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Selecting Best Practice Characterisation Methods for Impact Assessment

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Aims and principles

- **Basis of recommended**
  - LCIA framework
  - Characterisation models
  - Characterisation factors (Technical guidance document)
- **Both midpoint and endpoint**
- **Characterisation, not normalisation or weighting**
- **Global validity preferred (life cycle is global) *but……***
- **Recommendations among existing methods and factors – only very limited new developments**
- **Best attainable consensus among existing practices**
- **Extensive hearings of domain experts and stakeholders**

Identification of candidates

Selected among existing methodologies

- CML2002
- Eco-indicator 99
- EDIP 2003/EDIP97
- EPS 2000
- IMPACT 2002+
- LIME
- LUCAS
- MEEuP
- ReCiPe
- Swiss Ecoscarcity 07
- TRACI

… and other approaches for

- Respiratory inorganics
- Human and ecotoxicity
- Ionizing radiation
- Photochemical Ozone
- Acidification
- Land use
- Resource depletion
- Noise
- Climate change

1. Originality of approach
2. Only most recent version or update considered
3. Midpoint and endpoint methods

…. Among 157 characterisation methods, 92 were pre-selected

Table 1 Pre-selection of characterisation models for further analysis [3]

	Climate change	Ozone depletion	Respiratory inorganics	Human toxicity4	Ionizing radiation	Ecotoxicity	Ozone formation	Acidification	Terrest. Eutrophication	Aquatic Eutrophication.	Land use	Resource Consumption	Others
CML2002	O	o		M	o5	o	M	M	M	M	o	M	
Eco-indicator 99	E	E	E	o	o		E	E	E		E	E	
EDIP 2003/EDIP97[6]	O	M	o	M	o	M	M	M	M	M		M	Work environment Road noise
EPS 2000	E	E	E	E	o	E	E	o	o	o	E	E	
Impact 2002+	O	o	E	M E	o	M E	E	M E		M E	o	E	
LIME	E	E	M	E		o	M E	M E	o	E	E	E	Indoor air
LUCAS	O	o		o		o	o	o	o	o	o	o	
MEEuP	O	o	M	M		M	M	M	M	M		water	
ReCiPe	M E	E	M E	M E	o	M E	M E	M E	o	M E	M E	E	
Swiss Ecoscarcity 07	O	o	o	o	M E	M	o	o	o	o	M E	water	Endocrine disruptors
TRACI	O	o	M	M		M	M	M	o	M		o	
Specific methods to be evaluated	Ecological footprint		7	USETox		USETox		Seppälä		Payet	Ecological footprint	deWolf et al.	Noise: Müller Work
Specific methods of potential interest (not to be evaluated)				Walton (Bachmann)	Ecotoxicity of radiation (Lapidus et al.)		EcoSense (Krewitt et al.)	EcoSense (Krewitt et al.)		Kimman & Jonezon	8		Major indoor air UNEP Indoor air (Bruzzi et al., 2007)

α Available in the methodology, but not further investigated
M Midpoint model available and further analysed;
E Endpoint model available and further analysed

E= endpoint analysed

M= midpoint analysed

O= not analysed

	Climate change	Ozone depletion	Respiratory inorganics	Human toxicity	Ionising radiation	Ecotoxicity	Ozone formation	Acidification	Terrest. Eutrophication	Aquatic Eutrophication	Land use	Resource Consumption	Others
CML2002	O	o		M	o5	o	M	M	M	M	o	M	
Eco-indicator 99	E	E	E	o	o		E	E	E		E	E	
EDIP 2003/EDIP97[6]	O	M	o	M	o	M	M	M	M	M		M	Work environment Road noise
EPS 2000	E	E	E	E	o	E	E	o	o	o	E	E	
Impact 2002+	O	o	E	M E	o	M E	E	M E		M E	o	E	
LIME	E	E	M	E		o	M E	M E	o	E	E	E	Indoor air
LUCAS	O	o		o		o	o	o	o	o	o	o	
MEEuP	O	o	M	M		M	M	M	M	M		water	
ReCiPe	M E	E	M E	M E	o	M E	M E	M E	o	M E	M E	E	
Swiss Ecoscarcity 07	O	o	o	o	M E	M	o	o	o	o	M E	water	Endocrine disruptors
TRACI	O	o	M	M		M	M	M	o	M		o	

- Area of protection:
  - Damage to functional and intrinsic values
  - What is de damage measured
  - What can be the damage indicators

Table 3-1 Damage categories and possible damage indicators (modified from Margni *et al.*, 2008)

Subject considered	Damages related to intrinsic values	Damages related to functional values	Damage measured	Damage indicators
Human life	Human health (intrinsic)		Both mortality and morbidity over time and space	Number and age of death; number, type and duration of diseases, YLL, YLD, DALY
		Human health (labour and productivity)	Loss in productivity	Usually not considered, related to indicators for intrinsic damages on Human Health
Biotic environment	Biotic natural environment and ecosystem stability (biodiversity)		Loss or disappearance of species over time and space	PDF·m^2·yr
		Biotic productivity: biotic natural resources (e.g. tuna) and man-made biotic environment	Biotic productivity loss	Net Primary Production expressed in monetary units of productivity losses
	Abiotic natural environment (e.g. rapids)			
Abiotic environment		Abiotic natural resources (e.g. water, minerals)	Intermediary towards damages on biodiversity and human welfare	MJ surplus energy
	Man-made abiotic environment, cultural objects	Man-made abiotic environment (e.g. houses)	Physical destruction or impairment of objects	Cost for repair or loss in monetary units

Abbrevations: YLL: Years of Life Lost; YLD: Years of Life Disabled; DALY: Disability-Adjusted Life Years; PDF: Potentially Disappeared Fraction; MJ: megajoule

Criteria for analysis

Developed in advance to prevent bias

Scientific criteria

- Completeness of scope (8 sub criteria)
- Environmental relevance (4-12 sub criteria)
- Scientific robustness and certainty (8-15 sub criteria)
- Documentation, transparency and reproducibility (6 sub criteria)
- Applicability (4 sub criteria)

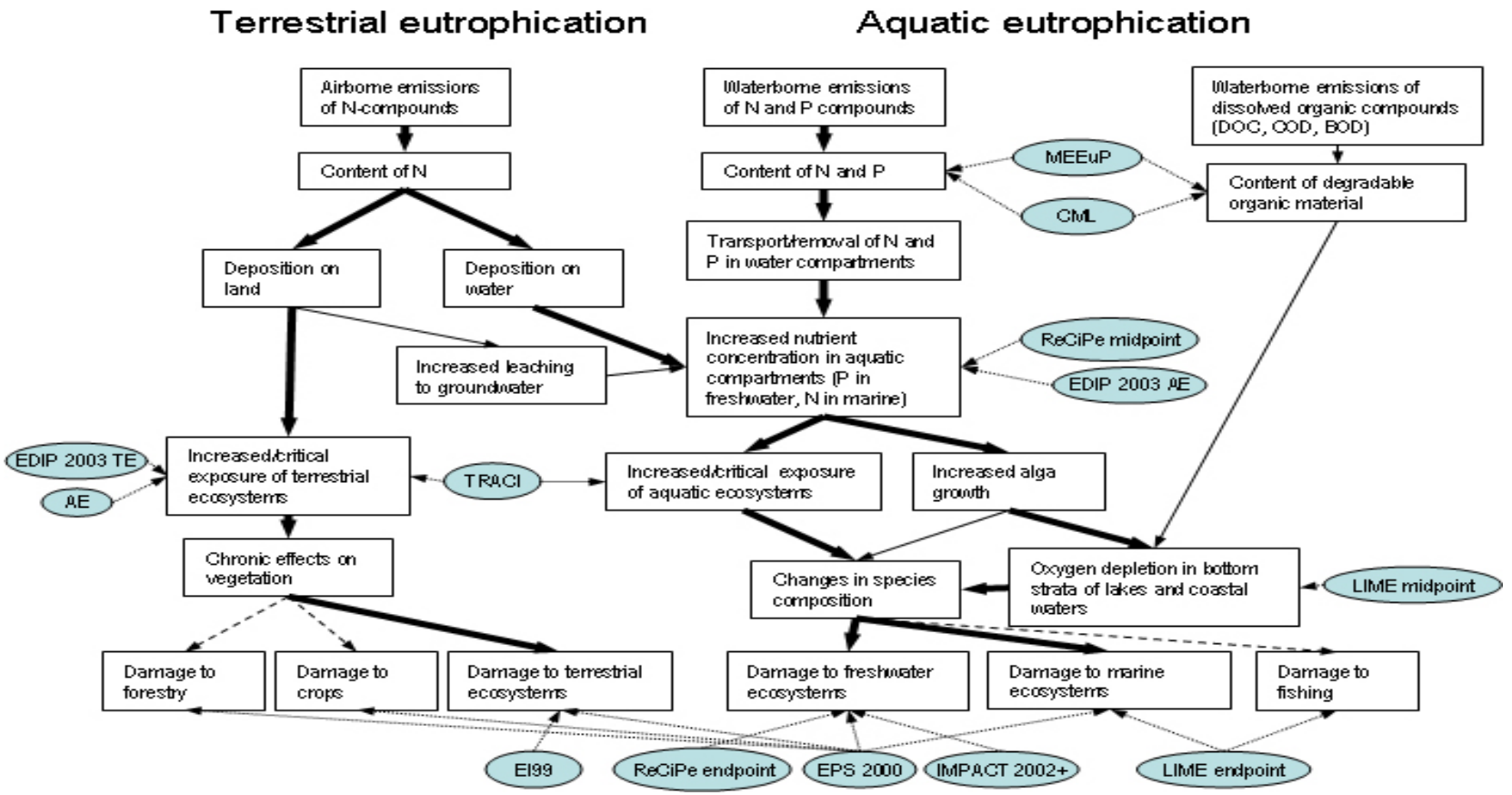
Stakeholder acceptance (5 sub criteria)

Sub criteria are weighted according to importance (high-low)

Thresholds are introduced on fundamental sub criteria

Specific criteria

Impact pathway helps identify sensitive parts and discriminate between methods



Specific criteria for aquatic eutrophication

Environmental relevance

Midpoint

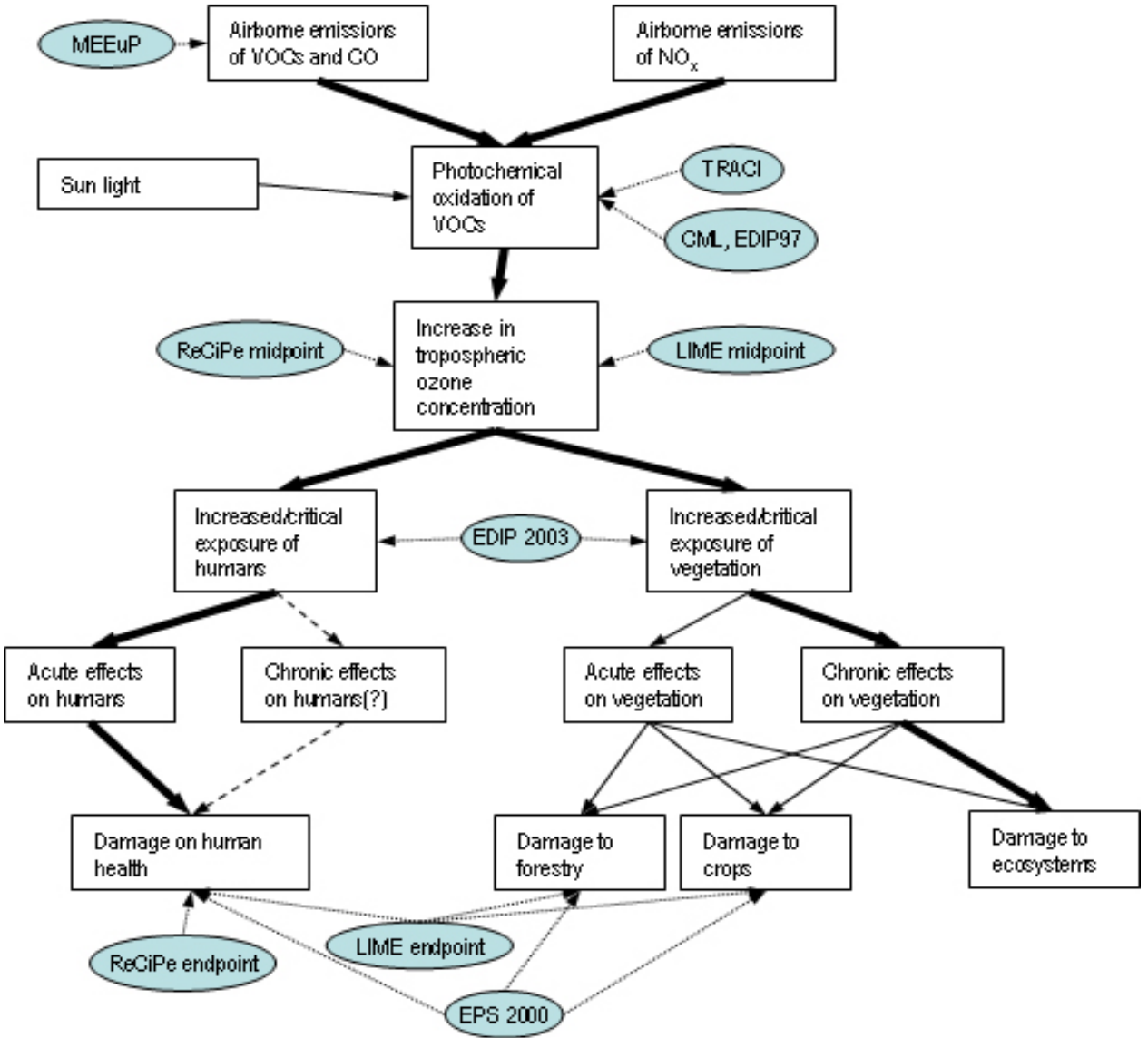
- Fate and transport is considered and advection out of a region is not considered a final loss
- Influential fate processes are considered (denitrification, precipitation and sedimentation of P)
- The factors allow distinction between individual N- and P-compounds

Endpoint

- For damages on ecosystems, the method discriminates exposed systems according to their sensitivity to eutrophication and oxygen depletion and limiting nutrient (N for marine, P for freshwater)
- Potency or dose-response is included

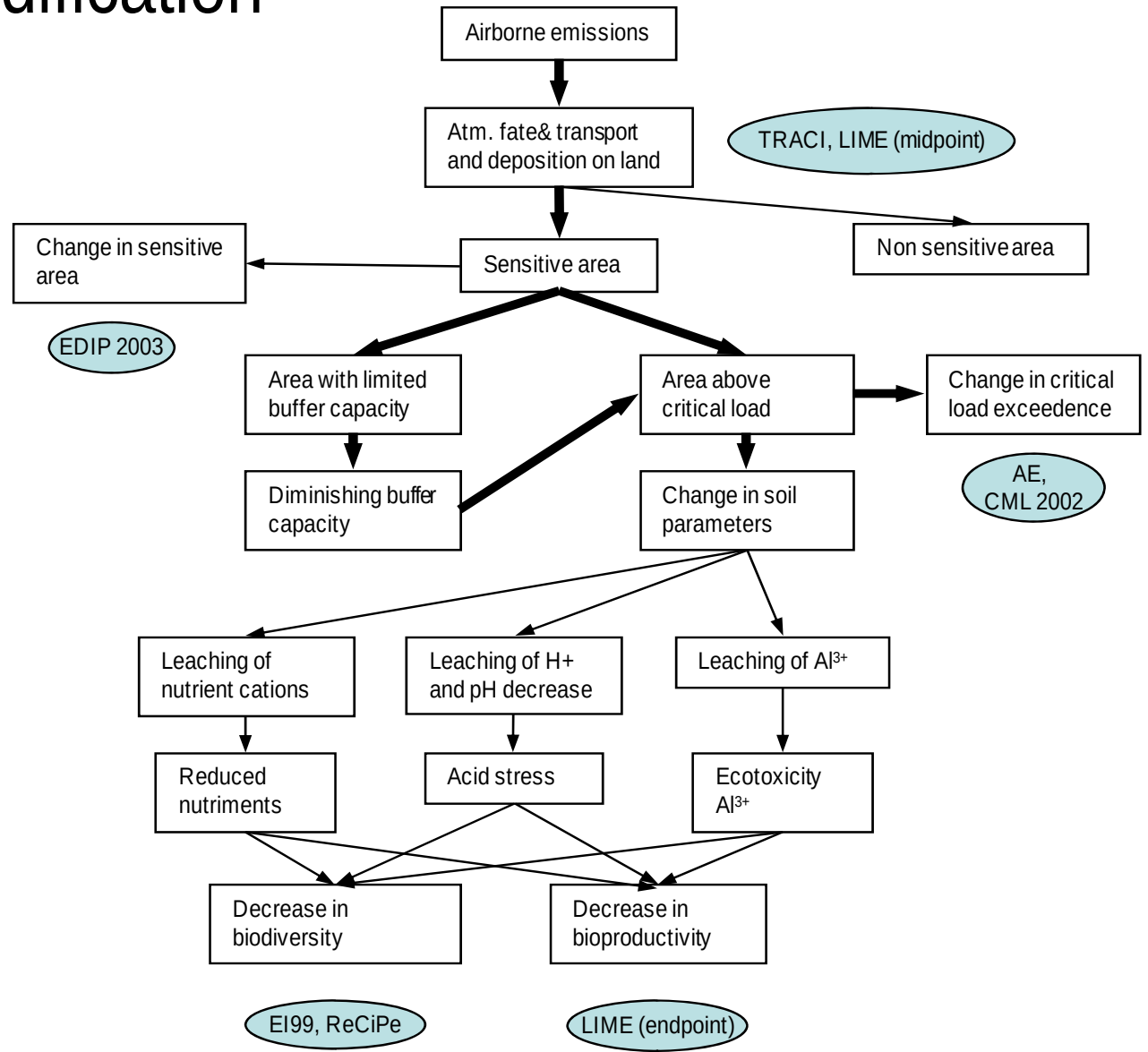
Ozone formation

Environmental mechanism

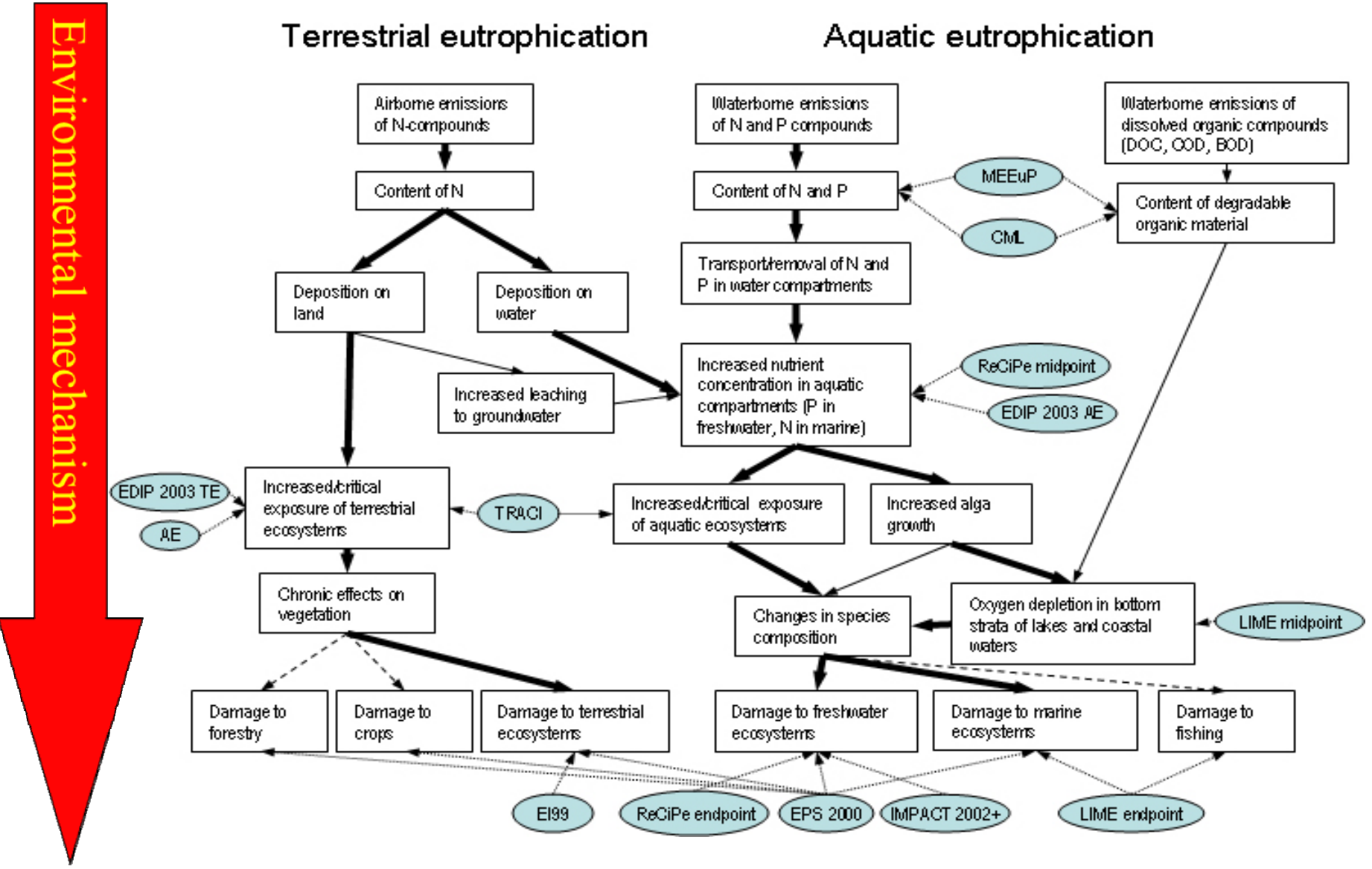


Acidification

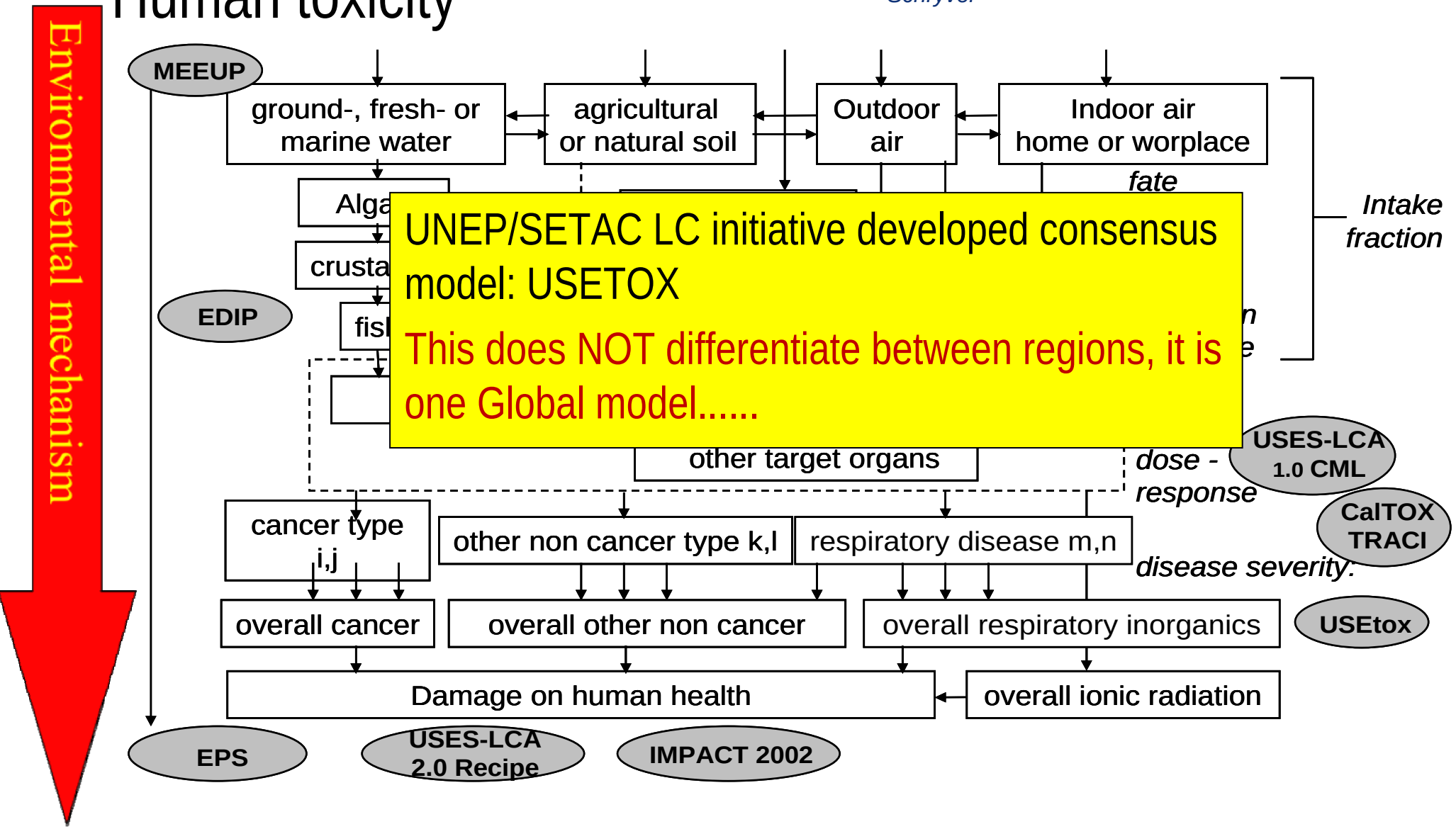
Environmental mechanism



Eutrophication

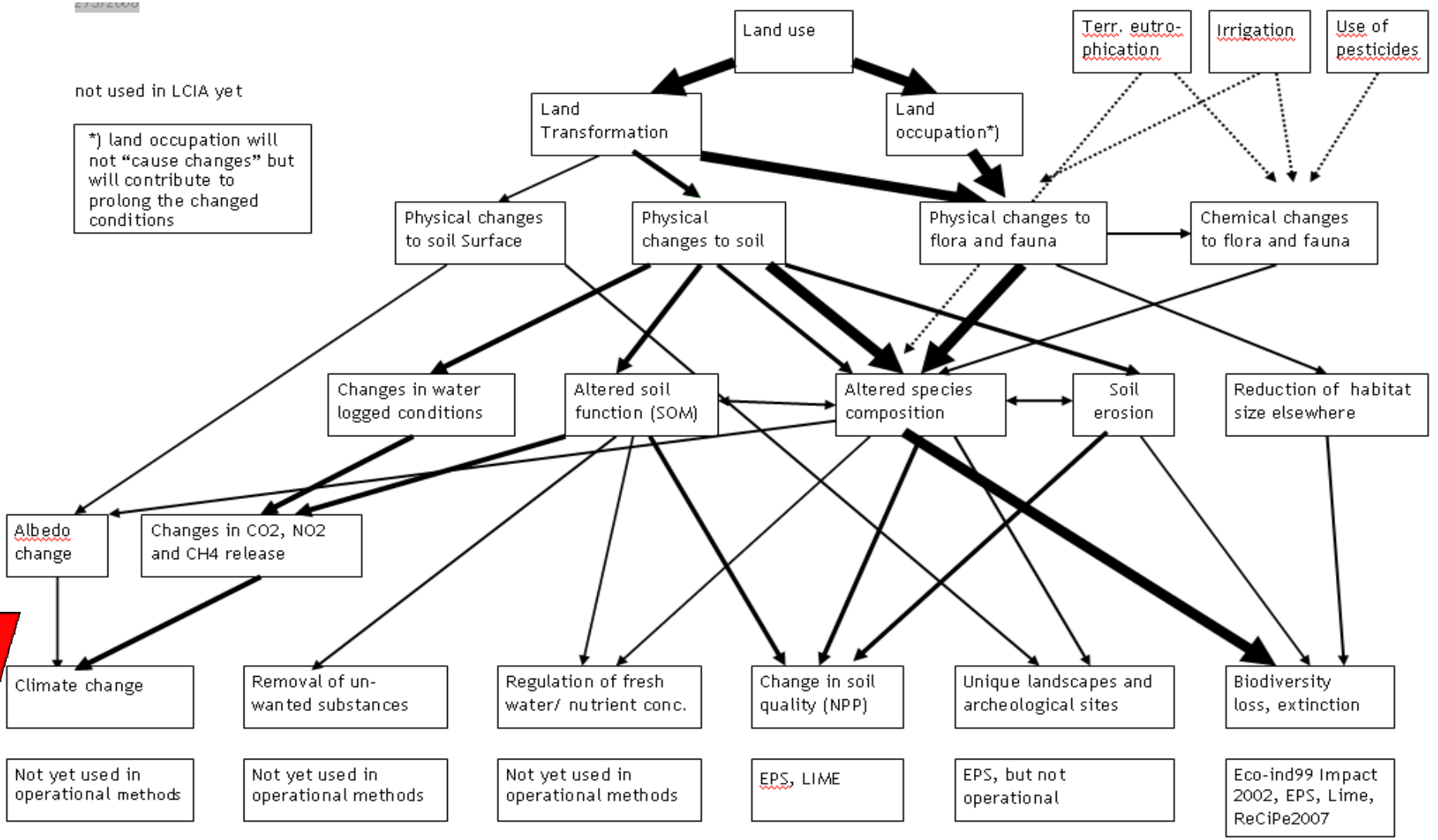


Human toxicity



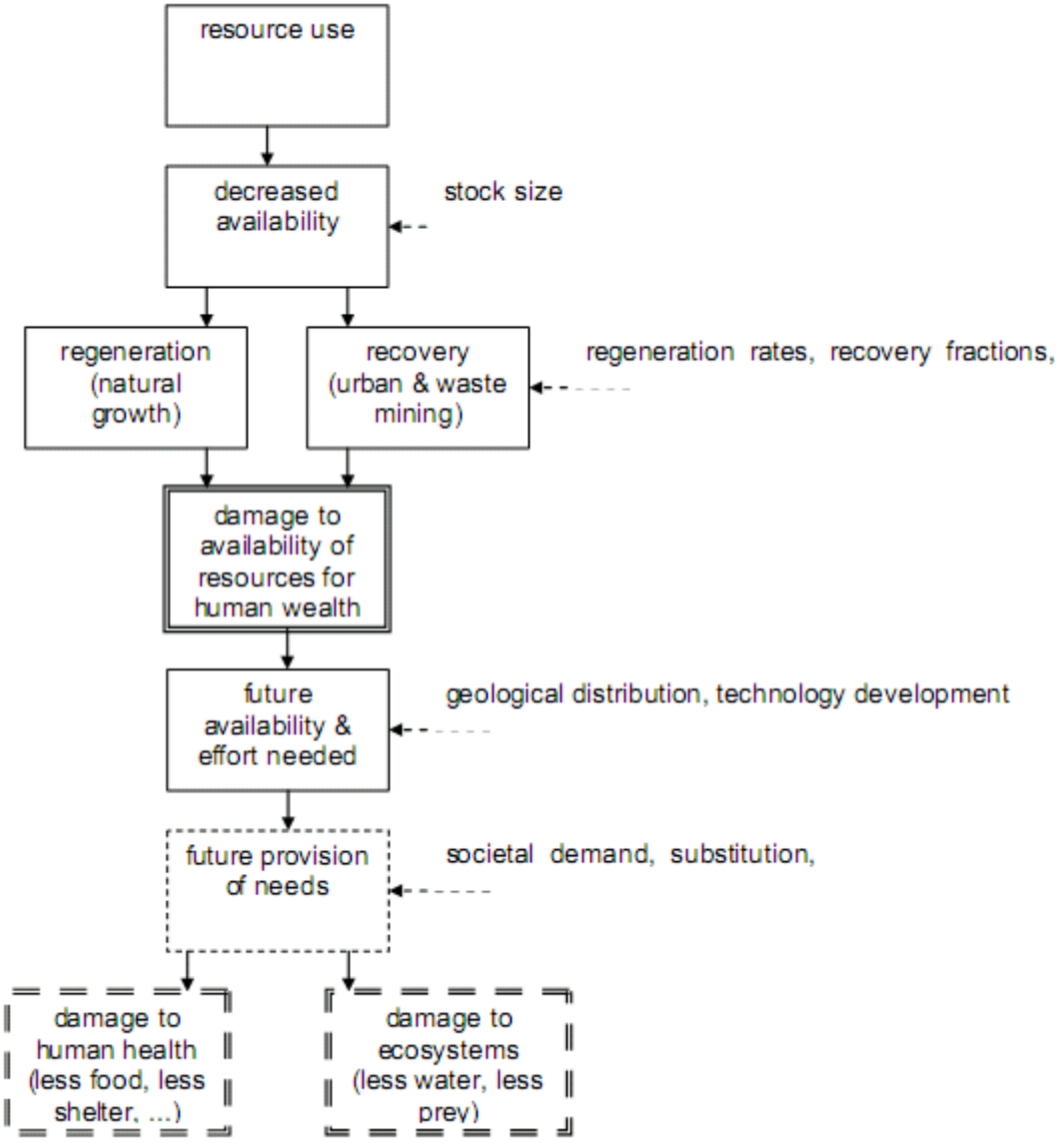
Land Use environmental mechanisms

Environmental mechanism



Source: Physical impacts of land use in product life cycle assessment by Bo P. Weidema with contributions from Erwin Lindeijer (2001). Subject report of the EURENVIRON LCAGAPS sub-project on land use

Environmental mechanism



- Four classes of methods

Category 1 methods are at the first step of the impact pathway. They use an inherent property of the material as a basis for characterisation. The environmental relevance is low in terms of expressing resource depletion, but the characterisation factors are relatively robust. As described in the AoP for 'Natural Resources', those methods that do not include the concept of resource scarcity are not considered. Therefore, this category is considered incompatible with the AoP 'Natural Resources' (irrespective of the quality of the method).

Category 2 methods address the scarcity of the resource by basing the characterisation factor on the ratio between what is extracted, and what is left. They have a higher environmental relevance, and potentially a higher uncertainty.

Category 3 methods focus on water and are treated as a separate category due to the regional dependence of this resource issue, which the characterisation model needs to consider.

Category 4 describes the endpoint methods. These aim to cover the entire environmental mechanism.

Specific problem resource depletion: what is the question?

- What should the indicator express?
  - .....your say

Analysis of characterisation models

Each model is scored against each sub criterion

- A: full compliance to E: no compliance

… for all five main Scientific criteria and the Stakeholder criteria (35-50 in total)

Each model is scored against each sub criterion

			CML 2002		EDIP2003 aquatic	
Check the following:	Threshold (Minimum score)	Importance (H-N)	Score	Comments	Score	Comments
Fate and transport is considered	B	H	D	Mineralisation with full release of nutrients in biologically available form assumed, Redfield ratio assumed for ration between N and P (not relevant for terrestrial systems)	A	Removal of nutrien hydrological cycle
Advection out of a region is not considered a final loss			n.r.	no fate model	A	No advection out o modelled region
Influential fate processes are considered For aquatic systems: denitrification, precipitation and edimentation of P For terrestrial systems: oxidation, deposition			E	Influential fate processes governing availability of nutrients not considered	B	Modelled by CARM model as fixed rem ratio for N- and P- compounds in diffe emission scenario
For damages on ecosystems, a fate sensitivity factor iscriminating between sensitive and insensitive ecipients is included For aquatic systems according to their sensitivity to		H	E	No distinction between sensitive and insensitive	C	No distinction betv freshwaters and m

Scores are aggregated under each main criterion

Criteria	CML 2002		EDIP2003 aquatic		LIME midpoint	
	Score	Comments	Score	Comments	Score	Comments
Completeness of scope: Overall evaluation	B-C	The scope of the model for the evaluation of eutrophying substances is applicable for aquatic as well as terrestrial ecosystems. Global validity, no temporal differentiation	A-B	The scope of the model for the evaluation of eutrophying substances is applicable for aquatic ecosystems on the European scale. No consideration of terrestrial ecosystems. Spatial differentiation at the level of countries, no temporal differentiation	C	The scope of the mode the evaluation of eutrophying substance limited to aquatic ecosystems and only addresses issues relat to oxygen depletion. N consideration of terrest ecosystems. The mod represents Japanese coastal waters, freshw systems ignored
Environmental relevance: Overall evaluation	D-E	Environmental relevance is low, most important fate processes determining availability and exposure of sensitive environments are missing	A-B	Environmental relevance high, removal processes in aquatic system modelled, but no distinction between freshwater and marine systems.	B-C	Environmental relevanc high although removal processes for nutrients missing
	D-	Midpoint model of limited	B	Underlying fate model and	C	Model components bas

Analysis of characterisation models

Each model is scored against each sub criterion

- A: full compliance to E: no compliance

… for all five main Scientific criteria and the Stakeholder criteria

Scores are aggregated under each main criterion

- Consideration of assigned importance

Resulting scores are interpreted to arrive at draft recommendation

Separate analysis of midpoint and endpoint models, accompanied by report (10-15 p per impact category)

Internal review, consistency

External domain experts consulted on analysis and recommendations

Preliminary draft results – pre consultation

Recommendations of methods and factors

- … at midpoint and at endpoint
- … in a consistent framework, where possible

Classification of recommendations (will be clarified further)

- I: Recommended and satisfactory
- II: Recommended, some improvements needed
- III: Interim, i.e. the most appropriate among the existing approaches but immature for recommendation

Identification of future research needs

- Classification according to importance
- Estimation of work load

Preliminary draft results – pre-Consultation- Can still change!

Impact category	Recommended model Midpoint	Class.	Recommended model Mid to Endpoint	Class.
Climate change	IPCC (GWP) (100 years)	I	ReCiPe	III
Ozone depletion	WMO (ODP) (infinite)	I	ReCiPe	III
Human toxicity, carcinogenics	USEtox	II/III	DALY calculation applied to USEtox midpoint	II/III
Human toxicity, non- carcinogenics	USEtox	II/III	DALY calculation applied to USEtox midpoint	III
Particulate matter/Respiratory inorganics	Not settled yet: Greco et al., 2007 or RiskPoll	I/II	Adapted DALY calculation applied to midpoint	II
Ionising radiation, human health	Frischknecht et al., 2000	II	Frischknecht et al., 2000	III
Ionising radiation, ecosystems	Garnier-Laplace et al., 2008	III	PDF calculation applied to midpoint	III

Preliminary draft results – pre-Consultation - Can still change!

Impact category	Recommended model Midpoint	Class.	Recommended model (Mid to) Endpoint	Class.
Photochemical ozone formation	LOTOS-EUROS as applied in ReCiPe	II	ReCiPe for human health, nothing for vegetation	II
Acidification	Accumul. Exceedance	II	ReCiPe	III
Eutroph. terrestrial	Accumul.Exceedance	II	None	-
Eutroph. aquatic	ReCiPe	II	ReCiPe for freshwater, none for marine waters	III
Ecotoxicity	USEtox	II/III	PDF calculation applied to USEtox midpoint	III
Land use	Milà i Canals	III	ReCiPe	III
Resource depletion, water	Swiss Ecoscarcity	III	None	-
Resource depletion, mineral . fossil (and renewable)	Category 1: None Category 2: EDIP97 update 2004	- II	Category 4: ReCiPe	III

What are the deliverables?

1. Analysis of existing LCIA methodologies (report)

2. Requirements for LCIA methods, models and indicators
   - Introduction to LCIA (steps and framework)
   - Criteria for assessment of characterisation models (per impact category)
   - Procedure for applying the criteria into the analysis

3. Recommendations based on existing LCIA models and factors, not out yet
   - Recommended models at midpoint and endpoint level **Can still change!**
   - Consistency across midpoint and endpoint indicators
   - Research needs (per impact category) is input to LC-impact EU project
   - Annexes with analysis results, procedure, LCIA glossary

4. Draft recommendation of characterisation factors in ILCD system; not out yet

Towards a worldwide method?

- Concerns form Japan and US that the EU cannot make global recommendations
- Global recommendations for regional impact categories?
  - Most product systems are global today
  - For most regional impact categories existing methods are based on regional models
  - Trade-off between other criteria and representativity for emission region
- Global models needed for regional impact categories
  - Harmonisation across existing models
  - Globalisation of existing or new models

… this is identified as a central research need in the project

- Why is all this interesting?
  - Criteria make it possible to assess methods
  - Structure of environmental mechanism makes clear what a method covers, and what not
  - Sets out a roadmap for method development, see www.lc-impact.net
- Should the EU make global recommendations?