Criteria for Measuring Transportation Sustainability

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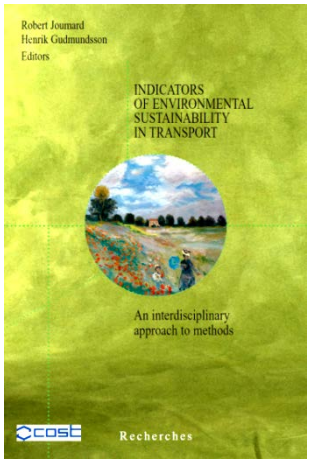

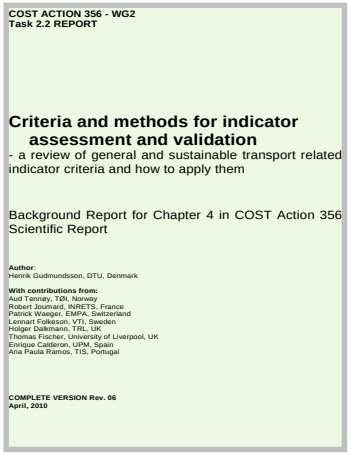
COST ACTION 356 - WG2
Task 2.2 REPORT

Criteria and methods for indicator assessment and validation
- a review of general and sustainable transport related indicator criteria and how to apply them

Background Report for Chapter 4 in COST Action 356 Scientific Report

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Overview

- Sustainability in transportation is **difficult to measure, indicators** are necessary tools to monitor and manage it
- There are numerous potential indicators of varying relevance and quality; **Criteria** for selection of indicators are needed
- Criteria can apply to the **general framework level** for measurement as well as to **individual indicators**
- The specific indicators that are most important will depend on the particular **context for** and **application of** indicators of transportation sustainability
- Would it be possible and useful to define an **application dependent indicator validation procedure** for transportation sustainability?

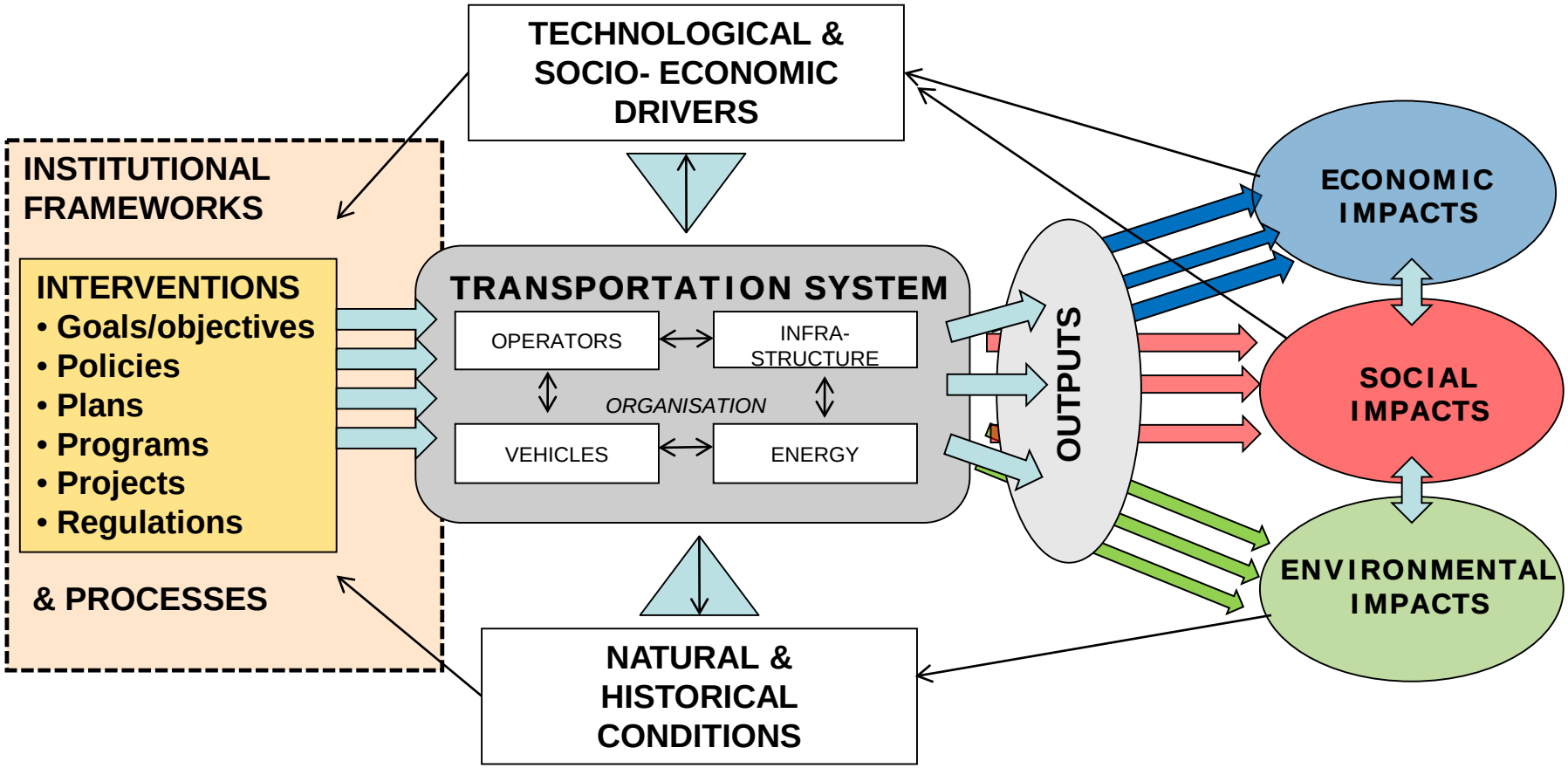
Dimensions of Sustainable Development

	ECONOMIC DIMENSION	SOCIAL DIMENSION	ENVIRONMENT DIMENSION
PRESENT	•Income for the present generation	• Human development for the present gereation	•Environmental quality for the present generation
equity			
FUTURE	•Income opportunities for future generations (capital and resource assets)	• Conditions for social stability and human development for the future	•Nature's life-support (Ecosystems, Climate, Biodiversity…)
	INSTITUTIONAL DIMENSION		
	•Integrated decision making •Participation of affected groups		

Impacts associated with transportation
(tentative)

	ECONOMIC DIMENSION	SOCIAL DIMENSION	ENVIRONMENT DIMENSION
PRESENT	•Transportation contributions to income and productivity • Transportation costs (time and money) • Costs associated with congestion and accidents •Maintenance costs	• Accessibility; Mobility • Livebility • Accidents • Mobility barriers for the disadvantaged • Health effects (other than env related and accidents)	•Air quality effects on health •Air pollution effects on vegeation • Noise effects • Light pollution • Waste production
equity			
FUTURE	• Construction costs and value of transportation assests • Use of non-renewable resources and energy	• Connectivity • Effests on cultural heritage	• Climate Change • Damage to ecosystems • Fragmentation of habitats • Release of toxic substances •Introduction of invasive spcies
	INSTITUTIONAL DIMENSION		
	• Transportation/land use integration • Multi-modal planning • interacency coordination •Participatory planning; Partnershups		

System interactions



Frameworks

- “No single measure is a sustainability measure, but a set of measures is required” > frameworks

- The framework (not the individual indicator) is really the level for composing a set of indicators for measuring transportation sustainability

“….frameworks are the conceptual and procedural constructs that assimilate, process and give meaning to information” (Assmuth and Hilden 2008)

Dimensions of indicator frameworks

- **Conceptual** dimension: *What to measure*
  (which impacts, system boundary, system interactions…)

- **Intentional** dimension: *Why to measure*?
  (which purpose, function, users)

- **Procedural** dimension: *How to measure*?
  (which indicators,measurement methods, reporting formats)

An effective framework for sustainable transport strategies…

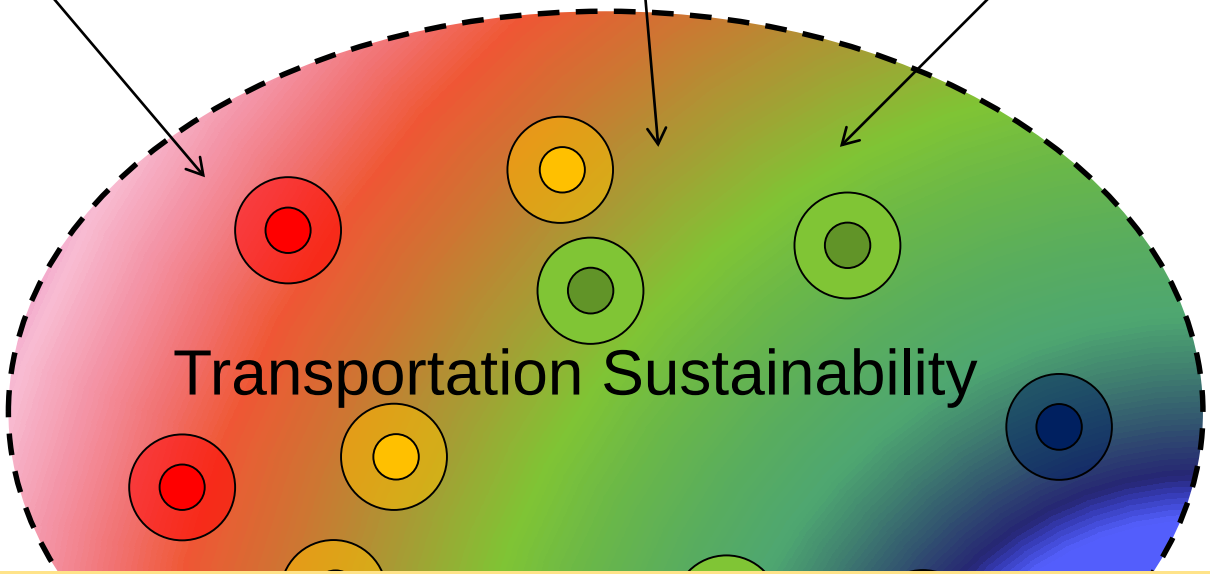
- Includes a comprehensive understanding of sustainability
- Has a good connection to the goals and objectives of an agency
- Supports vertical and horizontal integration in the agency
- Captures the interactions among variables
- Reflects stakeholder perspectives
- Considers the capabilities and constraints of an agency, and
- Is flexible to foster self-learning

(Source: Pei et al 2010)

- Sustainability dimensions?
- Understanding of system interactions?
- More detailed purpose and application criteria?

POLITICS CITIZEN'S CONCERNS SCIENCE

'WHAT IS AVAILABLE / POSSIBLE



"Indicator selection is rarely documented in practice, hence indicator lists are often applied with no or only not transparent justification"

Criteria for individual indicators

- Broad literature review of indicator selection criteria and procedures COST 356 (environment, ecology, health, sustainability transportation, natural resources…)

- Broadly similar types of criteria specified across areas, including sustainability of transportation (up to 34 in one reference)
- No uniform idea about how to categorize criteria (i.e what does a particular criterion help to accomplish?)
- Lacking definitions of criteria
- Many overlaps among criteria
- Limited guidance on how to select, and apply criteria

NCHOD 2005 (Clinical Health)	**Niemeijer & de Groot 2008** (environment)	**Jackson et al 2000** (ecosystems)	**OECD 2003** (env. policy)
Scientific criteria	**Scientific dimension**	**Conceptual Relevance**	**Analytically sound**
• Explicit definition • Indicator validity • Scientific soundness	• General importance • Credible • Analytically soundness • Integrative	• Relevance to the Assessment • Relevance to Ecological Function	• Theoretically well founded • Based on international standards and consensus • Linkable to economic models, forecasting etc
Policy Criteria	**Policy and management**	**Feasibility of Implementation**	**Policy relevant and useful**
• Policy relevance • Actionability • Perverse incentives	• Relevance • Comprehensible • International compatibility • Linkable to societal dimension • Links with management • Progress towards targets • Quantified • Relevance • Spatial and temporal • Thresholds • User-driven	• Data Collection Methods • Logistics • Information Management • Quality Assurance	• Representative • Simple, easy to interpret • Responsive • International comparison • Threshold or reference value
Methodological criteria	**Systemic dimension**	**Response Variability**	**Measurable**
• Explicit methodology • Attributability • Timeliness • Frequency • Sensitivity to change • Confounding • Acceptability • Measurability • Cost-effectiveness • Explicit methodology	• Anticipatory • Predictable • Robustness • Sensitive to stresses • Space-bound • Time-bound • Uncertainty about level	• Estimation of Measurement Error • Temporal Variability - Within Season • Temporal Variability - Across Years • Spatial Variability • Discriminatory Ability	• Available at reasonable cost/ • Documentation • Updated/ reliable procedures

10 criteria in three categories

Representation related criteria: Indicators assessed with regard to their accurate representation of an impact (as accurate as possible and necessary)

Representation
Validity
Reliability
Sensitivity

Operation related criteria: Indicators assessed with regard to how operational they are for practical assessment and continued monitoring

Operation
Measurability
Data availability
Ethical concerns

Intervention related criteria: Indicators assessed for their pertinence to and usefulness for policy and management decision making applications

Intervention
Transparency
Interpretability
Target relevance
Actionability

Adapted from : Joumard & Gudmundsson 2010

Representation related criteria

Criterion	Definition	Example
Validity	A valid indicator must actually measure the issue or factor it is supposed to measure	*High:* GWP for emission impact on climate *Low:* 'Potential Odor' for annoyance (smell)
Reliability	A reliable indicator must give the same value if its measurement is repeated in the same way on the same population and at almost the same time	*High:* Modern thermometer for air temprerature *Low:* Air temperature for road ice warning in cars
Sensitivity	A sensitive indicator must be able to reveal important changes in the factor of interest	*High:* Quick steering adjustments for driver fatigue *Low:* VMT for 'sustainable transport'
		High indicator example fulfilling criterion *Low* Indicator example not fulfilling criterion

Procedure for indicator selection

0. (Define framework)
1. Determine user needs (purpose)
2. Develop a list of candidate indicators
3. Determine screening criteria
4. Score indicators against criteria (e.g. 1-5)
5. Summarize scoring results
6. Decide how many indicators are needed
7. Make final selection
8. Report on the suite of indicators

(as appelied in COST 356)

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(as applied in COST 356, 2010)

Example: fragmentation indicators (1)

Number	Expression	Description
Number of patches, NP (Turner et al., 1989)		Number of patches caused by fragmentation
Mean patch size, MPS (McGarigal et al., 2002)	$MPS = \frac{S\ (largest\ patch)}{S_t} * 100$ S_i = area of patch N = number of patches	Average area of a patch of a particular class
Largest patch index, LPI (Saura and Martinez-Millán, 2001)	$MPS = \frac{\sum s_i}{N}$ S_t = total area of landscape	Percentage of landscape area occupied by the largest patch of a class
Patch density, PD (McGarigal and Marks 1995; Saura and Martínez-Millán, 2001)	$PD = \frac{N}{S_t}$ N = number of patches S_t = total area of landscape	Number of patches per unit area
Average patch carrying capacity, Kavg (Vos et al., 2001)	$Kavg = \sum reproductive\ areas$	Average of the number of reproductive areas of a species in the landscape
Core area (McGarigal and Marks, 1995; Schumaker, 1996)	$CORE = \frac{\sum s_c}{\sum s_i}$ S_i = area of patch S_c = area of core of patch	Core area inside a patch and percentage of the patch that is core area

(Source: Ortega Perez 2010)

Example: fragmentation indicators (2)

Indicator	Validity	Reliability	Sensitivity	Measurability	Data Availability	Ethical concerns	Transparency	Interpretability	Target relevance	Actionability
Number of patches, NP (Turner *et al.*, 1989)	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	x	x
Mean patch size, MPS (McGarigal *et al.*, 2002)	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	x	x
Largest patch index, LPI (With and King, 1999; Saura & Martínez-Millán, 2001)	xxx	xxxx	x	xxxx	xxxx	xxxx	xxxx	xxxx	x	x
Patch density, PD (McGarigal and Marks, 1995; Saura & Martínez-Millán, 2001)	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	x	x
Average patch carrying capacity, Kavg (Vos *et al.*, 2001)	x	xxxx	x	x	x	xxxx	xx	xx	x	x
Core area (McGarigal and Marks, 1995; Schumaker, 1996)	xxx	xxxx	x	x	x	xxxx	xx	xxx	x	x

(Source: Joumard & Gudmundsson, Perez 2010)

Limitations of the COST 356 work:

- Only environmental dimension was considered
- Only seven impacts were assessed
- Only 1-2 persons involved in each the assessment
- No consideration of overall framework
- No consideration of different context or different applications of indicators
- No consideration of criteria on indicator ’resonance’ (‘heartfelt’, difficult…)
- All criteria considered equally important

Contextual factors affecting indicator use

1. decision-making tier
• strategic (policy) • tactical (planning) • project selection (programming) • project design

2. decis.-making cycle
• ex-ante assessment • continuous monitoring • ex-post evaluation (auditing)

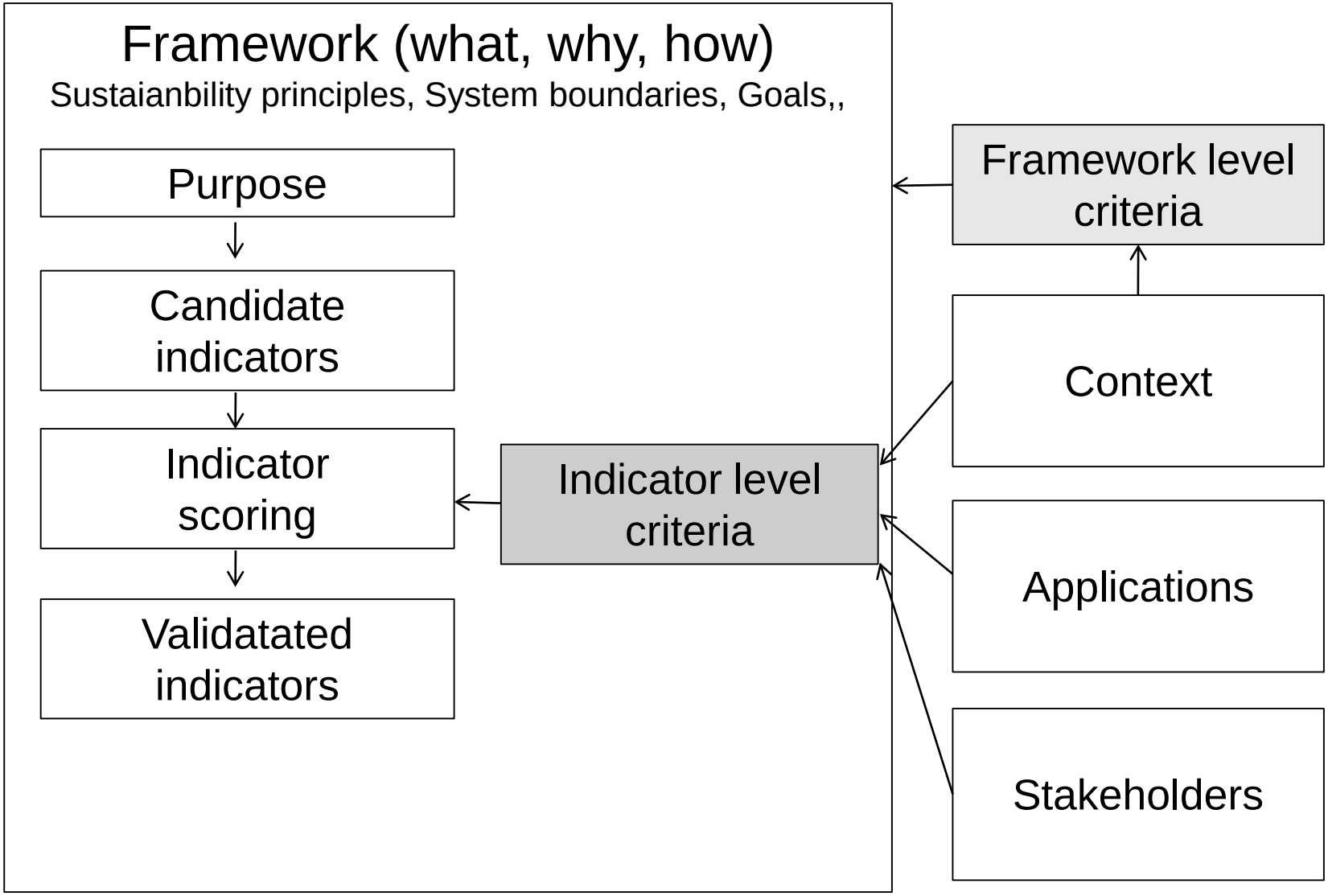
3. administrative level
• international / global • national • regional (network level) • corridor • neighbourhood • site specific

4. instruments
• fiscal incentives • regulation • technological innovation • information programmes • infrastructure • land use planning

5. transport mode
• walking • cycling • automobile • public bus • light rail or subway • train • boat, ferry, etc. • airplane, etc.

Application dependence – Climate ex

APPLICATION	KEY CRITERA	INDICATORS
Awareness raising	Resonnance	Retreating glaciers
Assesssing	Validity, Sensitivity Target relevance	Distance to transportation GHG emission target
Diagnosing	Validity, Sensitivity	Transportation fuel consumption due to increase in commuting distance
Decision making	Transparancy Interpretability Actionability	Tons GHG emission reduction per invested amount
Accounting	Reliability, Target relevance	% of Planned GHG reduction measures implemented
Learning	All of the above…	Share of staff with agency programs with a climate change component


Framework (what, why, how)
Sustaianbility principles, System boundaries, Goals,,
Purpose
Candidate indicators
Indicator scoring
Validatated indicators
Indicator level criteria
Framework level criteria
Context
Applications
Stakeholders

Suggestion

- In the area of sustainability of transportation….

- Criteria at the level of framework building need to be developed further
- Criteria at the level of indicator selection need to be more clearly defined and organized
- A procedure for applying framework and indicator criteria conditioned by context and applications need to be developed

- A possible research proposal: developing procedure and criteria for context-, application- and stakeholder perspective sensitive validation of indicators for sustainability in transportation!