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BSI Standards Publication

Sustainability in building construction — Sustainability indicators

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

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National foreword

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

Développement durable dans la construction — Indicateurs de développement durable —

Partie 2: Cadre pour le développement d'indicateurs pour les ouvrages de génie civil

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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. www.iso.org/directives

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT), see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 59, *Buildings and civil engineering works*, SC 17, *Sustainability in buildings and civil engineering works*.

ISO 21929 consists of the following parts, under the general title Sustainability in buildings and civil engineering works — Sustainability indicators:

— *Part 1: Framework for the development of indicators and a core set of indicators for buildings*

— *Part 2: Framework for the development of indicators for civil engineering works* [Technical Specification]

Introduction

This part of ISO 21929 describes and gives 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 construction works. The issue of sustainable development is broad and of global concern, and, as such, involves all communities and interested parties. 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 society lives and works.

The building and construction sector is highly important for sustainable development because:

— it is a key sector in national economies.

— it has a significant interface with 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 creates the built environment, which 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.

It can, in addition, particularly in developing countries, include poverty reduction, job creation, access to safe, affordable and healthy shelter, and loss of livelihoods.

This part of ISO 21929 defines a framework for the development of sustainability indicators for civil engineering works based on the premise that civil engineering works contribute to sustainable development about the required performance and functionality with minimum adverse environmental impact, while encouraging improvements in economic and social (and cultural) aspects at local, regional and global levels.

This part of ISO 21929 follows the general principles presented in ISO 15392.

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

The three main functions of indicators are quantification, simplification and communication. Targets can also be set with the help of indicators. Changes in a civil engineering works over time and the development of changes in relation to stated objectives can be monitored with the help of indicators. One of the important functions of an indicator with reference to decision-making is its potential to show a trend.

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 a number of interested parties, such as

a) public bodies and policy makers,

b) investors, owners and promoters,

c) planners, developers and designers,

d) governmental and non-governmental organizations (considering interest groups both at national and at local level),

e) manufacturers of products,

f) contractors,

g) operators and maintainers,

h) users and other stakeholders who are given service by the infrastructure, and

i) nearby local residents.

The civil engineering and construction sector needs sustainability indicators both for its own decision-making within design, production and management as well as for indicating to the public and to clients the economic, environmental or social impact of civil engineering works, their products and related processes.

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 different 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.

— 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.

This part of ISO 21929 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, along with the terminology of sustainability in buildings and civil engineering works (ISO/TR 21932).

The relationship among the International Standards is shown in Figure 1.

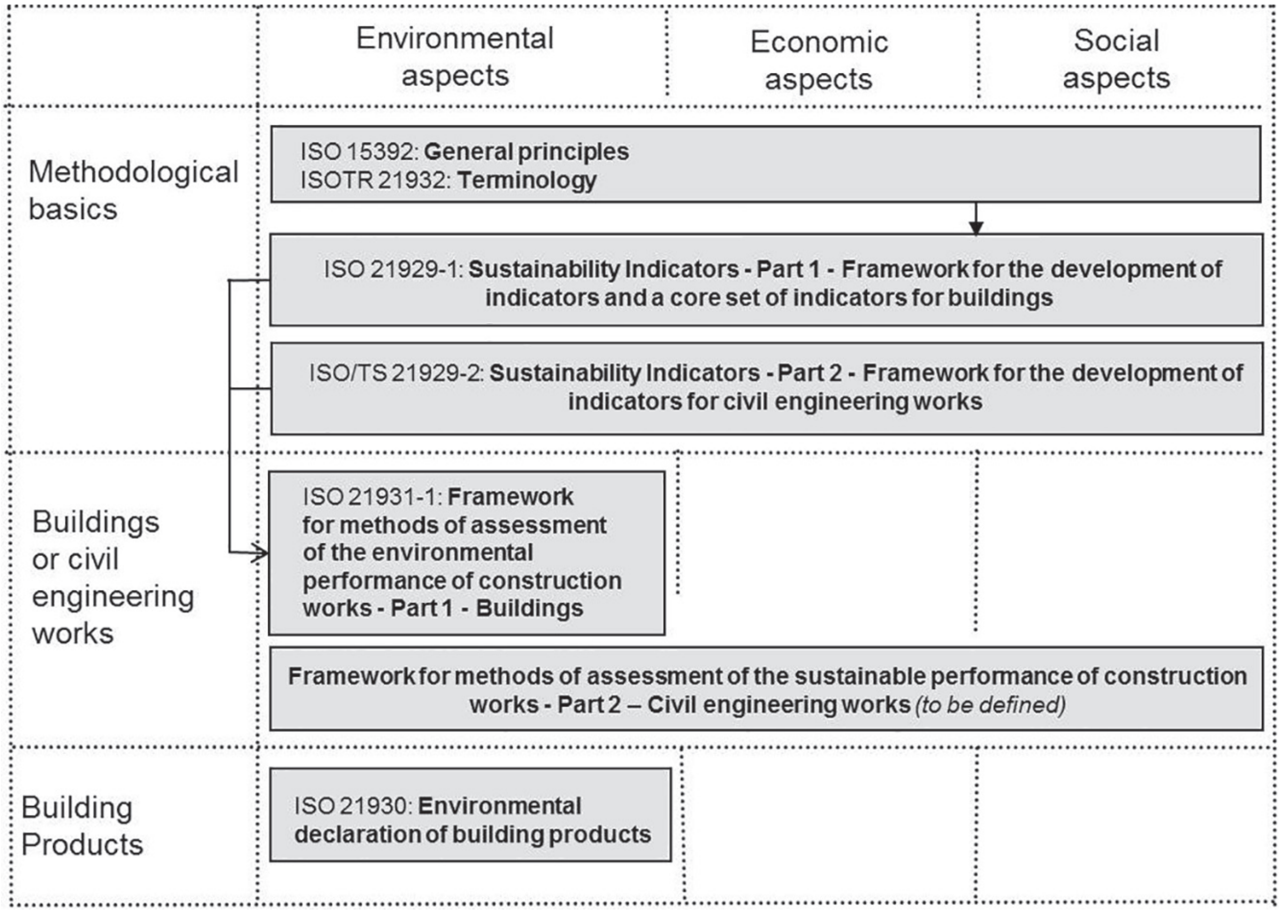

Figure 1 — Suite of related International Standards for sustainability in buildings and civil engineering works

Sustainability in building construction — Sustainability indicators —

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

1 Scope

This part of ISO 21929 establishes a list of aspects and impacts which should be taken as the basis 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. Together, the indicators developed from this list of aspects and impacts provide measures to express the contribution of a civil engineering works to sustainability and sustainable development. The developed indicators should represent aspects of civil engineering works that impact on issues of concern related to sustainability and sustainable development.

The object of consideration in this part of ISO 21929 is a civil engineering works, a part of the civil engineering works or a combination of several civil engineering works.

NOTE The aspects and impacts described in this part of ISO 21929 are intended to be used for all types of civil engineering works. Development of specific sets of indicators for different typologies of civil engineering works (industrial processes infrastructures; linear infrastructures; dams and other fluvial works; maritime works; public spaces; other civil engineering works-not contained in the previous typologies) will be the subject of future standardization work.

This part of ISO 21929

— adapts general sustainability principles for civil engineering works,

— includes a framework for developing sustainability indicators for use in the assessment of economic, environmental and social impacts of civil engineering works,

— establishes a core set of aspects and impacts, which should be taken into account, when developing systems of indicators for civil engineering works,

— describes how to use sustainability indicators with regard to civil engineering works, and

— gives rules for establishing a system of indicators.

This part of ISO 21929 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 or where more specific requirements are stated, this part of ISO 21929 takes precedence.

This part of ISO 21929 does not give guidelines for the weighting of indicators or the aggregation of assessment results.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 6707-1, *Buildings and civil engineering works — Vocabulary — Part 1: General terms*

ISO 14020, *Environmental labels and declarations — General principles*

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

ISO 14050, *Environmental management — Vocabulary*

ISO 15392, *Sustainability in building construction — General principles*

ISO 21929-1, *Sustainability in building construction — Sustainability indicators — Part 1: Framework for the development of indicators and a core set of indicators for buildings*

ISO 21931-1, *Sustainability in building construction — Framework for methods of assessment of the environmental performance of construction works — Part 1: Buildings*

ISO 26000, *Guidance on social responsibility*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 6707-1, ISO 14040, ISO 14050, ISO 15392 and the following apply. Where differences or conflicts occur, the definitions in 3.1 to 3.44 take precedence.

NOTE 1 Several terms and definitions from these other sources have been repeated below for ease of reference.

NOTE 2 ISO/TR 21932 is another source of terminological data on concepts related to sustainability in civil engineering works and sustainable development that is applicable to the different aspects of both the construction (process) and use of a civil engineering works and the effect of the civil engineering works on sustainable development.

3.1
airport
area containing an airfield and facilities for handling passengers and cargo

[SOURCE: ISO 6707-1:2014, 3.3.12]

3.2
area of influence
area or combination of areas surrounding a *civil engineering works* (3.5) that can be affected with changes to their economical, environmental or social conditions by the civil engineering works' operations throughout its *life cycle* (3.24)

Note 1 to entry: the area of influence is variable and dependent on the construction works (3.9) project, its location and its life cycle stage. As an overall approach, the area of influence will be usually limited to the civil engineering works itself and its immediate surroundings.

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 a particular 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 (3.9) within the area under consideration.

[SOURCE: ISO 21929-1:2011, 3.7]

3.5
civil engineering work
work of constructing *civil engineering works* (3.6)

[SOURCE: ISO 6707-1:2014, 7.1.3]

3.6
civil engineering works
construction works (3.9) comprising a *structure* (3.35), such as a *dam* (3.9), bridge, *road* (3.35), *railway* (3.31), runway, utilities, *pipeline* (3.30), or *sewerage system* (3.37), or the result of operations such as dredging, *earthwork* (3.12), geotechnical processes, but excluding a building and its associated site works

[SOURCE: ISO 6707-1:2014, 3.1.2]

3.7
civil engineering work system boundary
set of criteria specifying which unit processes are part of the specific analysis of a *civil engineering works* (3.6)

[SOURCE: ISO 14050:2009, 6.6; modified and adapted to civil engineering works]

3.8
construction work
activities of forming a *construction works* (3.9)

[SOURCE: ISO 6707-1:2014, 7.1.1]

3.9
construction works
everything that is constructed or results from construction operations

Note 1 to entry: It includes both buildings and *civil engineering works* (3.6).

[SOURCE: ISO 6707-1:2014, 3.1.1; modified and adapted to civil engineering works]

3.10
dam
barrier constructed to retain water in order to raise its level, form a reservoir, or reduce or prevent flooding

[SOURCE: ISO 6707-1:2014, 3.2.24]

3.11
dock
partially enclosed or sheltered area of water where vessels may be moored or docked, used for shipping

[SOURCE: ISO 6707-1:2014, 3.3.69: modified and adapted to civil engineering works by elaborating text to explicitly describe concept of basin (used) for shipping]

3.12
earthwork
work of excavating, or the raising or sloping of ground

[SOURCE: ISO 6707-1:2014, 7.1.6]

3.13
economic aspect
part of civil engineering works, processes or services related to their *life cycle* (3.24), that can cause a change to economic conditions

[SOURCE: ISO 15392, 3.13; modified and adapted to civil engineering works]

3.14
environmental aspect
part of civil engineering works, processes or services related to their *life cycle* (3.24), that can cause a change to the environment

Note 1 to entry: Adapted from ISO 14001:2004.

[SOURCE: ISO 15392, 3.14; modified and adapted to 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 LCC analysis but should be explicitly identified.

[SOURCE: ISO 15686-5:2008, 3.1.6]

3.16
impact
any change that may be adverse or beneficial

[SOURCE: ISO 15392:2008, 3.13]

3.17
impact category
class representing an economic, environmental or social *issue(s) of concern* (3.22) (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]

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 14040:2006, 3.40: modified and adapted to civil engineering works]

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), a part of the civil engineering works or a combination of several civil engineering works

Note 1 to entry: In this part of ISO 21929, the term infrastructure is sometimes used as a synonym for civil engineering works.

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

3.21
interested party
person or group concerned with or affected by the environmental *performance* (3.28) of a *civil engineering works* (3.6)

[SOURCE: ISO 21931-1:2010, 3.18; modified and adapted to civil engineering works]

3.22
issue of concern
aspect(s) of the economy, the environment or the society that can be impacted by *construction works* (3.9), goods or services

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

Note 1 to entry: The preferred term to designate this concept has been changed from 'areas of concern' to 'issue of concern' and the admitted terms removed

[SOURCE: ISO/TR 21932:2013, 3.6]

3.23
land take
total area of land required for the *civil engineering works* (3.6)

3.24
life cycle
consecutive and interlinked stages of the object of consideration

Note 1 to entry: For consideration of environmental *impacts* (3.16) and *environmental aspects* (3.14), the life cycle comprises all stages, from raw material acquisition or generation of natural resources to final disposal.

Note 2 to entry: For consideration of economic impacts and *economic aspects* (3.13), in terms of costs, the life cycle comprises all stages from construction to decommissioning. A *period of analysis* (*3.29*) can be chosen to be different from the life cycle, see ISO 15686-5.

[SOURCE: ISO 14040:2006; modified and adapted to civil engineering works; ISO 15392:2008, 3.15]

3.25
life cycle cost (LCC)
cost of an asset or its parts throughout its *life cycle* (3.24), while fulfilling its *performance* (3.28) requirements

[SOURCE: ISO 15686-1:2011, 3.11]

3.26
life cycle costing
methodology for systematic economic evaluation of *life cycle costs* (3.25) over a period of *analysis* (3.29), as defined in the agreed scope

Note 1 to entry: Life cycle costing can address a period of analysis that covers the entire *life cycle* (3.24) or (a) selected stage(s) or periods of interest thereof.

[SOURCE: ISO 15686-5:2008, 3.1.8]

3.27
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), *railways* (3.31), bridges, *pipelines* (3.30) or channels.

3.28
performance
ability to fulfil required functions under intended use conditions or behaviour when in use

Note 1 to entry: Derived from the definition of performance in ISO 6707-1.

Note 2 to entry: The required functions address both the functionality requirements as well as the technical requirements.

[SOURCE: ISO 15392:2008, 3.16]

3.29
period of analysis
period of time over which *life-cycle costs* (3.25) or *whole-life costs* (3.43) are analysed

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

[SOURCE: ISO 15686-5:2008, 3.3.6]

3.30
pipeline
long continuous line of pipe(s), including ancillary equipment, used for transporting liquids or gases

[SOURCE: ISO 6707-1:2014, 3.2.32]

3.31
railway
national or regional transport system for guided passage of wheeled vehicles on rails

[SOURCE: ISO 6707-1:2014, 3.3.3]

3.32
recovery
waste (3.42) treatment operation that serves a purpose in replacing other resources or prepares waste for such a use

3.33
recycling
any *recovery* (3.32) operation by which *waste* (3.42) materials are reprocessed into products, materials or substances whether for the original or other purposes

3.34
re-use
any operation by which products or components that are not *waste* (3.42) are used again for the same purpose for which they were conceived

3.35
road
way mainly for vehicles

[SOURCE: ISO 6707-1:2014, 3.3.1]

3.36
set of indicators
non-structured list of *indicators* (3.18)

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

3.37
sewerage system
system of sewer(s) and ancillary works that conveys the contents to a sewage treatment works or other place of disposal

[SOURCE: ISO 6707-1:2014, 5.4.40]

3.38
social aspect
issue of *construction works* (3.9), parts of works, processes or services related to their *life cycle* (3.24), that can cause a change to society or quality of life

[SOURCE: ISO 15392:2008, 3.33: Modified and adapted to civil engineering works]

3.39
structure
construction works (3.9) having an organized combination of connected parts designed to provide some measure of rigidity

[SOURCE: ISO 6707-1:2014, 3.1.4; modified and adapted to civil engineering works by elaborating text to explicitly describe the concept as being an organized set of parts providing rigidity]

3.40
sustainability indicator
indicator (3.18) related to economic, environmental, or social impacts

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

3.41
system of indicators
structured list of *indicators* (3.18)

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

3.42
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 part of ISO 21929 this concept is not confined to hazardous waste.

Note 2 to entry: Adapted from the Basel Convention on the Control of Trans-boundary 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]

3.43
whole-life cost
all significant and relevant initial and future costs and benefits of an asset, throughout its *life cycle* (3.24), while fulfilling the *performance* (3.28) requirements

[SOURCE: ISO 15686-5:2008, 3.1.14]

3.44
whole-life costing
methodology for systematic economic consideration of all *whole-life costs* (3.40) and benefits over a *period of analysis* (3.29), 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* (3.24) or (a) selected stage(s) or periods of interest thereof.

[SOURCE: ISO 15686-5:2008, 3.1.15]

4 General rules for sustainability indicators development and its framework

4.1 General

There are a number of issues that must 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 also 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 will address more than just a single aspect of sustainability.

NOTE For instance, the hypothetical indicator "reused excavation material", that may be developed under the aspect "use of material resources" could 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 construction work 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 in order 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. In the life cycle of a civil engineering works, the following stages should be considered:

Production stage: covers the period from “cradle” (extraction of material) to the factory “gate” (before the products are transported to the site). It includes:

— material extraction and/or harvesting;

— transport;

— manufacturing and all upstream processes from cradle to gate.

Construction stage: covers the transportation of products to the site and the period between the point of time when construction work start 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 Design and procurement are included in the construction 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 stage.

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;

— decommissioning.

End-of-life stage: covers the stages that occur during the end-of-life process. It includes:

— deconstruction, demolition;

— transport;

— processing for reuse, recovery and / or recycling of construction materials;

— disposal of construction material;

— re-landscaping.

NOTE 1 Impacts and benefits during and beyond end of life stage (reuse, recovery and recycling) can be expressed as additional information.

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 2 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.

4.3 Area of influence

Civil engineering works affect a specific area throughout their 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. These border demarcations are carried through with the 'spatial boundaries'. 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 has to 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 will, in general, be 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 could extend many miles downstream. Additionally, the spatial boundaries of the construction stage will normally include the civil engineering works area and immediate surroundings, and the socioeconomic regions supplying workers, whereas the spatial boundaries of the use stage will 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 interested parties and the overall assessment goal. The selection of the relevant set of indicators shall reflect the concerns of interested parties and the proper representation of the assessment goal.

4.4 Civil engineering works typologies

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

— industrial processes infrastructures;

— linear infrastructures (including above and below ground);

— dams and other fluvial works;

— maritime works;

— public spaces;

— other civil engineering works (not contained in the previous typologies).

4.5 Relationship to ISO 15392 and other general principles

4.5.1 Relation to ISO 15392

In addition to the requirements of this part of 21929, the principles and procedures set out in ISO 15392, ISO 14040 and the ISO 14020 family of standards, which includes ISO 14020, ISO 14021, ISO 14024 and

ISO 14025, shall apply. The principles set out in ISO 26000 should also be taken into consideration, where appropriate. Where this part of ISO 21929 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:

a) improvement of the construction sector and the built environment;

b) 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;

c) stimulation of a proactive approach;

d) stimulation of innovation;

e) decoupling of economic growth from increasing adverse impacts on the environment and/or society;

f) reconciliation of contradictory interests or requirements arising from short-term and long-term planning or decision.

ISO 15932 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 interested parties,

— long term consideration,

— precaution and risk,

— responsibility, and

— transparency.

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

4.5.2 Relation to ISO 14000- series

The ISO 14000- series of standards generally are intended to address the implementation of environmental management systems within organizations to help them manage the environmental impacts of their operations. In regards to 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.

4.5.3 Relation to ISO 26000

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 a number of core subjects (issues), such as human rights, 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 will vary, and will depend on the issue of concern under consideration. It will also depend 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 will be influenced by the specific scenario and different stakeholders involved. ISO 21931-1:2010, Annex B of 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 in particular.

Indicators shall be:

a) relevant*:* indicators should be able to accomplish the goal of the intended use of the interested parties;

b) simple*:* indicators should present information in an easily understandable way to the different users of indicators;

c) valid*:* indicators should be objective, verifiable and reproducible and be based on available and affordable standardized data and methodologies, whenever possible;

d) informative*:* indicators should impart knowledge and reflect information which can have an influence or effect;

e) sensitive: *and responsive:* indicators should detect changes in the system;

f) reliable*:* indicators should give the same result on successive trials (measurements under the same circumstances).

Information about an indicator shall include the following:

— name;

— 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, it is recommended that the indicator also contains 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;

— data required in order 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, qualitative or descriptive measure related to economic, environmental or social aspects. Generally indicators have numerical values. However, in cases where indicators cannot be measured with quantitative data, qualitative assessments or logical assumptions be used.

Ideally a sustainability indicator should be linked to the three dimensions of sustainability. When developed, a set of indicators be organized according to the aspects and impacts described in this part of ISO 21929.

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 can 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 may be developed under the name “Land take”, 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 may 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 might be justified to exclude the impacts from the original construction stage.

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

— production stage;

— construction stage;

— use stage;

— end-of-life stage.

NOTE 4 The assessment of the economic impact of civil engineering works should, whenever possible, be based on a life cycle 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 production stage to end-of-life stage.

4.7.2 Aspects 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, following environmental impacts and aspects shall be taken into consideration:

— use of energy resources;

— use of material resources;

— production and management of wastes;

— use of water;

— land use changes;

— emissions to local environment (air, soil and water);

— noise and vibrations;

— landscape changes;

— ecosystem processes and services;

— global warming potential;

— ozone depletion potential;

— eutrophication potential;

— acidification potential;

— photochemical ozone creation potential.

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

a) service life assessment methods;

b) environmental assessment methods;

c) energy-efficiency assessment methods;

d) 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 Aspects for the development of economic indicators

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

The following economic aspects shall be considered for developing a system of economic indicators of civil engineering works:

a) external costs;

b) life cycle costs.

The following issues can be considered when developing the previous aspects:

— Direct costs, such as cost of water and energy supply, cost of material acquisition, cost of preventive measures, cost of waste management, etc.;

— Direct benefits, such as operating income from a toll road or financial benefits received from the government;

— 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;

— Urban- and landplaning: the construction works can change the way areas are used. These changes can lead either to a revaluation or to a depreciation of its economic value;

— Territorial relations and connectedness: the selected infrastructure alternative can boost tourism in one area, since its communications or supplies will be more efficient or it can cause rural areas to depopulate, making these social groups more vulnerable.

The economic indicators of civil engineering works shall provide a balance between its long-term and short-term economic aspects. When an economic indicator considers a period of analysis that is different from the life cycle, this shall be transparent and adequately justified.

In addition to the life cycle costs, when assessing the whole-life costing, one has also to take into account the potential income and value developed from the civil engineering works during its service life. Potential income depends on variety of aspects including location, spaces and services available for users and the overall infrastructure performance. Income can be improved by ensuring the appropriate performance of the civil engineering works with regard to user needs. Potential income also depends on the ability to implement planned periodic infrastructure maintenance while minimising the disruptions of the services provided by the infrastructure.

When analysing a civil engineering works alternative, it is recommended to consider whole-life costs, including both the income and benefits, and the external costs of the civil engineering works. The externalities which can have an impact on the others in society are generally not included in what the client or public authority pay; therefore they are typically not considered in the life cycle costs analysis. Internalising externalities means taking into account the project external effects, which can be negative (costs imposed on others) or positive (benefits for others). Externalities also change as technologies change, so the analysis must be on-going in the infrastructure life cycle. The degree to which the costs for a project are externalised from the direct benefits for the users of the infrastructure needs to be considered in the system boundary.

4.7.4 Aspects 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:

a) access to nature;

b) population system;

c) job creation;

d) cultural heritage elements;

e) social inclusion and acceptability;

f) risks and resilience;

g) health and comfort.

The following issues can be considered when developing the previous aspects:

— Population dynamic: changes in the number 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 in order to build a dam;

— 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;

— Aesthetic or cultural concerns, such as preserving historical or archaeological sites, value of nearby properties, safety and public health;

— Users' acceptance of the infrastructure and satisfaction with the civil engineering Works;

— Stakeholder and community engagement and participation;

— Robustness and resilience of the infrastructure: durability, resistance to adverse conditions (climate change, natural disasters like fire or earthquakes, terrorism, etc.);

— Health and safety of construction workers;

— Retaining function: in case of disaster or after a terror action carried out against a civil engineering works, it must have mechanisms to restore its function and value in a short period of time, so that normality in society is re-established;

— 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;

— Access to basic services: users have to be able to access the service the civil engineering works is providing (water or energy supply, mobility services…). That means that the infrastructure has to be functional and easy to use. However, there are some assets in civil engineering works that need to be inaccessible, in order to avoid accidents.

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 could be:

— co-operation with the people who are benefiting from the infrastructures 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.

5 Sustainability issues of concern

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 in particular.

This part of ISO 21929 establishes a core set of aspects and impacts as well as its relation with 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. When developed, the sustainability indicators should be:

— essential from the view point 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 can be categorised in the three dimensions of sustainability as follows:

a) Environmental: protection of climate protection of natural resources, and protection of ecosystems;

b) Economic: cost and value;

c) Social: health and safety, satisfaction, population and community, and cultural heritage.

The sustainability indicators having an effect on these issues of concern will be developed according to the following aspects and impacts listed from 4.7.2 to 4.7.4.

Table 1 — Sustainability aspects and impacts and interactions with the issues of concern

	ISSUES OF CONCERN								
	ENVIRONMENTAL			ECONOMIC		SOCIAL			
ASPECTS AND IMPACTS	Protection of Climate	Protection of natural resources	Protection of Ecosystems	Cost	Value	Health and Safety	Satisfaction	Population and Community	Cultural heritage
Use of energy resources		X							
Use of material resources		X							
Management of wastes		X							
Use of water		X							
Land use changes			X						
Emissions to local environment (soil, air and water).			x			x			
Noise and vibrations						x			
Ecosystem processes and services			x						
Landscape changes							x		x
Global warming potential	x								
Ozone depletion potential			x						
Eutrophication potential			x						
Acidification potential			x						
Photochemical ozone creation potential			x						
External costs				x					
Life cycle costs				x					
Access to nature							x	x	
Population system								x	
Job creation					x		x		
Cultural heritage elements									x
Social inclusion and acceptability							x		
Risks and resilience				x		x		x	
Health and comfort						x	x		
The “X” in the table indicates the issues of concern which the sustainability indicators that could be developed under the proposed aspects and impacts are more likely to interact with.									

The following list describes the aspects and impacts which shall be taken into account for developing a system of indicators for assessing the sustainability performance of new or existing civil engineering works.

5.1.1 Use of energy resources

The use of energy resources refers to the total ***energy required*** by the civil engineering works. This aspect could be 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 sources which could be used for defining the indicators are classified into the following ones:

— Non renewable primary energy-sources, such as coal, natural gas and fuel distilled from crude oil as gasoline, diesel liquid petroleum gas (LPG), compressed natural gas (CNG), liquid natural gas (LNG), butane, propane, ethane, etc.;

— Renewable primary energy sources, such as biofuels, solar and ethanol.

— Non-renewable secondary energy sources, such as electricity, heating and cooling, steam, nuclear energy or other forms of imported energy;

— Renewable secondary energy-sources, such as solar, wind, geothermal, hydro energy, and biomass based intermediate energy.

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

NOTE Total energy consumed by the civil engineering works during construction can be reported separately.

5.1.2 Use of material resources

There are different types of indicators which could be developed under the aspect of material resources use.

On the one hand, it would be interesting to develop indicators related to the ***consumption of raw materials***, since that has a potential impact on the depletion of natural resources. In order to define the materials used, both the purchases of raw materials and the stock variations in which this purchase may result (adding the initial stock and subtracting the final one) shall be taken into account, 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. If appropriate, indicators related to the ***consumption of recycled resources*** in the construction work could also be developed, because the use of these materials minimises the impact on the depletion of natural resources.

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

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

Another indicator which could be developed under this aspect is the ***abiotic resource depletion***, since it encompasses both the use of non-renewable and renewable abiotic resources. The indicator for abiotic resource depletion is the decrease in the availability of said resource.

5.1.3 Management of waste

In order to complement the indicators described, it would be relevant to include under this aspect 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. The generation of such waste can result from the production of building 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.

5.1.4 Use of water

The water used in civil engineering works can be withdrawn from the following sources: surface water (including water from wetlands, rivers, lakes and oceans), groundwater, rainwater, municipal water supplies or wastewater. It could be measured by indicators that report amount and quality (such as the total, peak annual or average annual ***consumption of fresh water resources*** for each life cycle stage). The information on water withdrawal may be obtained from water meters, water bills or calculations derived from other available water data.

5.1.5 Land use changes

This aspect should include indicators that report the ***land use changes inside the project boundaries*** for the civil engineering works development. It should be taken into account the fact that the land take may change during the life cycle of the civil engineering works. For instance, there is a temporary need of auxiliary areas in the construction stage, whereas these areas are no longer needed in the use stage.

For the development of indicators, the previous land use and land-cover category could also be considered, including:

— *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 could 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 could 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.

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.

5.1.6 Emissions to local environment (air, soil and water)

5.1.6.1 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 in their quality.

5.1.6.2 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 has to decide which emissions to air it will measure and report, (according to its local context, infrastructure typology and boundaries), some ***significant emissions to air*** to measure are: NO_x, SO_x, CO, NH_3, 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.

Particularly important for some civil engineering works are the ***dust emissions***. An indicator could 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. It is important that accepted standard methods are followed. In some cases dust monitoring will not be 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.

The ***greenhouse gases emissions*** should be measured and reported separately, because of their importance, since they have a potential impact on the climate.

NOTE 2 The main greenhouse emissions are: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydro fluorocarbons (HFCs-a group of several compounds), per fluorocarbons (PFCs-a group of several compounds) and sulfur hexafluoride (SF_6).

To help delineate direct and indirect emission sources, ISO 14064-1:2006 defines the three following “scopes” for greenhouse emissions accounting and reporting purposes.

— **Scope 1: Direct greenhouse emissions:** direct GHG emissions occur from sources that are owned or controlled by the civil engineering works. For example, emissions from combustion in owned or controlled boilers, furnaces, vehicles, etc.;

— **Scope 2: Electricity indirect GHG emissions:** greenhouse gases emissions from the generation of the purchased electricity for use at the civil engineering works.

— **Scope 3: Other indirect GHG emissions:** Scope 3 is an optional reporting category that allows for the treatment of all other indirect emissions. Scope 3 emissions are a consequence of the activities of the civil engineering works, but occur from sources not owned or controlled by the company. Some examples of Scope 3 activities are extraction and production of purchased materials and its transportation to the site, emissions of the transport used by employees, emissions associated with sub-contractors works at the site, emissions produced as a result of the disposal of waste, including transport off site, etc.

NOTE 3 In order to calculate the amount of greenhouse gas emissions per source, some of the following methodologies are indicated as an example:

— direct measurement (e.g. continuous online analyzers, etc.);

— calculation based on site specific data (e.g. for fuel composition analysis, etc.);

— calculation based on default data;

— estimations.

As an addition to the GHG emissions, it would be interesting to develop an indicator which measures the ***avoided GHG emissions***.

NOTE 4 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.

NOTE 5 If the emissions reductions are mandatory (derived from regulations or trading systems at international or national levels), they have to be quantified separately from the voluntary emissions reductions.

5.1.6.3 Emissions to soil

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 could be determined based on the following easily 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.

Other indicators which may be useful to develop could provide information about the amount of ***contaminated land*** (according to applicable legal designations) and remediated land, since it may affect soil quality, water quality, human health or other environmental or ecological receptors.

NOTE 2 Contamination may occur as a result of civil engineering work activities, may have occurred as a result of prior use or activities by an unrelated entity or may 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.

5.1.6.4 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, nitrates...) and giving each of them a relative weight. The necessary information could be drawn from water meters, *in situ* analysis, laboratory tests, parameters' limits established in the wastewater discharge authorization, calculations derived from other available water data, local or national water-related Administrations sources, or research studies data.

Depending on the typology of the civil engineering works, it might be interesting to measure the ***changes in the water regime*** due to the construction work, such as 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.

5.1.7 Noise and vibrations

The noise and vibrations caused by the civil engineering works could be represented by indicators based on calculations, simulations or measurements. Some potential data sources could be acoustic studies, environmental impact assessment, noise maps, noise legislation with local allowed noise levels or competent Administration's studies.

5.1.8 Ecosystem processes and services

The indicators developed under this aspect should 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 instance 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.

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

For instance, the biodiversity of species, genes, ecosystems or landscapes could be measured by indicators which report the number of animal and vegetal species located in the system boundaries, the types of landscape which are partially affected by the infrastructure or the change of the number and extension of the habitat areas affected by the civil engineering works.

NOTE 2 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 specie, the conservation status or the protection status of the specie or ecosystem shall be taken into account.

It could also be interesting to develop indicators for measuring some ecosystem services which are made available for the civil engineering works' area of influence, such as: the protection from avalanches, rock falls and debris falls 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 or 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.

5.1.9 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 could 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.

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

5.1.10 Global warming potential, GWP (emissions to air)

This indicator should be used to measure the potential ***impact on climate***. Global warming potential translates the quantity of gases emissions into a common measure to compare their contributions – relative to carbon dioxide – to the absorption of infrared radiation in 100 years perspective.

The indicator's value should be assessed with the help of life cycle assessment of the civil engineering works by assessing the total magnitude(s) of those GHG emissions to air that potentially affect global warming and by expressing the result in terms of CO_2 equivalent.

Measurement (calculation) in the design phase is generally accomplished by assessing the material and energy flows during the entire life cycle, whereas measurement in the construction and use stage is normally accomplished by assessing the material flows caused by the different uses and operations occurring and monitoring the energy flows.

NOTE Several gases in the earth's atmosphere, called greenhouse gases, can absorb some of the infrared radiation emitted back into space, causing an increase in the surface temperature. In addition to the natural mechanism, increasing emissions of GHGs due to human activities have led to an increase in atmospheric concentrations of the long-lived GHG gases [carbon dioxide, methane, nitrous oxide, perfluorocarbons, hydrofluorocarbons, sulfur hexafluoride and ozone-depleting substances (chlorofluorocarbons, hydrochlorofluorocarbons, halons)]. This may alter the climate over time as these gases increase in concentration.

Civil engineering works can affect global warming, especially through the use of fossil energy sources, both in own and subcontracted activities, and the embodied energy in construction products.

5.1.11 Ozone depletion potential, ODP (emissions to air)

This indicator should be used to measure the potential ***impact on the stratospheric ozone layer***. Ozone depletion potential translates the quantity of emission of gases into a common measure to compare their contributions – relative to CFC-11 (a freon) – to the breakdown of the ozone layer.

The indicator's value should be assessed with the help of life cycle assessment of the civil engineering works by assessing the total magnitude(s) of those emissions to air that potentially affect ozone depletion and by expressing the result in terms of CFC-11 equivalent.

Measurement (calculation) in the design phase is generally accomplished by assessing the material and energy flows during the entire life cycle, whereas measurement in the construction and use stage is normally accomplished by assessing the material flows caused by the different uses and operations occurring and monitoring the energy flows.

NOTE 1 Stratospheric ozone protects earth's flora and fauna against the sun's harmful ultraviolet (UV) radiation. An excess of UV radiation increases the risk of cancer or ocular diseases; it also reduces animals' and humans' resistance, and curbs the growth of plants both on land and in the sea. A depletion of the ozone layer will increase the UV-radiation at ground level.

NOTE 2 The cause of the chemical ozone depletion is the presence of chlorine and bromine originating in man-made freons and halogen compounds. For half a century, they have been used among other things in producing refrigerators, air conditioning devices and insulating materials. More recently, international agreements have been made that reduce and forbid the use of such chemical compounds destructive to the ozone.

Civil engineering works can affect ozone depletion, especially through the use of refrigerants in heating, ventilating, air conditioning and refrigeration equipment and through the use of CFCs, HCFCs or halons in fire suppression systems.

5.1.12 Eutrophication potential, EP (emissions to water)

This indicator should be used to measure the potential ***impact on the eutrophication of water bodies***. Eutrophication translates the quantity of emission of substances into a common measure expressed as the oxygen required for the degradation of dead biomass.

The indicator's value should be assessed with the help of life cycle assessment of the civil engineering works by assessing the total magnitude(s) of those emissions to water that potentially affect eutrophication and by expressing the result in terms of PO_4 equivalent.

NOTE 1 Eutrophication happens when water systems receive excess nutrients (mainly nitrogen and phosphorus) that cause excessive plant growth (such as algae). Air pollutants, waste water and fertilizer in agriculture all contribute to eutrophication. The accelerated algae growth prevents sunlight from reaching the lower depths, which leads to a decrease in photosynthesis and less oxygen production. In addition, oxygen is needed for the decomposition of dead algae. Both effects cause a decreased oxygen concentration in the water, which can eventually lead to fish dying and to anaerobic decomposition. Hydrogen sulphide and methane are thereby produced. Where eutrophication becomes predominant, overall biodiversity is likely to decline.

NOTE 2 When analysing eutrophication, it should be considered that although it is a global problem, the effects of eutrophication potential differ regionally.

Civil engineering works may affect eutrophication because of defective or missing wastewater systems and sewage treatment.

5.1.13 Acidification potential, AP (emissions to soil or water)

This indicator should be used to measure the potential ***impact on the acidification of land and water resources***. Acidification potential translates the quantity of emission of substances into a common measure to compare their contributions to the capacity to release hydrogen ions.

The indicator's value is assessed with the help of 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 SO_2 equivalent.

NOTE 1 Acidification occurs when the capacity of the soil or water bodies to resist or neutralize acidifying atmospheric deposition begins to decline. Acidification of soils and waters occurs predominantly through the transformation of air pollutants (mainly emissions of sulfur dioxide and nitrogen oxide) into acids. These acidifying compounds can fall to the ground with rain or snow as wet deposition, or in the form of particles or gases as dry deposition. Ecosystems can eventually lose their neutralising or buffering capacity completely, if acid deposition rates persistently exceed their levels of tolerance.

NOTE 2 When analysing acidification, it should be considered that although it is a global problem, the regional effects of acidification can vary.

Civil engineering works can affect acidification, especially on the basis of the energy use, when the sources of energy are fossil fuels and when there is no efficient de-sulfurization.

5.1.14 Photochemical ozone creation potential, POCP (emissions to air)

This indicator should be used to measure the potential ***impact on the formation of photochemical ozone***. Photochemical ozone creation potential translates the quantity of emission of gases into a common measure to compare their contributions – relative to ethylene – to the formation of photochemical oxidants.

The indicator's value is assessed with the help of life cycle assessment of the civil engineering works by assessing the total magnitude(s) of those emissions that potentially affect the formation of tropospheric ozone and by expressing the result in terms of ethylene equivalent.

NOTE 1 Despite playing a protective role in the stratosphere, at ground-level ozone is classified as a damaging trace gas. Photochemical ozone or ground-level ozone is formed by the reaction of volatile organic compounds and nitrogen oxides in the presence of heat and sunlight. Ground-level ozone forms readily in the atmosphere, usually during hot summer weather. Ozone is the primary ingredient of photochemical smog. Ozone is a harmful pollutant because it affects health and especially the respiratory system. Ozone levels in urban areas during pollution events can be high enough to affect human health. Ozone is also harmful because it can affect both forests and agricultural crops.

NOTE 2 It is important to remember that the actual ozone concentration is strongly influenced by the weather and by the characteristics of the local conditions.

Civil engineering works can affect the photochemical ozone formation, especially through the use of fossil energy sources, solvent-based paints and plastics.

5.1.15 External costs

The indicators developed under this aspect should report certain costs associated with an investment which can have an impact on the others in society, but are not paid by the client or public authority. These costs are regularly not considered in the LCC analysis although they can have an enormous importance.

For a translation of the externalities into external costs, a monetization can be performed. The monetarization rates are dependent on international and national guidelines. A very common application of external costs is the use of external-cost estimates in cost benefit analysis, where the costs for the establishment of measures to reduce an environmental impact are compared with the benefits, i.e. the damage avoided due to this impact reduction.

Potential sources of information used to create the indicators could 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).

5.1.16 Life cycle costs

The life cycle costs indicators should measure all the costs of the civil engineering works, including the costs of construction, operation, maintenance and disposal that have a potential impact on the value of the infrastructure. Information can be obtained from balance sheets and bills from manufacturers, suppliers, subcontractors; from own construction's management invoices, delivery notes, historical records, accounting systems and calculations and estimations from the financial department; or from economic audits and modelling techniques.

NOTE 1

— Measurement in the design is accomplished with the help of an assessment, using life cycle costing, on the basis of investment cost and the estimated costs in the rest of the life cycle of the civil engineering Works;

— Measurement in the use stage should take place with the help of assessment, using life cycle costing, on the basis of estimated cost related to the maintenance and refurbishment and verified cost of operation.

NOTE 2 ISO 15686-5 establishes guidelines for performing life cycle cost analyses of buildings and constructed assets and their parts.

NOTE 3 Life-cycle costing is a technique for estimating the cost of civil engineering works, systems and/or civil engineering works components and materials, and for monitoring the cost incurred throughout the life cycle. Life-cycle costing is used to evaluate the costs of a civil engineering works throughout its life cycle, including acquisition, development, operation, management, repair, disposal and decommissioning.

NOTE 4 Additionally to Life Cycle Costs the following cost components can be taken into account: external costs, income and non-construction costs. The sum of these components and the Life Cycle Costs is defined as "Whole-Life Costs". Depending on the effects, externalities can be negative or positive. The following costs shall be considered when calculating the "Whole-Life Costs":

— Life Cycle Costs (e.g. costs for construction, operation, maintenance, renovation...);

— Externalities (e.g. additional travel time of road users, additional environmental pollution, ...);

— Income (e.g. income from sales of constructed assets, tolls, ...);

— Non-construction costs (e.g. site costs, interests, ...).

5.1.17 Access to nature

The indicators included in this aspect relate 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 could be measured by indicators which report the extent of accessible natural green space or the ratio 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 GIS data sets 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 stud reports and site's records.

5.1.18 Population system

The indicators included in this aspect could for instance evaluate the changes in the way the land is used, due to the construction 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.

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, it could be also interesting to develop other indicators related to the changes in the territorial relation system of the civil engineering works' areas of influence. For instance, changes in the population centres distribution (disappearance of population centres due to the submergence of the houses or lands or to the loss of livelihoods, creation of new population centres or resettlement from the population in other centres).

The data could 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.

5.1.19 Job creation

The job creation as a result of a civil engineering works could be demonstrated by indicators such as the proportion of workers, suppliers or subcontractors employed directly or indirectly by the civil engineering works, the jobs created as a result of a better or worst access, etc.

The data could 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.

5.1.20 Cultural heritage elements

This aspect could include indicators that report the number of cultural heritage elements affected due to the civil engineering works, taking into consideration the level of effect from the civil engineering works on the cultural or historic element, as well as its protection category.

NOTE On this matter it would be advisable to notice that cultural heritage elements could be classified according to its social and political significance, scientific significance, historical significance, education and economic significance or aesthetic significance.

At the Convention Concerning the Protection of the World Cultural and Natural Heritage, it was defined what shall be considered as cultural heritage:

— 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.

5.1.21 Social inclusion and acceptability

This aspect could include indicators that reflect the participation of public or private persons and organizations in the decision-making process and their levels of satisfaction with the civil engineering works.

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 Stakeholders acceptance (social acceptance by key stakeholders and policy makers).

5.1.22 Risks and resilience

In order to measure the risk and resilience of a civil engineering works, indicators should describe if risks are assessed and what probability of occurrence are given on a specific location. In order to measure the resilience of a civil engineering works, indicators which describe the resistance to an unusual shock and the ability to recover quickly could be developed.

Safety and condition indexes may be useful indicators.

NOTE Safety indexes may vary depending on the civil engineering works typology. Some examples of these indexes are:

— Dam’s safety index: it 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’s safety index: it generally measures the probability of accident in certain areas, taking into account parameters, such as number of curves or number of slope changes;

— Harbour’s safety index: it usually measures the probability of the sea water to rise above the dock and to break it totally or partially, taking into account parameters, such as risk of life losses, population affected or value of the material losses.

Other possible indicators could be the number of lost days because of an occupational accident or disease or the number of employees’ accidents with sick leave.

5.1.23 Health and comfort

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

Information concerning this subject could be obtained from surveys, researches, complaints and monitoring reports.

6 Development of a system of sustainability indicators

6.1 General

This part of ISO 21929 provides guidance and rules for establishing individual as well as a set or sets of indicators, that are used either separately or together to indicate various aspects of civil engineering works that contribute to sustainability and sustainable development.

Focusing on one particular 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 part of ISO 21929 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 can be developed taking into consideration the aspects and impacts described in the previous clause. Sets of indicators can be organized in order to allow the inclusion of a broad representation of sustainability aspects while being relevant to the stakeholders' perspectives.

The use of a system of indicators helps to implement a number of the general principles described in ISO 15932. 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 interested parties'*;

— consideration of all the different individual indicators within the core set of indicators embodies the principle of a *'holistic approach'*;

— consideration of a number of 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 a number of different individual indicators within the aspects and impacts related to "social inclusion and acceptability" show concern as it relates to improved *'equity'.*

6.2 Requirements for developing a system of indicators

Developing a system of indicators consists of:

a) choosing relevant indicators;

b) developing and/or finding suitable methods and information to measure or assess the values of individual indicators.

The choice of relevant indicators will depend on the needs of interested parties, 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 in order to assign values to the selected indicators:

— Firstly, 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 and 80 dB may be translated into 1, 2, 3,…)

— Secondly, weighting may be applied, in order 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 may need to 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 part of ISO 21929 shall be motivated by, and explained with reference to, 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 view points of sustainability and sustainable development.

6.3 Usability of sustainability indicators

In order 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 (for example, against stated target values);

— diagnosis (for example to point out affecting factors);

— comparison (of alternatives, based on a defined method of assessment);

— monitoring (for example the change over time).

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

— evaluation of options for:

1) design and construction of a new civil engineering works;

2) the analysis of the performance of an existing infrastructure;

3) improving operation of an existing infrastructure;

4) designing for retrofit and refurbishment during the use and maintenance stage;

5) the deconstruction and disposal at the end-of-life stage;

— use as the basis for benchmarking, and

— 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 part of ISO 21929 does not otherwise address subjects related to weighting of indicators or aggregation of results.

6.4 Users of indicators

6.4.1 General

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.

NOTE The following text gives examples of user needs for sustainability indicators. However, the role of interested parties varies from one country to another, which may affect how these different parties use the different indicators.

6.4.2 Public bodies and policy makers

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

6.4.3 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 may also apply indicators in marketing plans to show the contribution of the civil engineering to sustainability and sustainable development.

6.4.4 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.

6.4.5 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 is able to recognize the design features that may have an effect on 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.

6.4.6 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.

6.4.7 Contractors

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

6.4.8 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.

6.4.9 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.

6.4.10 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 may have over the population density, or amount working opportunities in the area.

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