Life Cycle Assessment

A product-oriented method for sustainability analysis

UNEP LCA Training Kit

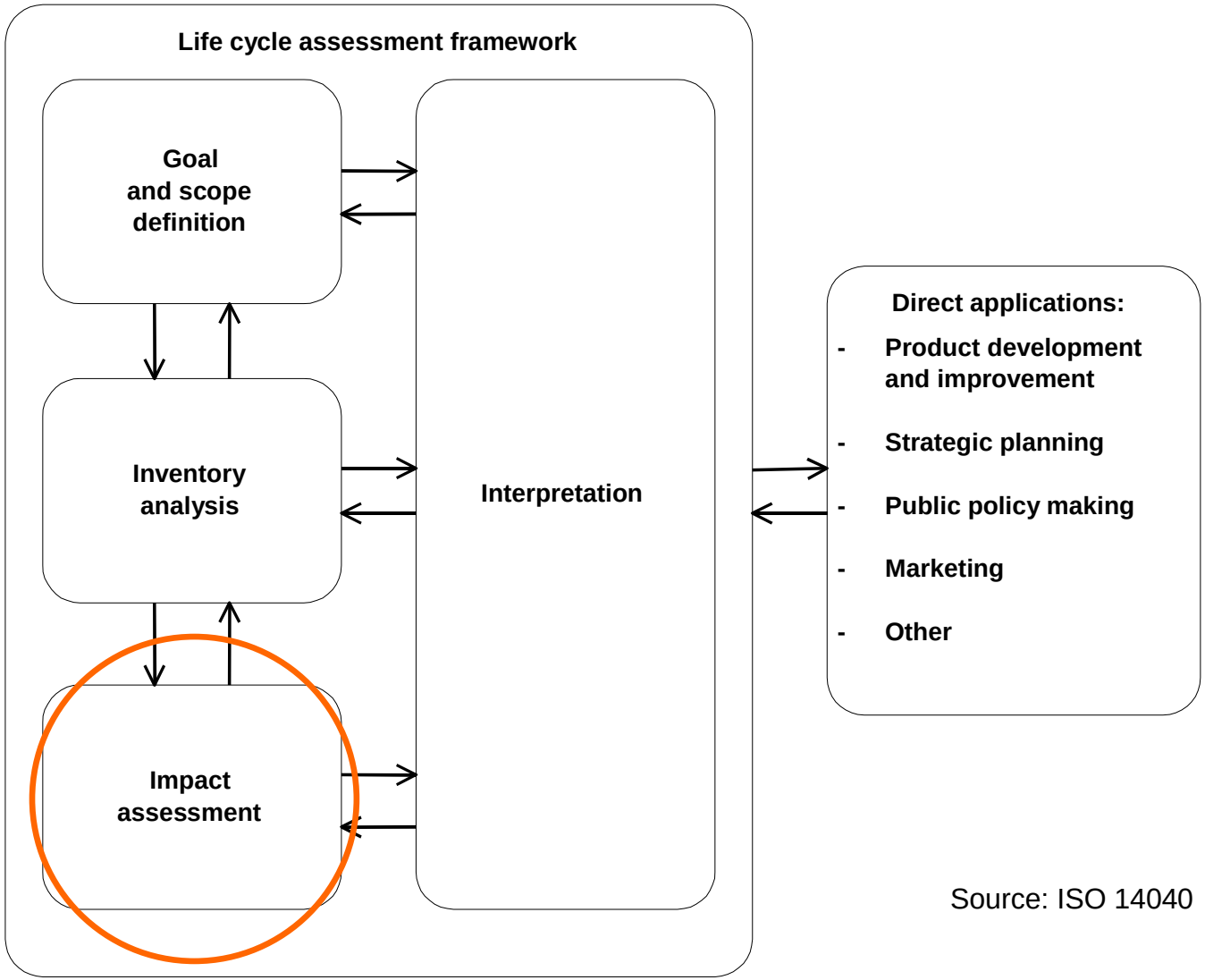
Module e – ***Impact assessment***

SETAC

UNEP

Life Cycle Initiative

ISO 14040 framework



Source: ISO 14040

Life cycle impact assessment

- **ISO: This LCA phase is aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts of a product system.**
  - International Standard ISO 14044
  - Technical Report ISO/TR 14047
- **This is the third phase of an LCA**
  - LCIA

Contents

Modules B, C and D provide necessary background information for this module.

- **The principle of characterisation**
- **Selection of impact categories, category indicators and characterisation models**
- **Classification**
- **Characterisation**
- **Optional elements**
  - **normalisation**
  - **grouping**
  - **weighting**

The principle of characterisation

impact category

- CO_2 and CH_4 both contribute to climate change.
- Global Warming Potential (GWP) is a measure for climate change in terms of radiative forcing of a mass-unit of greenhouse gas.
- Example calculation:
  - **5** kg CO_2
  - **3** kg CH_4
  - 1 x **5** + 21 x **3** = 65
  - 68 kg CO_2-eq

characterisation factor

GWP = 1

GWP = 21

category indicator

category indicator result

The principle of characterisation

Simple conversion and aggregation:

$$\text{IndicatorResult}_{cat} = \sum_{subs} \text{CharFact}_{cat,subs} \times \text{InventoryResult}_{subs}$$

68 kg CO_2-eq

CO_2 and CH_4

GWP (1 and 21)

IPCC climate model

climate change

5 and 3 kg

infrared radiative forcing

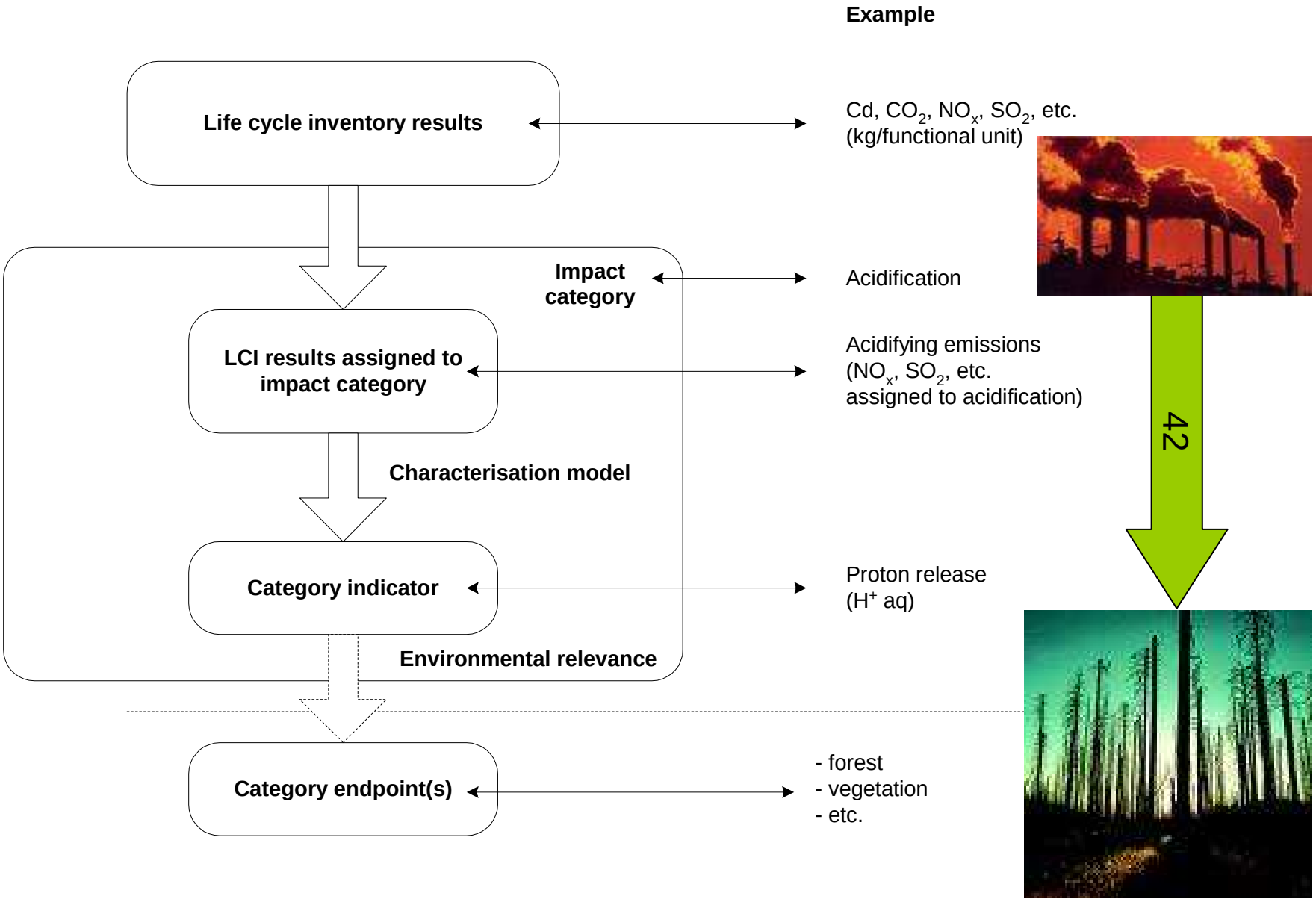
The principle of characterisation

- **Two main groups of choice for indicator**
  - **Midpoint-oriented** place indicators relatively close to the interventions.
  - These have the advantage of relying primarily on scientific information and well-proven facts
  - The amount of subjectivity and uncertainty involved is limited.
  - **Endpoint-oriented** place indicators relatively close to the endpoints.
  - These have the advantage of presenting information in an appealing and understandable way: human health is easier to interpret and communicate than ozone layer depletion.

The principle of characterisation

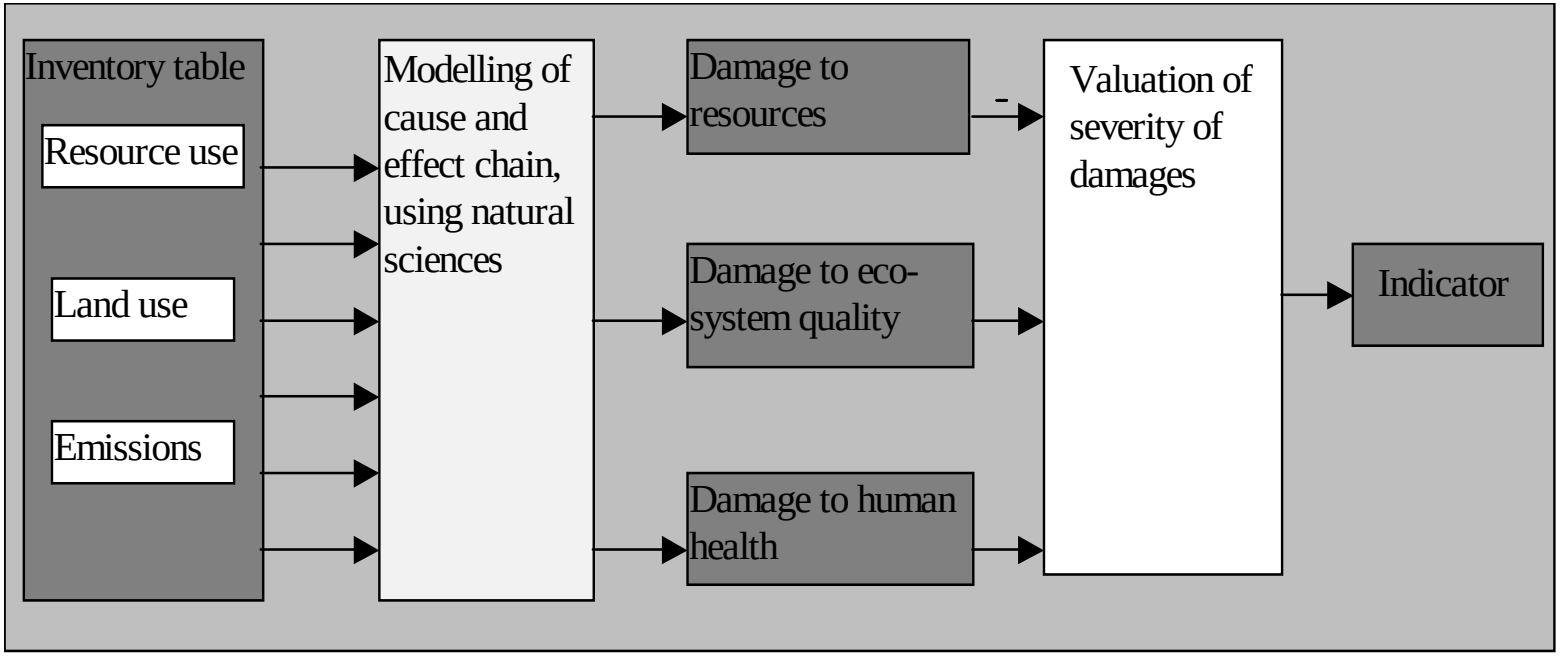
- **Midpoint characterisation**
  examples: CML-IA, EDIP, TRACI, …
- **Endpoint characterisation**
  examples: Eco-indicator 99, Eco-scarcity, EPS, …
- **Efforts to combine/harmonize midpoint and endpoint**
  examples: Impact 2002+, Recipe, ...

The principle of characterisation



The principle of characterisation

- **Structure of endpoint-oriented model** (Eco-indicator 99)



Impact categories, category indicators, characterisation models

- **Impact category**
  - ISO 14040 definition: class representing environmental issues of concern to which LCI results may be assigned
- **Examples:**
  - climate change
  - acidification

Impact categories, category indicators, characterisation models

- **Category indicator:**
  - ISO 14040 definition: quantifiable representation of an impact category
- **Examples:**
  - infrared radiative forcing
  - proton release

Impact categories, category indicators, characterisation models

- **Characterisation model:**
  - non-ISO definition: mathematical model of the impact of elementary flows with respect to a particular category indicator
- **Examples:**
  - IPCC model for climate change
  - RAINS model for acidifying substances
- **Provides the basis for a characterisation factor**

Impact categories, category indicators, characterisation models

- **Characterisation factor:**
  - ISO 14040 definition: a factor derived from a characterisation model which is applied to convert the assigned LCI results to the common unit of the category indicator.
- **Examples:**
  - Global warming potential (GWP)
  - Acidification potential (AP)

Impact categories, category indicators, characterisation models

Example Impact categories, characterisation models, factors & units

Impact category	Indicator	Characterisation model	Characterisation factor	Equivalency unit
Abiotic depletion	Ultimate reserve/ annual use	Guinee & Heijungs 95	Abiotic depletion potential	kg Sb eq.
Climate change	Infrared radiative forcing	Intergovernmental Panel on Climate Change	Global warming potential	kg CO_2 eq.
Stratospheric ozone depletion	Stratospheric ozone breakdown	World Meteorological Organization model	Stratospheric ozone layer depletion potential	kg CFC-11eq.
Human toxicity	Predicted daily intake, Accepted daily intake	EUSES, California Toxicology Model	Human toxicity potential	kg 1,4-DCB eq.
Ecological toxicity	PEC, PNEC	EUSES, California Toxicology Model	AETP, TETP, etc.	kg 1,4-DCB eq.
Photo-oxidant smog formation	Tropospheric ozone production	UN-ECE trajectory model	Photo-oxidant chemical potential	kg C_2H_6 eq.
Acidification	Deposition/ critical load	Regional Acidification Information & Simulation	Acidification potential	kg SO_2 eq.
. . .	. . .	. . .	. . .	. . .

Impact categories, category indicators, characterisation models

- **LCA has essentially a flow character:**
  - emissions/ resource extractions in kg per functional unit
- **Impacts have therefore a similar character:**
  - climate change/toxicity/depletion/etc. per functional unit
- **Some impacts do not fit well:**
  - loss of biodiversity/introduction of GMOs/etc.

Classification

- **ISO 14040 definition: Classification is the assignment of LCI results to impact categories**
- **Example:** CO_2 and CH_4 are assigned to climate change

Classification

Impact category	Incandescent lamp	Fluorescent lamp
Climate change		
CO_2 to air	800000 kg	50000 kg
CH_4 to air	230 kg	24 kg
Ecotoxicity		
Copper to water	3 g	20 g

Characterisation

- **ISO 14040 definition: Characterisation is the calculation of category indicator results**
- **Example:** 5 kg CO_2 and 3 kg CH_4 yield 68 kg CO_2-eq

Characterisation

- **Formula:**

$$\text{IndicatorResult}_{cat} = \sum_{subs} \text{CharFact}_{cat,subs} \times \text{InventoryResult}_{subs}$$

- **Unit of characterisation result:**
  - kg CO_2-eq (climate change)
  - kg SO_2-eq (acidification)
  - …

Characterisation

- **Example of a characterisation table**

Impact category	Incandescent lamp	Fluorescent lamp
Climate change	120000 kg CO2-eq.	40000 kg CO2-eq.
Ecotoxicity	320 kg DCB-eq.	440 kg DCB-eq.
Acidification	45 kg SO2-eq.	21 kg SO2-eq.
Depletion of resources	0.8 kg antimony-eq.	0.3 kg antimony-eq.
etc	…	…

Normalisation

- **ISO 14040 definition: calculation of the magnitude of category indicator results to reference information**
- **Reference information** (over a given period of time):
  - area (e.g., France, Europe, the world)
  - person (e.g., a Danish citizen)
  - product (e.g., the most frequently used product)

Normalisation

- **Aim: to better understand the relative magnitude for each indicator results of the product system under study.**
  - checking for inconsistencies
  - providing and communicating information on the relative significance of the indicator results
  - preparing for additional procedures

Normalisation

- **Formula:**

$$\mathrm{NormalizedIndicatorResult}_{cat} = \frac{\mathrm{IndicatorResult}_{cat}}{\mathrm{ReferenceValue}_{cat}}$$

- **Unit of normalisation result: year**

Normalisation

- **Example of a normalisation table**

Impact category	Incandescent lamp	Fluorescent lamp
Climate change	1.2×10^{-11} yr	4×10^{-12} yr
Ecotoxicity	1.6×10^{-10} yr	2.2×10^{-10} yr
Acidification	9×10^{-11} yr	4.2×10^{-11} yr
Depletion of resources	24×10^{-12} yr	9×10^{-13} yr
etc	…	…

Grouping

- **ISO 14040 definition: assigning impact categories into one or more sets**
- **Sorting: grouping on a nominal basis**
  - e.g., global versus regional
- **Ranking: grouping on an ordinal basis**
  - e.g., high, medium and low priority
  - based on value choices

Grouping

- **Example of the results of grouping**

Impact category	Incandescent lamp	Fluorescent lamp
Global		
Climate change	1.2×10^{-11} yr	4×10^{-12} yr
Depletion of resources	24×10^{-12} yr	9×10^{-13} yr
Regional		
Acidification	9×10^{-11} yr	4.2×10^{-11} yr

Weighting

- **ISO 14040 definition: converting and possibly aggregating indictor results across impact categories using numerical factors**
  - based on value-choices
  - ISO: “weighting shall not be used for comparative assertions disclosed to the public”

Weighting

- **Basis for weighting factors:**
  - monetary values
    - willingness-to-pay
    - damage costs
    - reduction costs
  - **distance-to-target methods**
  - **panel methods**
    - expert panels
    - non-expert panels
  - ...

Weighting

- **Some methods that include weighting**
  - ecopoints/ ecoscarcity
  - Eco-indicator 99
  - EPS

Weighting

- **Formula:**

$$\mathrm{WeightedIndex} = \sum_{cat} \mathrm{WeightingFact}_{cat} \times \mathrm{IndicatorResult}_{cat}$$

- or

$$\mathrm{WeightedIndex} = \sum_{cat} \mathrm{WeightingFact}_{cat} \times \mathrm{NormalizedIndicatorResult}_{cat}$$

- **Unit of weighted index:**
  - year (when based on normalized results)
  - euro, dollar, etc. (when based on monetary valuation)
  - but often renamed: ecopoints, millipoints, ELU, etc.

Weighting

- **Example of the results of weighting**

Weighed index	Incandescent lamp	Fluorescent lamp
Weighted index	8.5×10^{-10} yr	1.4×10^{-10} yr

Do you need to review any of the contents of this module?

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  - **weighting**

This is an overview of all of the remaining modules in the toolkit.

Module	contents
f	**LCA interpretation**
g	Allocation in LCA
h	LCA mathematics
i	LCIA mathematics
j	Life cycle costing
k	Uncertainty in LCA
l	Carbon footprint