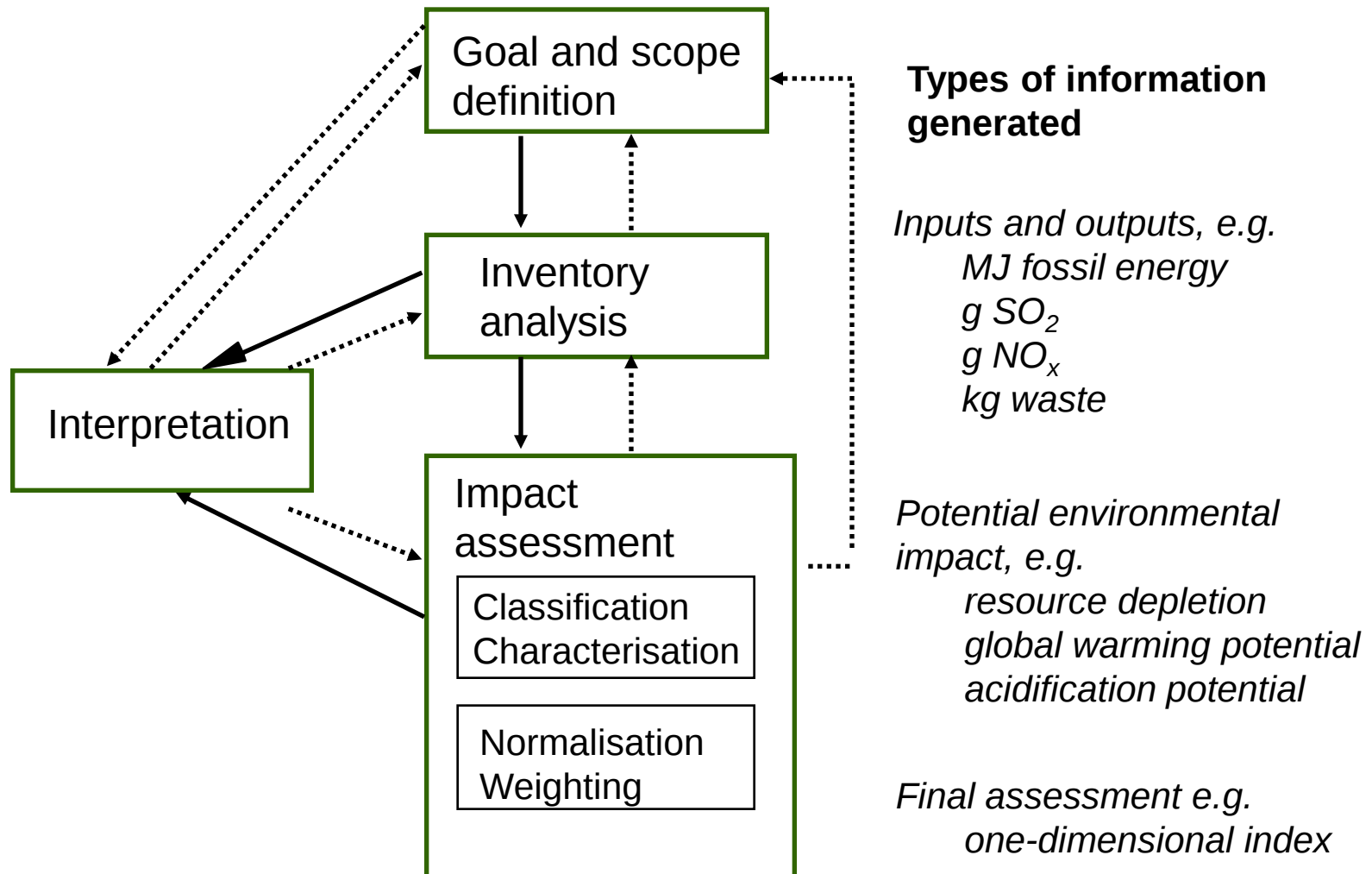


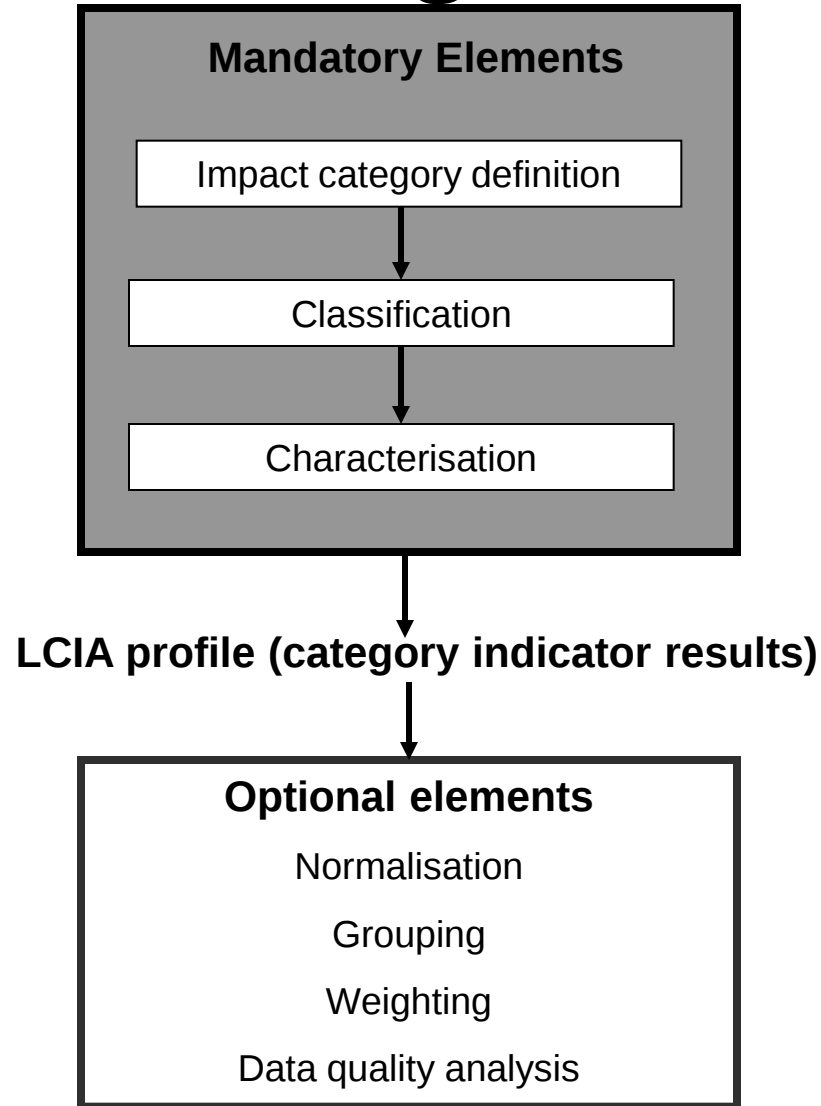
LCA procedure



Life Cycle Impact Assessment

- The purpose of the Life Cycle Impact Assessment (LCIA) is to provide additional information to help assess the results from the Inventory Analysis so as to better understand their environmental significance (ISO 14040).
- The LCIA should translate the inventory results into their potential impacts.

LCIA according to ISO 14042



Impact category definition Criteria

Completeness

Practicality

Possibility to integrate with LCA calculations

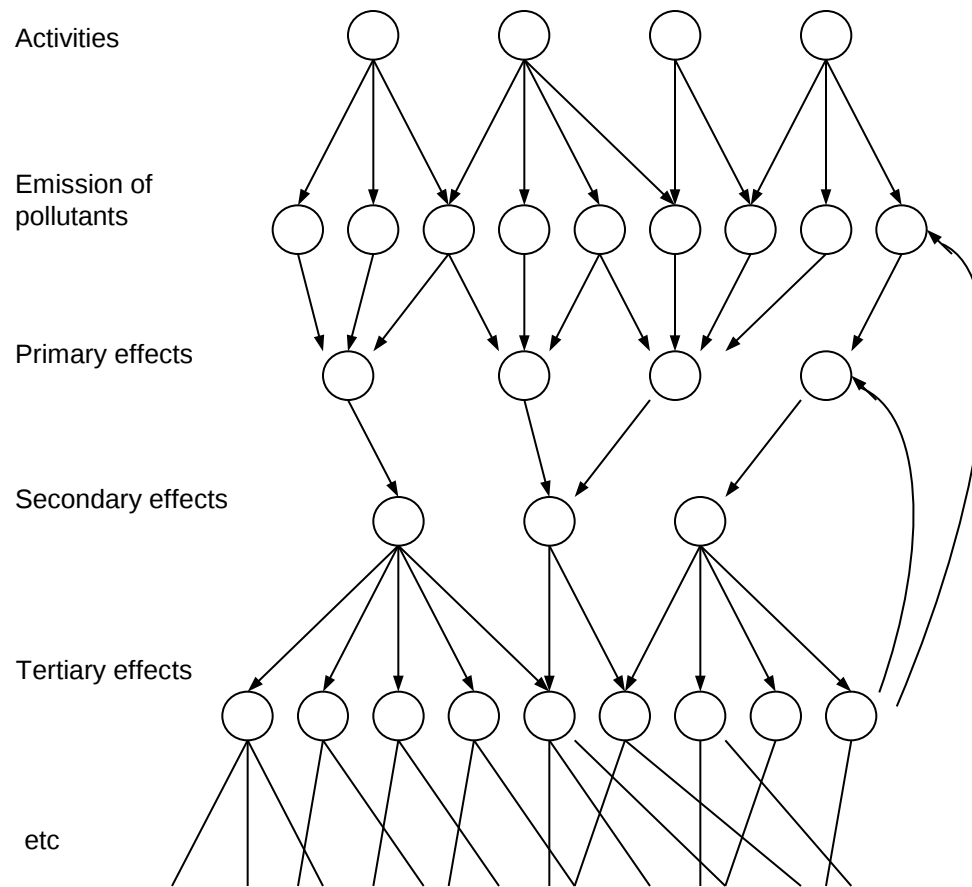
Environmental relevance

Scientific method

What's an impact? (1)

- The DPSIR-framework for indicators
 - D: Driving force (in society)
 - P: Pressure (from society to environment)
 - S: State (in the environment)
 - I: Impact (in the environment)
 - R: Response (in society)
- In LCA results from the inventory analysis is often P-type, results from Life Cycle Impact Assessment is often I-type.

What is an impact? (2)



Definition of the impact

- Early in the cause-effect chain (mid-points)
 - Often chemical or physical changes
 - Often easier
 - Results in mid-point methods
- Late in the cause-effect chain (end-points)
 - Often biological changes
 - Often more relevant
 - Results in end-point or damage methods
- The choice is influenced by views on our possibilities to predict environmental impacts and on views on what basis decisions should be made.

Selection of impact categories

General impact categories ("areas for protection", "end-points")

- resource use
- human health
- ecological consequences

Discuss

- Which impact categories are most important for your case studies?
- Which interventions (emissions, resource uses) are most important?

Impact categories (EU guidelines)

The following impact categories at midpoint level ... shall be checked per default for relevance for the study:

Climate change,

(Stratospheric) Ozone depletion,

Human toxicity,

Respiratory inorganics,

Ionizing radiation,

(Ground-level) Photochemical ozone formation,

Acidification (land and water),

Eutrophication (land and water),

Ecotoxicity,

Land use,

Resource depletion (minerals, fossil and renewable energy resources, water).

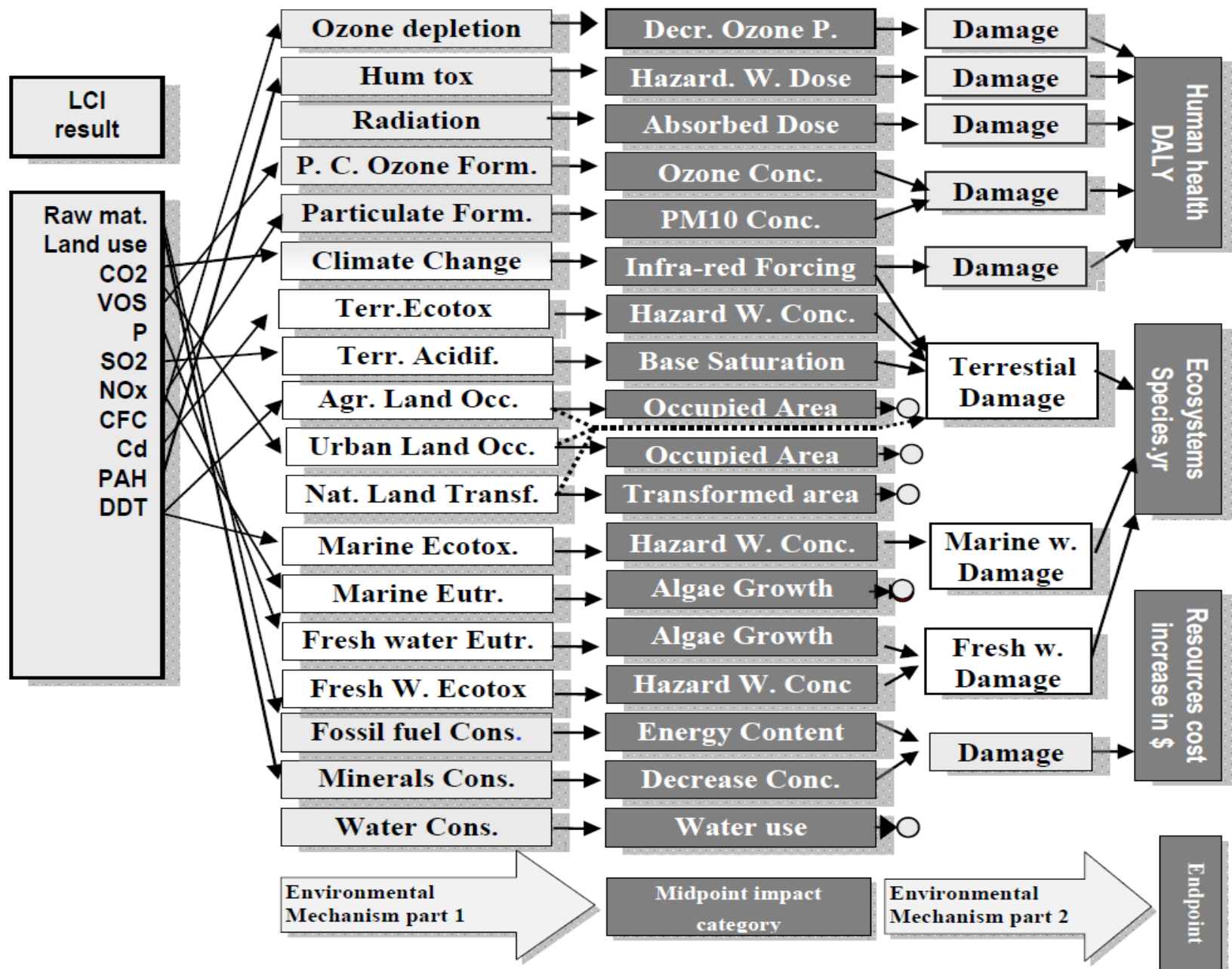
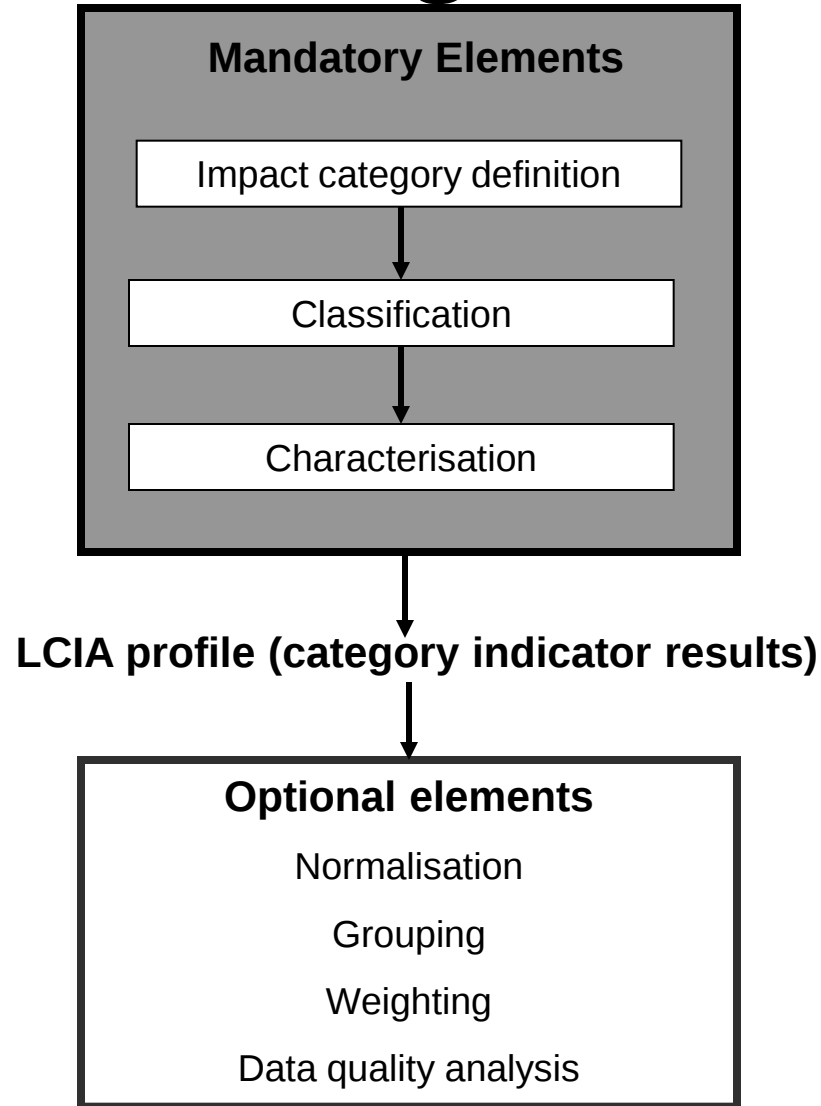


Figure 1.2: Relationship between LCI parameters (left), midpoint indicator (middle) and endpoint indicator (right) in ReCiPe 2008.

LCIA according to ISO 14042



Characterization

- Definition of the effect
- A model for quantification
 - Characterisation factors
For emissions: CF_{ij} [contribution to category i from substance j /emitted amount]
 - Potential contribution to category $i = CF_{ij} * m_j$
 - Total contribution is the sum
 - m_j = emitted amount of substance j

Example, contribution to global warming

- Prod A: 12 kg CO₂ and 0.5 kg CH₄
- Prod B: 2 kg CO₂ and 1.5 kg CH₄
- What is the contribution to global warming from prod A and B?
- The Global Warming Potential (100 years) of CO₂ is 1 and of CH₄ is 21.
- The Global Warming Potential (500 years) of CO₂ is 1 and of CH₄ is 6.5.

Example, contribution to global warming

- Prod A: 12 kg CO₂ and 0.5 kg CH₄
- Prod B: 2 kg CO₂ and 1.5 kg CH₄
- What is the contribution to global warming from prod A and B?
- 100 years perspective:
A: $12 \cdot 1 + 0.5 \cdot 21 = 22.5$ kg CO₂-eqv.
B: $2 \cdot 1 + 1.5 \cdot 21 = 33.5$ kg CO₂-eqv
- 500 years perspective:
A: $12 \cdot 1 + 0.5 \cdot 6.5 = 15.25$ kg CO₂-eq
B: $2 \cdot 1 + 1.5 \cdot 6.5 = 11.75$ kg CO₂-eq

Site-dependency?

- Site-specific assessment: "perfect knowledge about the site"
- Site-generic assessment: globally averaged
- Site-dependent: some information about the site is used, e.g. the region or stack-height

Site-dependency (2)

- A-site-specific approach is typically not possible in LCA
- A site-generic approach may hide variations and uncertainties
- A site-dependent approach using data for different regions or systems is possible and appropriate in many cases

Time aspects

- Compare discussion on site-dependency and time aspects for landfills
- When does emissions occur?
- For how long should impacts be considered?
 - Infinite
 - 100 years

Examples of LCIA methods

- CML 2002, midpoint, Netherlands, characterization
- EDIP, midpoint, Denmark, characterization (weighting)
- TRACI, midpoint, USA, characterization
- IMPACT 2002, midpoint-endpoint, Switzerland, characterization
- LIME, midpoint-endpoint, Japan, characterization and weighting
- Ecoindicator, endpoint, Netherlands, (characterization) weighting
- Recipe, midpoint-endpoint, Netherlands, characterization (weighting)
- EPS, endpoint, Sweden, (characterization) weighting
- Ecotax, midpoint, Sweden, weighting
- Ecovalue, midpoint, Sweden, weighting

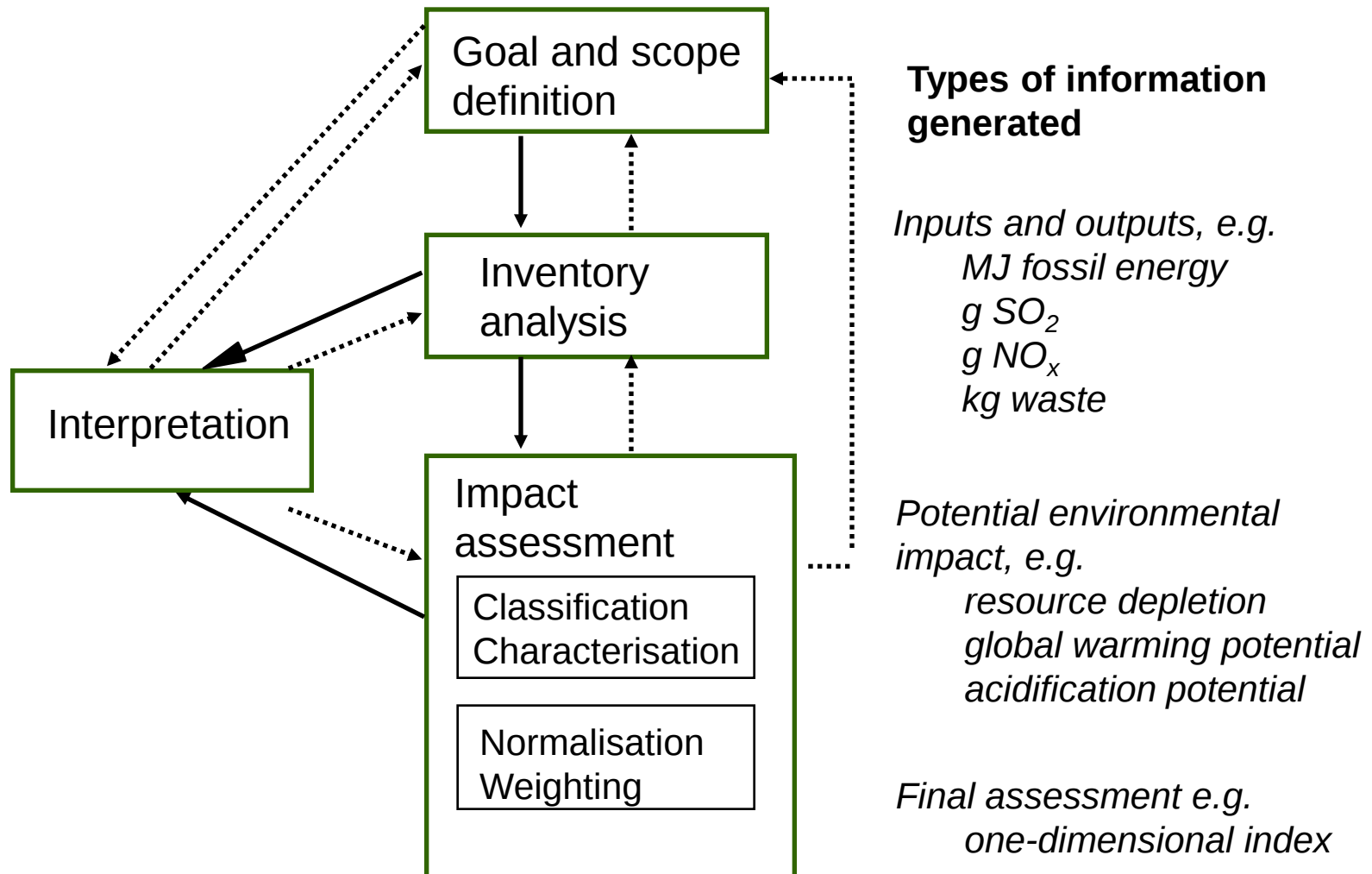
Some aspects when choosing characterisation method

- The relevance of the definition of the effect
- Mid-point or end-point
- The scientific basis
- Scientifically reviewed?
- Transparency?
- Practical?
- Possibilities for further interpretation
- Valid for a relevant time perspective?
- Valid for a relevant region?

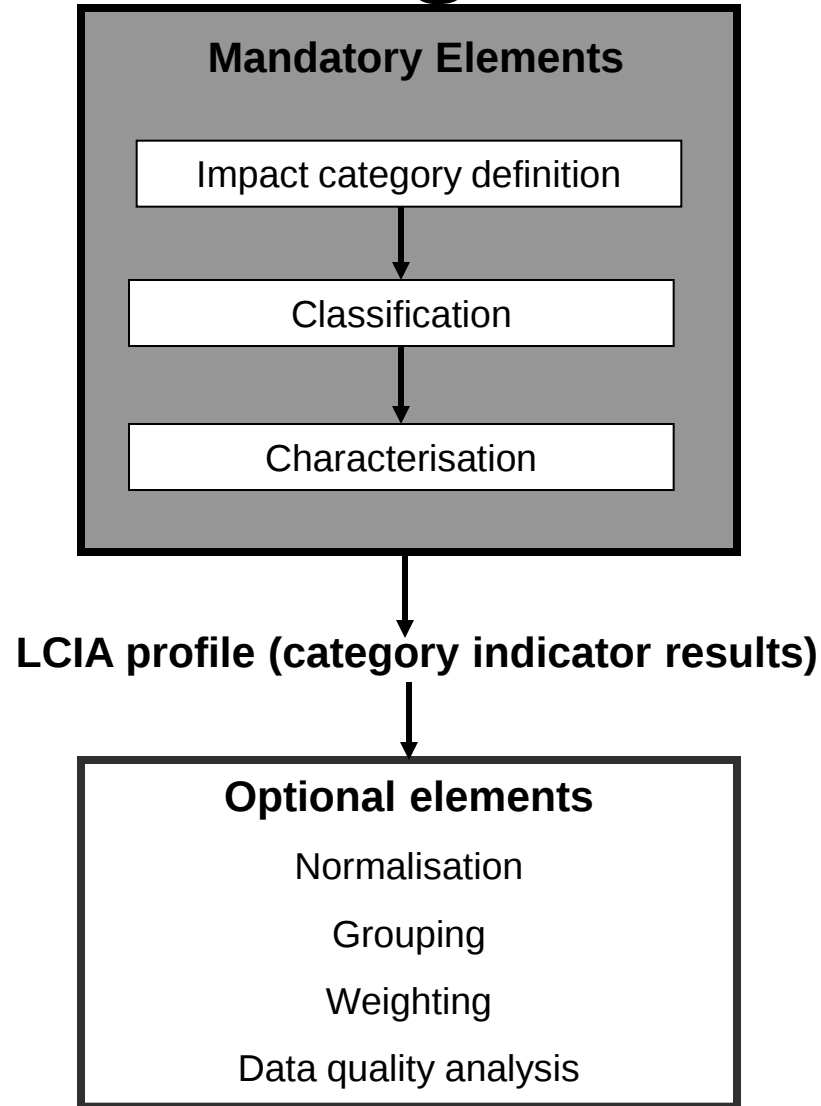
Current recommendations for characterization

- (Use recommendations from European Commission)
- ReCiPe
 - Available in Simapro
- Use several methods to assess robustness of results.

LCA procedure



LCIA according to ISO 14042



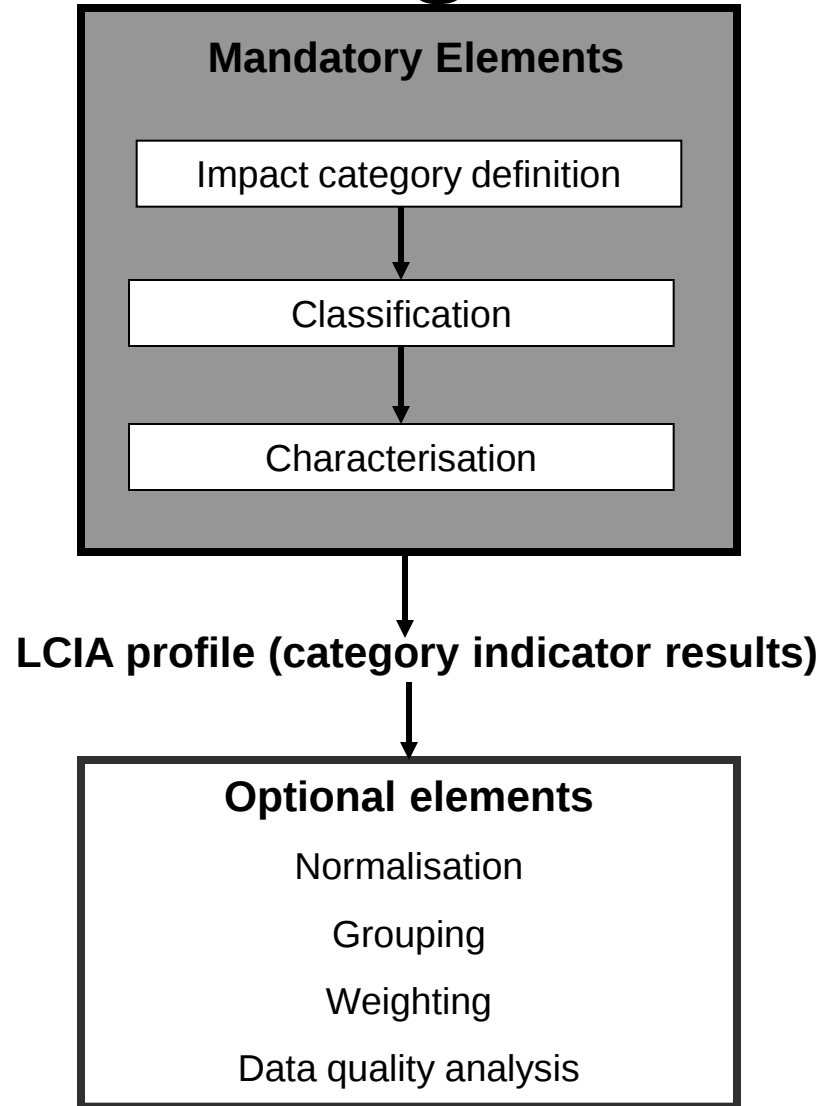
Normalisation

- $N_i = I_i / R_i$
- N is the normalised result
- I is the result from the characterisation
- R is a reference value

...normalisation...

- Normalisation places results in a broader context and gives the results common dimensions
- Choice of reference value is important
- Often total contribution to impact category in a country is used as reference values

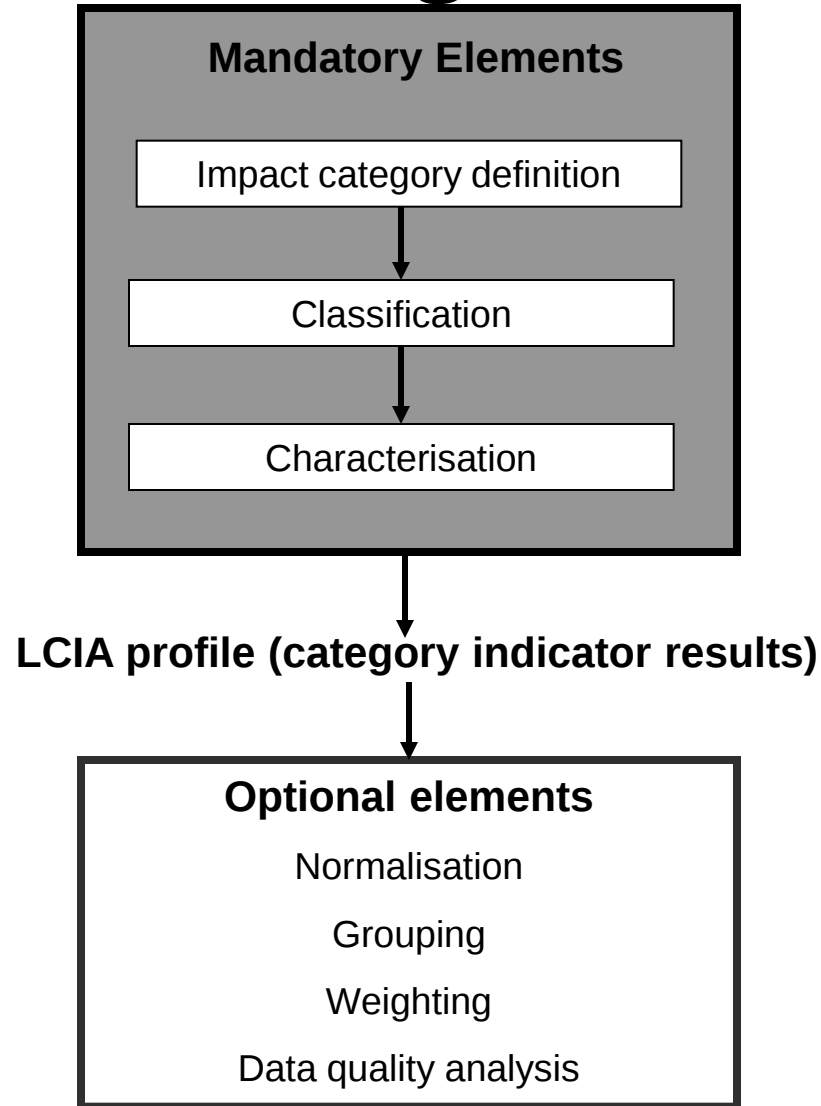
LCIA according to ISO 14042



Grouping

- Introduced in the ISO process
- Can include ranking
- Can be seen as a qualitative valuation

LCIA according to ISO 14042



Weighting

- Weighting is the process to convert indicator results by using numerical factors based on value choices, it may include aggregation across impact categories.

(Based on the ISO standard for LCA)

Case-specific or ready-made

- In case-specific methods, the weighting factors are developed within the specific case, involving the specific stakeholders
- Ready-made methods are developed and can be used in many cases

Different classifications of valuation methods

- Panel methods (Based on multi-criteria decision analysis)
Monetisation methods (Based on environmental economics)
(Distance-to-target methods)
- Stated preferences
Revealed preferences
- End-points – assessments of damages
Mid-points – assessments of threats

Total environmental impact is calculated as

- Weighting factors, W_i
E.g for emissions [kg^{-1}]
- Environmental impact is $W_i I_i$
where I_i is the impact score from the characterization or normalisation
- Total environmental impact = $\sum W_i I_i$

Panel methods

- Methodology: questionnaires, interviews, group discussions
- Panel members: Experts, stakeholders, citizens
- Procedure: once or several times with feedback (Delphi)
- Results: Consensus, statistics

Critical discussion on panel methods

- Some published studies show strange results
- Limited difference between different impact categories
- Cognitive stress
- Large possibilities for beginner's errors
- Normally requires normalization

What is weighted in panel methods?

- Very important to define what is weighted
- The normalisation reference, e.g. the total emissions in a country during one year
- (or something else that can be scaled with the normalisation reference)

Monetisation methods

- Many methods available for monetisation
- There are different types of economic values
- Different methods capture different values
- One should not mix different types of economic values

Distance to target methods

- In distance-to-target methods are different targets normally not weighted against each other. Therefore they are not weighting methods (if targets are not explicitly stated so that the targets are equally important).
- Distance to target methods can be seen as normalisation methods

Some aspects of different approaches

- A problem with methods based on "stated preferences" is that values are constructed during the valuation process. The results are therefore sensitive to the process.
- A problem with methods based on "revealed preferences" is the difficulties to transfer values from one area to another.

Examples of LCIA weighting methods

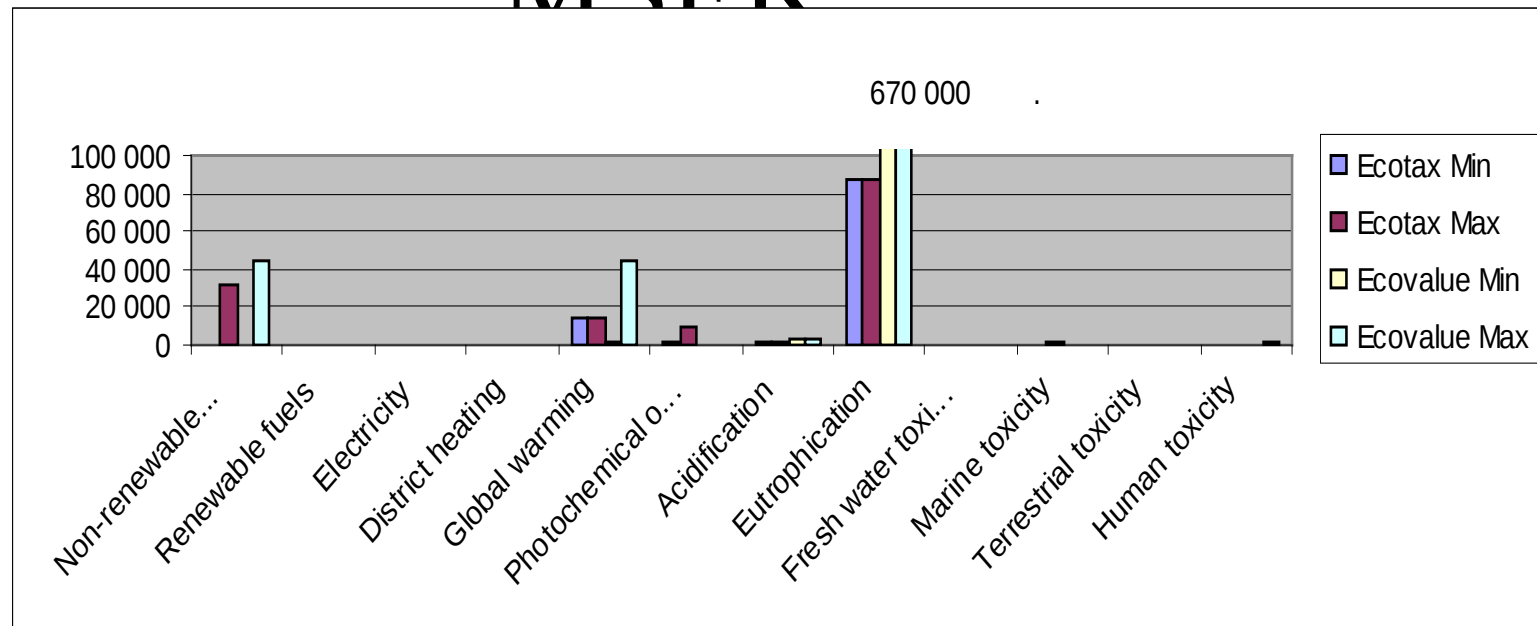
- Recipe, endpoint, Netherlands, (characterization), weighting
- Ecoindicator, endpoint, Netherlands, (characterization) weighting
- EPS, endpoint, Sweden, (characterization) weighting
- Ecotax, midpoint, Sweden, weighting
- Ecovalue, midpoint, Sweden, weighting

Basis for weighting

- Recipe and Ecoindicator: Not clearly described, panel approach.
- EPS: Damage modelling and willingness to pay to avoid damages
- Ecotax: Swedish environmental taxes and fees
- Ecovalue: Damage costs

Environmental and health impacts from agriculture in Sweden.

MSEK

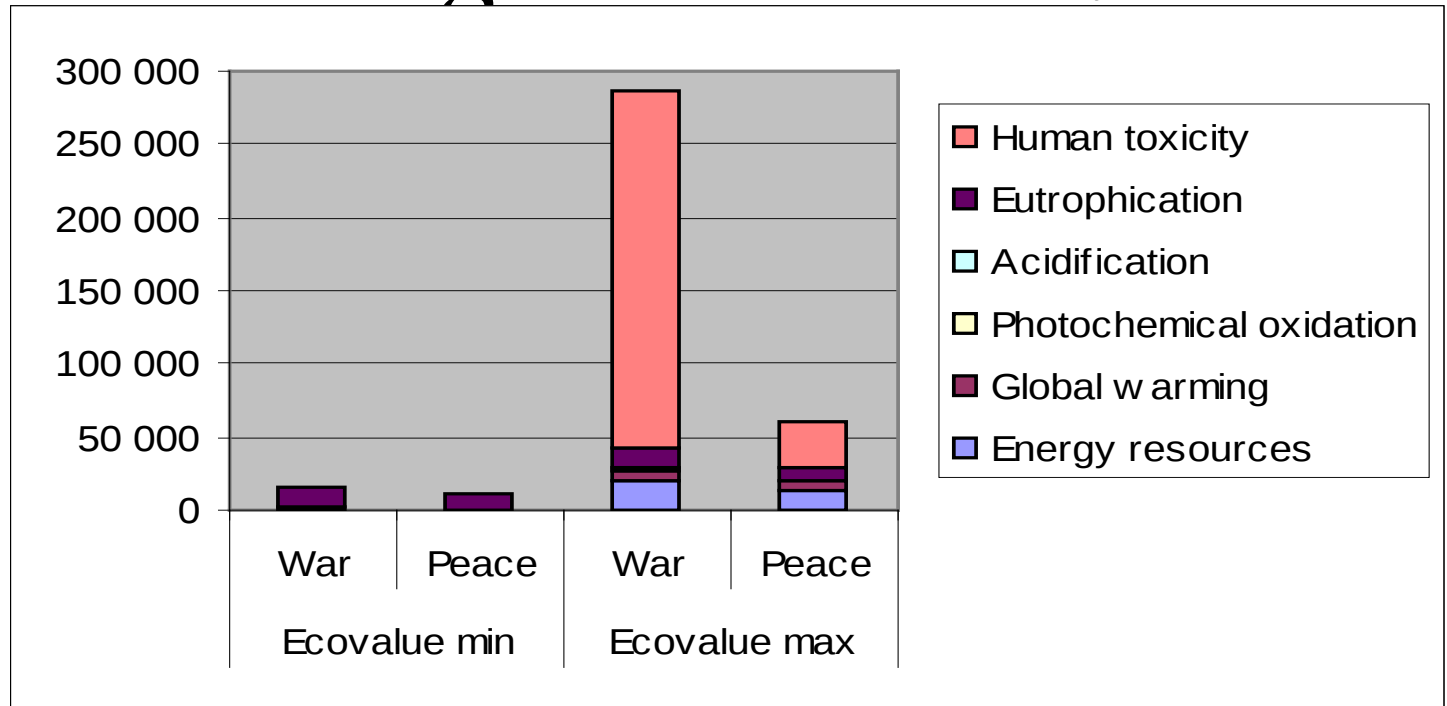


Most important impacts:

EPS: Abiotic resources and Global warming

Ecoindicator: Respiratory diseases

Impacts from a grenade according to Ecovalue. SEK



Most important impacts:

Ecotax: Ecotox

EPS: Abiotic resources

Ecoindicator: Ecotox

Conclusions

- Different weighting methods give different results. This is reasonable if this reflect different values. However, differences can also be explained by datagaps and different methodological choices.
- Thus it is important to critically evaluate and discuss different weighting methods.
- It is important to use several weighting methods

Work in pairs

- What are advantages and disadvantages of using weighting methods?
- When is it needed?
- When is it necessary?
- Will you use weighting methods?
- If so, for what?

Values in the valuation/weighting

- Should a weighting be performed at all or should some aspects be given absolute priority?
- If a weighting is to be made, which approach should be used?
- If a certain approach is used, which are the weighting factors?

Examples of values in the weighting/valuation

- View of society
 - View of market economy
 - View of representative democracy
 - View of experts
- Ethical standpoints
 - Are all living persons equally valuable?
 - Are coming people of value and if so how much?
 - Do animals, plants and/or ecosystems have an intrinsic value and if so, how much?
 - Do equity and justice have a value?
- View of nature
 - To what extent can we foresee environmental impacts

Conclusions on weighting

- An optional step
- Useful to identify "hotspots"
- Useful for comparisons
- Not allowed according to ISO for comparative assertions
- Different methods give different results
- If you use weighting methods, use several, lookout for datagaps, be careful with your conclusions.