impacts

5.4.1 General

[5.4.2](#) to [5.4.7](#) describe the aspects and impacts which shall be considered for developing a system of indicators for assessing the economic pillar of sustainability performance of new or existing civil engineering works. When some of them are not considered or are excluded from consideration, the reasons for such omission or exclusion shall be clearly explained and justified. Net present values (NPV) and annual equivalent values (AEV) used as economic indicators shall be determined by applying the rules and guidance given in ISO 15686-5. [Annex B](#) provides guidance about cost and revenue categories.

5.4.2 Life-cycle costs

The following indicator shall be used when addressing the economic sustainability performance of the civil engineering works.

Indicator: net present value or annual equivalent value of the total costs for:

- a) before use stage (modules A0-A5, [Table B.1](#));
- b) use stage (modules B1-B7, [Table B.2](#));
- c) end of life (modules C1-C4 and D, [Table B.3](#)).

5.4.3 External costs

The assessment can include (but are not limited to):

- Indicator: net present value or annual equivalent value of total costs and benefits generated for the users of the civil engineering works that is not covered by revenues.
- Indicator: net present value or annual equivalent value of total costs and benefits generated for the neighbourhood of the civil engineering works.
- Indicator: net present value or annual equivalent value of total costs and benefits related to changes on the environment caused by the civil engineering works.

NOTE 1 For infrastructures in the traffic system, changes in traveling time are often considered as costs or benefits for the user.

NOTE 2 Changes in the environment can be evaluated with the concept of ecosystem services.

EXAMPLE For a road there can be costs of operational handicaps and accidents caused by construction or maintenance works, quality deficits and service disruptions as externalities.

Examples of external costs are environmental damage costs (some countries have cost factors that allow the factoring of CO₂ related costs or health related costs resulting from the construction of a civil engineering works or environmental impacts).

Potential sources of information used to create the indicators can be:

- international studies on external costs (normally divided in the fields: road, rail shipping, aviation, buildings and energy) and international and national guidelines for the calculation of external costs;
- balance sheets and bills from manufacturers, suppliers, subcontractors, etc.;
- own construction's management invoices, delivery notes, historical records, accounting systems and calculations and estimations from the financial department;
- other needed data (for example traffic data like daily traffic);
- modelling techniques, e.g. application of traffic models;
- national standards or studies on external costs/benefits.

NOTE 3 Ecosystem services are also externalities. The main ecosystem service categories are:

- regulating services: regulation of biophysical conditions, biotic environment or against hazards; for example, air quality regulation, climate regulation, moderation of extreme events, erosion prevention, maintenance of soil fertility or biological control;
- provisioning services: provision of food and beverages, raw materials, energy, medical resources, genetic resources or ornamental resources;
- cultural services: spiritual or aesthetical value, recreation and tourism;
- supporting services: existence of biodiversity at the level of species, genes, ecosystems and landscapes.

5.4.4 Effects on local economy

Indicator: net present value or annual equivalent value of total income generated by construction operation and end of life of the civil engineering works that is spent for locally supplied production factors (labor, energy and natural resources).

Income can include revenues generated by goods and services provided by the civil engineering works as well as public funding (e.g. by taxes and subsidies).

NOTE For infrastructures in the traffic system, changes in accessibility are (partly) represented by the indicator “external costs and benefits for users”.

5.4.5 Sustainable funding

Indicator: ratio of net present value of total income generated by operating the civil engineering works and net present value of total life-cycle costs.

5.4.6 Social internal rate of return

Internal rate of return is the value of discount factor which makes the NPV equal to zero.

Indicator: social internal rate of return.

Social internal rate of return is based on NPV calculation integrating external costs and benefits.

5.4.7 Management mechanisms

Indicators related to management mechanisms provide information related to those actions or processes that minimise the probability of negative impacts or maximize the achievement of the intended performance of the civil engineering works, as well as those that help to obtain data of the different phases.

Indicator: management systems implemented in each phase of the life cycle of the civil engineering works (construction, operation, etc.).

This indicator describes relevant management procedures resulting from the implementation of standards such as ISO 14001; ISO 9001; ISO 45001 and ISO 26000.

EXAMPLE 1 WATER: the category covers whether management actions have been taken to avoid the accidental spillage of any water polluting substances (e.g. not to store materials which can cause pollution near the water environment).

EXAMPLE 2 TOXIC SUBSTANCES: Toxic substances appear in the life cycle of the project are listed. Depending on the previous quality of the soil, the pollution can be less or more harmful, and based in this information, scenarios can be developed. Decontamination of the asset can be one of the end of life or refurbishment scenarios according to SEVESO directive.

EXAMPLE 3 COMPLAINT PROCEDURES: during construction phase to ensure that neighbourhoods have the possibility to address the work site and express any possible damages or annoyances and to obtain a response.

6 Development of a system of sustainability indicators

6.1 General

This document provides guidance and rules for establishing individual as well as a set or sets of indicators, which are used either separately or together to indicate various aspects of civil engineering works that contribute to sustainability and sustainable development.

Focussing on one indicator or only a few indicators can be helpful for users to define objectives or monitor progress towards certain goals or objectives in a non-structured way. However, it is not intended by this document to use any such individual or group of indicators as a basis to assess the contribution of a civil engineering works to sustainability or sustainable development, and it neither gives guidelines for the weighting of indicators or the aggregation of assessment results. The users of sustainability indicators are responsible for developing the rules for aggregation, when and where it is considered appropriate.

The simultaneous assessment of environmental, economic and social aspects with help of relevant indicators requires the establishment of systems of indicators specific for each case, based on core indicators that shall be developed taking into consideration the aspects and impacts described in the previous clause. Sets of indicators should be organised to allow the inclusion of a broad representation of sustainability aspects while being relevant to the stakeholders' perspectives.

When establishing a set of indicators for a civil engineering works, the whole set of aspects and impacts of this document shall be considered. If any aspect and impact is not considered for the development of indicators, this shall be declared. In addition, if the aspect and impact is considered core for the specific typology of the civil engineering works, a justification shall be provided if it is excluded.

Additional case specific aspects and impacts can be considered, and indicators developed in addition to the ones specified in this document.

The use of a system of indicators helps to implement several the general principles described in ISO 15392. This is reflected as follows:

- consideration throughout the civil engineering works' life cycle of the different aspects related to the core set of indicators provides an instrument for 'long term consideration' by the different users for 'continual improvement' and monitoring, while 'involving stakeholders';
- consideration of all the different individual indicators within the core set of indicators embodies the principle of a 'holistic approach';
- consideration of several the different individual indicators within the core set of indicators reflects expression of social, economic and environmental responsibility involving 'global thinking with local action';
- consideration and compliance with the guidelines and requirements described in this clause regarding the core set of indicators ensures the 'transparency' of the process;
- consideration of several different individual indicators within the aspects and impacts related to 'social inclusion and acceptability' show concern as it relates to improved 'equity'.

6.2 Rules for developing a system of indicators

Developing a system of indicators consists of:

- choosing relevant indicators;
- developing and/or finding suitable methods and information to measure the values of individual indicators, whether positive or negative.

The choice of relevant indicators depends on the needs of stakeholders, decision-making bodies, the civil engineering works and its (local) context and the availability of information.

The other step is to gather information and use the relevant methods to assign values to the selected indicators.

- First, the data shall be collected and translated into a homogeneous measurement system, which is suitable for the selected indicators (e.g. establishing value ranges, so noise between 70 dB and 80 dB may be translated into 1, 2, 3, etc.).
- Second, weighting may be applied, to state the relative importance of the selected indicators in the indicator system.

The choice of suitable methods will be limited by their availability as well as their applicability relevant to the users' needs.

The following general requirements for developing a system of sustainability indicators within the abovementioned aspects and impacts for civil engineering works shall be respected.

- The system of indicators shall contain indicators that are quantitative, qualitative or descriptive measures representative of one or more of the essential (core) environmental, economic and social impacts and aspects of a civil engineering works.
- The process of selection, development and application of indicators and the qualitative, quantitative or descriptive methods of assessing individual indicators shall be transparently reported.
- When developing a system of indicators, these core indicators shall be complemented with some additional indicators depending on the typology of the civil engineering works. For instance, if a building is part of a civil engineering works (e.g. an airport), relevant indicators of ISO 21929-1 should be included as additional indicators in the system used for the assessment.
- The selection of indicators that are not defined as core indicators in this document shall be motivated by, and explained regarding, both the local and global context, as appropriate.

NOTE When developing a system of indicators to be used in a single country, the infrastructure and construction of which is regulated by common construction regulations, it can be that some indicators are adequately covered by existing regulations, considering the general viewpoints of sustainability and sustainable development.

6.3 Usability of sustainability indicators

To be usable, an indicator shall be accompanied by an explanation that describes how to assign the value of the indicator. Indicators also should have a source of information that provides the basis on which the value of an indicator is calculated.

With indicators being used to simplify and communicate complex information, they are useful for:

- assessment (e.g. against stated target values);
- diagnosis (e.g. to point out affecting factors);
- comparison (of alternatives, based on a defined method of assessment);
- monitoring (e.g. the change over time).

NOTE 1 Intended uses of a system of indicators for assessing overall sustainability can include:

- evaluation of options for
 - design and construction of a new civil engineering works,
 - the analysis of the performance of an existing infrastructure,
 - improving operation of an existing infrastructure;
- designing for retrofit and refurbishment during the use and maintenance stage;
- the deconstruction and disposal at the end-of-life stage;
- use as the basis for benchmarking;
- communication to third parties.

Weighting of indicators and aggregating of results is sometimes applied in practice, either implicitly through the choice of indicators or explicitly through the application of weights. As the aggregation of results typically relates to subjective value choices, and as there are no commonly agreed methods

for weighting, clear and transparent documentation should be provided where weighting methods are applied.

NOTE 2 This document does not otherwise address subjects related to weighting of indicators or aggregation of results.

6.4 Users of indicators

The application of indicators may vary according to users, the related needs of those users, and application stage. When developing indicators, one should be aware about the context of their intended application. The context relates to the field of application (assessment, diagnosis, comparison, monitoring), the stakeholder's scope, the decision-maker's scope, the stage(s) of the life cycle of the object and the availability of information.

The following are examples of user needs for sustainability indicators. However, the role of stakeholders varies from one country to another, which can affect how these different parties use the different indicators.

— Public bodies and policy makers

Public bodies and policy makers can use indicators to state and show sustainability-related requirements on infrastructures. Administrative bodies can also use indicators to evaluate sustainability-related performance of civil engineering works. Administrative bodies can relate incentives to certain indicator-related performance aspects, possibly in line with their policy objectives.

— Investors, owners, promoters and facility managers

Indicators help investors, owners, promoters and facility managers to state sustainability-related requirements and objectives. Indicators and related methods help to show the conformity of the design or the construction with stated requirements. Owners or asset managers can also apply indicators in marketing plans to show the contribution of the civil engineering to sustainability and sustainable development.

— Non-governmental organizations (considering interest groups both at national and at local level)

As a committed part of society, these organizations need instruments like indicators to evaluate the social and environmental repercussion of a civil engineering works, in order to make actions and allegations.

— Planners, developers and designers

Indicators aid planning and design by identifying critical aspects related to sustainability, such as use of resources, socio-economic repercussions or effects in the related ecosystems and species. This ensures that the designer can recognise the design features that may influence the chosen indicators. Using indicators and corresponding assessment methods and tools allows for comparison of alternative designs and verifying conformity of a design against stated objectives.

— Manufacturers of products

Production processes should focus on sustainability requirements. Therefore, indicators and related methods help manufacturers of products to state that their production processes fulfil these requirements.

— Contractors

Contractors should be aware of stated sustainability-related requirements for the civil engineering works in terms of indicators. In addition, contractors can apply sustainability indicators to monitor the construction process.

- Operators and maintainers

Sustainability indicators provide parameters for monitoring the use and maintenance stage of the infrastructure and can help in the decision-making process of these users.

- Users and people who are given service by the infrastructure

Sustainability indicators provide parameters for monitoring the use stage of the infrastructure, the transparency in the communication with society and analysis of the infrastructure's contribution on it, and the user's satisfaction concerning the infrastructure.

- Nearby local residents

Sustainability indicators should enable the evaluation of the compliance with nuisance requirements (regarding public health), as well as the effect that the civil engineering works can have over the population density, or amount working opportunities in the area.

7 Reporting and communication

7.1 General

The indicators developed considering the aspects and impacts specified in this document shall be reported and can be communicated. The report relates to the final document result of the works done and the communication relates to public dissemination of the result. Both shall contain any information of importance to the content of the report/communication.

The basis of the aspects and impacts considered, and why they have been taken or not into account is the transparency and traceability of information used and therefore the reporting and communication shall be accurate, verifiable, relevant and not misleading or deceptive.

7.2 Information on the report

The information shall be presented in sufficient detail to allow the reader to estimate the quality of the information.

Reporting shall include (but is not limited to) the following information and/or assumptions regarding:

- identification of civil engineering works (address, etc.);
- purpose of developing a set of indicators (intended use and scope);
- client;
- name and qualification of the developers of the set;
- point of the civil engineering work's life cycle where the indicators are applicable;
- date of development;

General information on the object of assessment shall include (but is not limited to) the following information:

- functional equivalent;
- civil engineering works type (e.g. dam or road);
- relevant technical and functional requirements (e.g. the regulatory and client's specific requirements);
- pattern of use (e.g. vehicles/year);

- additional functions considered;
- required service life;
- reference study period considered.

It may also include other civil engineering works information.

EXAMPLE Technical type of the civil engineering work; year of commissioning; year(s) of refurbishment.

7.3 Statement of boundaries, scenarios used and additional functions considered in the assessment

For the civil engineering works under consideration the relevant assumptions and scenarios taken into account shall be described or referenced in the report. The additional functions addressed shall be declared as well.

7.4 Data sources

Data sources, references, type and quality of data used shall be reported.

7.5 Communication of assessment results

7.5.1 General

If the results are to be communicated, to any entity beyond the client, they shall be made as clearly and simply as possible.

The communication shall include the following information:

- identification of civil engineering works (address, etc.);
- purpose of developing a set of indicators (intended use and scope);
- major assumptions and considerations;
- client;
- name and qualification of the developers of the set;
- point of the civil engineering work's life cycle where the indicators are applicable;
- date of development;
- functional equivalent:
 - civil engineering works type (e.g. dam or road);
 - relevant technical and functional requirements (e.g. the regulatory and client's specific requirements);
 - pattern of use (e.g. vehicles/year);
 - additional functions considered;
 - required service life;
 - reference study period considered.

For each indicator that is included, and if a value is provided for it, the measured value or measures shall be stated together with reference to relevant documentation.

The set of indicators developed for a civil engineering works shall cover the whole set of aspects and impacts of this document. If any aspect and impact is not considered for the development of indicators, this shall be declared in the communication. In addition, if the aspect and impact is one of the core ones for the civil engineering works typology, a justification shall be provided.

If an indicator was not developed for any aspect and impact, this shall be stated with a reference "IND" (indicator not developed). A reference to the full list of aspects and impacts shall be provided in the report and in the communication. This can be provided by a printed list, an URL list or by any other way. If core aspect and impacts are flagged as "IND", the report and the communication shall explain why.

Results shall be presented separately for all the civil engineering works life cycle stages and information modules. Results for different scenarios and for different additional functions shall be presented separately. In order to facilitate future decision making, results of alternatives with different additional functions shall be presented in parallel with the base case (current client's brief), presenting only the relevant differences between them.

7.5.2 Simplifications and additional remarks

The communication of results shall be based on and be limited to the report in accordance with this document, but it may be simplified according to the following rules:

- if some aspects and impacts do not have accompanying indicators, this shall be reported as IND (indicator not developed);
- if some modules are not included it shall be reported as MNI (module not included);
- the communication may be limited to a selection of indicators.

Any of the previous options shall be justified.

Annex A (normative)

Core indicators by civil engineering works (CEW) typology

A.1 Environmental indicators

Tables A.1 to A.9 contain a relation between environmental indicators and the CEW typologies.

Table A.1 — Relation between CEW typologies and the indicators for water management (5.2.2)

WATER MANAGEMENT	Industrial process infrastructures	Linear infrastructures	Dams and other fluvial works	Maritime works	Public spaces
QUANTITY	x			x	x
Consumptive use of fresh water	x				x
Non consumptive use of fresh water					
Water scarcity			x		
Water flooding	x			x	
QUALITY	x	x	x	x	x
Dissolved oxygen	x		x		
Total suspended solids	x	x	x	x	
pH	x				
Biochemical Oxygen Demand	x		x		x
Turbidity	x	x	x	x	
Others	x				

Table A.2 — Relation between CEW typologies and the indicators for energy management (5.2.3)

ENERGY MANAGEMENT	Industrial process infrastructures	Linear infrastructures	Dams and other fluvial works	Maritime works	Public spaces
Total renewable primary energy resources (primary energy and primary energy resources used as raw materials)	x		x	x	
Total non-renewable primary energy resources (primary energy and primary energy resources used as raw materials)	x	x	x	x	
Renewable secondary energy sources	x				
Non-renewable secondary energy sources	x				
Abiotic depletion potential (ADP-fossil fuels) for fossil resources					

Table A.2 (continued)

ENERGY MANAGEMENT	Industrial process infrastructures	Linear infrastructures	Dams and other fluvial works	Maritime works	Public spaces
Reduction of peak energy capacity requirements via DSM (MW)	x	x			
Reduction of over-all consumption via DSM (MWh)	x	x		x	x
Flexibility of consumption via DSM (able to shift to off peak periods)	x				
Ratio between useful energy output over total energy input	x		x		
On-site energy generation/recovery, co-generation, energy storage contributions (MW)	x		x		

Table A.3 — Relation between CEW typologies and the indicators for material management (5.2.4)

MATERIAL MANAGEMENT	Industrial process infrastructures	Linear infrastructures	Dams and other fluvial works	Maritime works	Public spaces
Virgin material		x	x		
Recycled material		x	x	x	
Recyclable material					
Non-recyclable material	x				
Reused material					x

Table A.4 — Relation between CEW typologies and the indicators for waste management (5.2.5)

WASTE MANAGEMENT	Industrial process infrastructures	Linear infrastructures	Dams and other fluvial works	Maritime works	Public spaces
Hazardous waste disposed	x				
Non-hazardous waste disposed		x	x		x
Radioactive waste disposed					
Components for re-use					
Materials for recycling					
Materials for energy recovery (not being waste incineration)					
Exported energy					

Table A.5 — Relation between CEW typologies and the indicators for emissions to environment (5.2.6)

EMISSIONS TO ENVIRONMENT	Industrial process infrastructures	Linear infrastructures	Dams and other fluvial works	Maritime works	Public spaces
Emissions to air	x	x			
Depletion potential of the stratospheric ozone layer, ODP					

Table A.5 (continued)

EMISSIONS TO ENVIRONMENT	Industrial process infrastructures	Linear infrastructures	Dams and other fluvial works	Maritime works	Public spaces
Global warming potential, GWP (kg CO ₂ eq.) SUM (GWP fossil + GWP biogenic + GWP land use)					
GWP fossil					
GWP biogenic					
GWP land use and land use transformation					
Formation potential of tropospheric ozone, POCP					
Emissions to water	x		x	x	
Eutrophication aquatic freshwater: Fraction of nutrients reaching freshwater end compartment, Eutrophication potential, EP freshwater (kg PO ₄ eq.)					
Eutrophication aquatic marine: Fraction of nutrients reaching freshwater end compartment, Eutrophication potential, EP marine (kg N eq.)					
Eco-toxicity (freshwater): Potential Comparative Toxic Unit for ecosystems (CTUe)					
Emissions to soil	x				
Soil quality: Potential soil quality index (dimensionless)					
Eutrophication terrestrial: Accumulated Exceedance, Eutrophication potential, EP terrestrial					
Biogenic carbon (C)					
Acidification for soil and water	x				
Acidification: Accumulated Exceedance, Acidification potential AP	x				

Table A.6 — Relation between CEW typologies and the indicators for noise, vibrations and light impacts (5.2.7)

NOISE, VIBRATIONS AND LIGHT IMPACTS	Industrial process infrastructures	Linear infrastructures	Dams and other fluvial works	Maritime works	Public spaces
Disturbance because of noise, vibrations and light impacts on ecological species		x			

Table A.7 — Relation between CEW typologies and the indicators for landscape changes (5.2.8)

LANDSCAPE CHANGES	Industrial process infrastructures	Linear infrastructures	Dams and other fluvial works	Maritime works	Public spaces
Permanent land occupation: Land surface occupied by the asset		x	x		x
Temporary land occupation: Land surface occupied by the temporary works			x		

Table A.8 — Relation between CEW typologies and the indicators for ecosystem health (5.2.9)

ECOSYSTEM HEALTH	Industrial process infrastructures	Linear infrastructures	Dams and other fluvial works	Maritime works	Public spaces
Changes in ecosystem services		x	x		
Biodiversity change		x	x		x
Protected areas affected					
Non-protected areas with biodiversity quality changes					
Ecological connectivity (Landscape connectivity)		x	x		
Degree to which CEW facilitates or impedes the movement through the landscape for flora and fauna					

Table A.9 — Relation between CEW typologies and the indicators for land use changes (5.2.10)

LAND USE CHANGES	Industrial process infrastructures	Linear infrastructures	Dams and other fluvial works	Maritime works	Public spaces
Surface of land that changes its previous use because of the CEW (because the land is occupied by it or because of its influence)		x	x		x

A.2 Social indicators

Tables A.10 to A.23 contain a relation between social indicators and the CEW typologies.

Table A.10 — Relation between CEW typologies and the indicators for accessibility (5.3.2)

ACCESSIBILITY	Industrial process infrastructures	Linear infrastructures	Dams and other fluvial works	Maritime works	Public spaces
Inclusive access					
Provisions included in the civil engineering works to facilitate access to people with disabilities	x				x
User's affordability such as toll charges, electricity charges, price of water or equity of financial mechanisms		x			

Table A.10 (continued)

ACCESSIBILITY	Industrial process infrastructures	Linear infrastructures	Dams and other fluvial works	Maritime works	Public spaces
Access to basic supplies provided by the civil engineering works					
Service level		x			
Changes of people's opportunity to access a good quality natural environment, including access to natural green areas					x
Net change in the utility supply					
Connectivity					
Travel time		x			
Fragmentation of settlements		x			x
Design features incorporated that enable transit for all relevant users		x			x

Table A.11 — Relation between CEW typologies and the indicators for adaptability (5.3.3)

ADAPTABILITY	Industrial process infrastructures	Linear infrastructures	Dams and other fluvial works	Maritime works	Public spaces
Number of measures of the CEW to accommodate technical changes, change of use, complementary uses and external events.	x				

Table A.12 — Relation between CEW typologies and the indicators for population system (5.3.4)

POPULATION SYSTEM	Industrial process infrastructures	Linear infrastructures	Dams and other fluvial works	Maritime works	Public spaces
Number of people resettled voluntarily or involuntarily and directly or indirectly because of the CEW		x	x		

Table A.13 — Relation between CEW typologies and the indicators for job creation (5.3.5)

JOB CREATION	Industrial process infrastructures	Linear infrastructures	Dams and other fluvial works	Maritime works	Public spaces
Number of people to be employed					
Type of employees (local or not local)					
Number of local disadvantaged people to be employed					

Table A.14 — Relation between CEW typologies and the indicators for cultural heritage elements (5.3.6)

CULTURAL HERITAGE ELEMENTS	Industrial process infrastructures	Linear infrastructures	Dams and other fluvial works	Maritime works	Public spaces
Number and value of cultural heritage elements affected due to the civil engineering works					

Table A.15 — Relation between CEW typologies and the indicators stakeholder's involvement (5.3.7)

STAKEHOLDERS INVOLVEMENT	Industrial process infrastructures	Linear infrastructures	Dams and other fluvial works	Maritime works	Public spaces
Consideration of end users' involvement and their needs					
Consideration of stakeholders (other than end users) involvement and their needs	x	x	x	x	x
Existence of a procedure for management and resolution of contradictions or conflicts					
Degree of satisfaction of affected parties					
Number of documented lessons learned					

Table A.16 — Relation between CEW typologies and the indicators for human rights (5.3.8)

HUMAN RIGHTS	Industrial process infrastructures	Linear infrastructures	Dams and other fluvial works	Maritime works	Public spaces
Number of failures to comply with relevant standards or declarations of Human Rights					

Table A.17 — Relation between CEW typologies and the indicators for resilience (5.3.9)

RESILIENCE	Industrial process infrastructures	Linear infrastructures	Dams and other fluvial works	Maritime works	Public spaces
Structural stability					
Safety indexes	x	x	x	x	
Consequences of climate change	x	x	x	x	x
Measures adopted for each one of the climate aspects considered					
— Rain effects					
— Wind effects, sand and dust storms					
— Hail					
— Snow and ice					
— Flood					

Table A.17 (continued)

RESILIENCE	Industrial process infrastructures	Linear infrastructures	Dams and other fluvial works	Maritime works	Public spaces
— Temperature variation					
— Droughts					
— Sea level, waves and coastal effects					
— Glacier, geological impacts and changes to permafrost					
— Wild fires					
Future changes of impacts: altered conditions in the future, such as possible changes of wind and snow loads, the amount of rain and higher sea levels					
Incidental actions					
Mass movements		x	x		
Earthquake resistance	x	x	x		
Explosion resistance	x				
Fire Performance for inside or outside events	x				x
Traffic accidents (collisions)		x			
Personal safety and security against intruders and vandalism					
Measures of the capacity of the civil engineering works to resist forced access and deliberate damage as well as to satisfy the users need to feel safe and secure	x		x		
Security against interruptions of utility supply					
Provisions made for increased security against interruptions of utility supply					

Table A.18 — Relation between CEW typologies and the indicators for health and comfort (5.3.10)

HEALTH AND COMFORT	Industrial process infrastructures	Linear infrastructures	Dams and other fluvial works	Maritime works	Public spaces
Workers' health and comfort					
Number and quality of sanitary and rest facilities					
Protection of workers against the potential environmental adverse effects					
Design of the CEW in order to allow a more comfortable and safe construction and maintenance					
Characteristics of air quality					