Indicators of ‘environmentally sustainable transport’ -why, what and how to measure? Results of the European ‘COST Action 356’

Gudmundsson, Henrik

Publication date:
2011

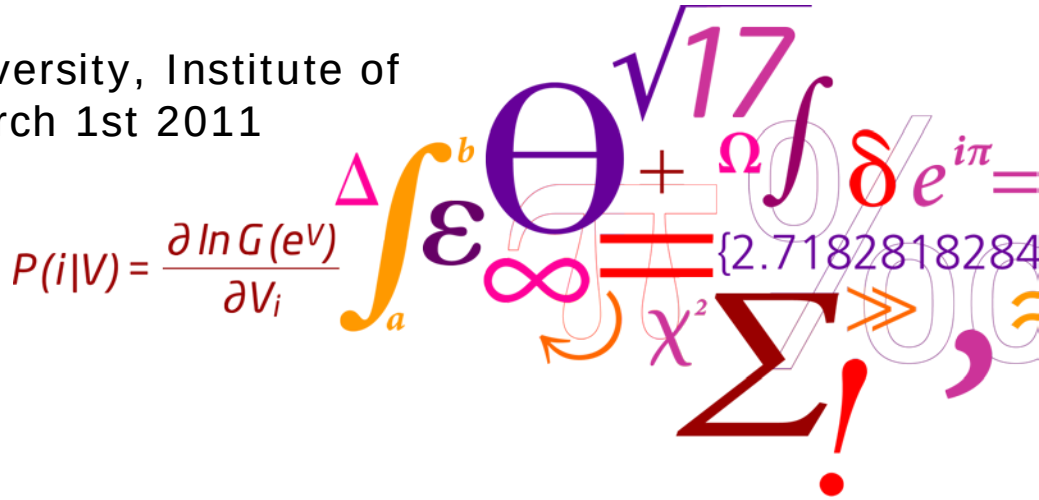
Document Version
Publisher's PDF, also known as Version of record

Indicators of ‘environmentally sustainable transport’ - why, what and how to measure?

Results of the European ‘COST Action 356’

Henrik Gudmundsson
Senior researcher, Technical University of Denmark
Guest researcher, Tokyo Institute of Technology

Presentation at United Nations University, Institute of Advanced Studies, Yokohama, March 1st 2011



DTU Transport
Department of Transport

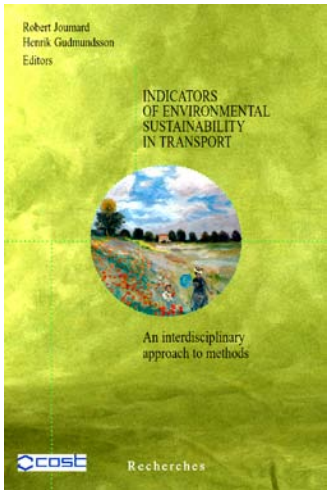
Personal introduction

- Senior Researcher, Dept. of Transport, Technical Univ. of Denmark (DTU)
- Environmental planner 1988, Ph.D. Copenhagen Business School 2000
- Former Employment at Danish Ministry of Environment
- Guest Reseacher at Tokyo Tech Jan - July 2011, sponsored by JSPS

- Working with transport and sustainability indicators since 1990, as:
  - Indicator user
  - Indicator developer
  - Indicator researcher

Co-authors of presentation

- Robert JOUMARD, INRETS, France (Chairman COST 356)
- Lennart FOLKESON, VTI, Sweden (WG leader COST 356)



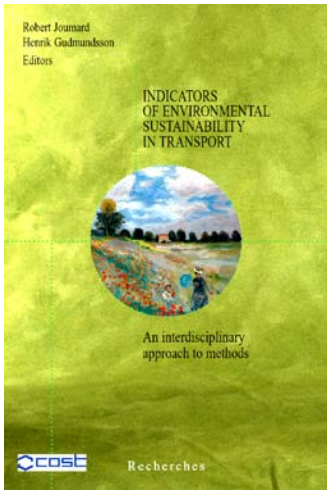
’COST Action 356’

COST = ’European Co-operation in Science and Technology’

- European countries – not European Union
- Actions: 4 - year Researcher networks
- Support: 2-3 annual meetings, conferences, young researcher visits (1-5 weeks), website, publications…

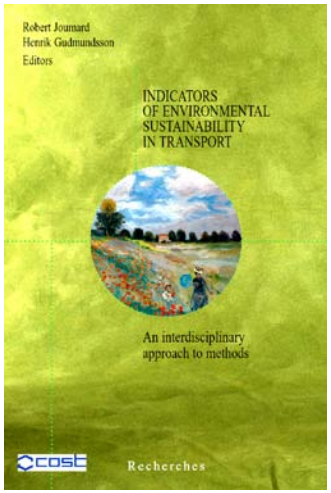
Action 356 ’EST’

- 2006-2010
- Members from 20 countries
- Natural and social scientists
- Objectives:
  - make ’Environmentally sustainable transport’ measurable
  - design harmonised and scientifically sound methods to build better environmental indicators for transport
- Output: report, conference 2010



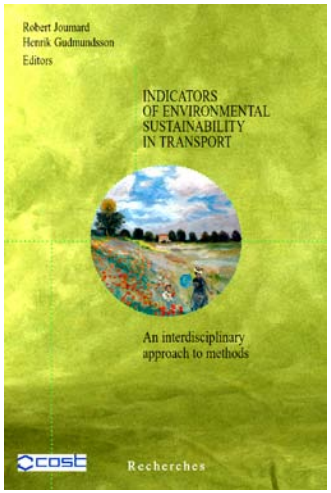
Report outline

1. Indicators and their functions
2. Transport, environment and sustainability
3. The dimensions and context of transport decision making
4. Criteria and methods for indicator assessment and selection
5. Assessment of some indicators within an impact
6. Methods for joint consideration of indicators
7. Research needs



Overview

- **Why** to measure with indicators? The background and functions of indicators generally and with regard to sustainable transportation
- **What** to measure with indicators? The 'chains of causality' approach to identify impacts of transport on the environment, leading to a list of 49 impacts
- **How** to measure with indicators? Criteria and methods for selection of indicators, with examples
- Key **conclusions** and **recommendations**
- **Discussion**

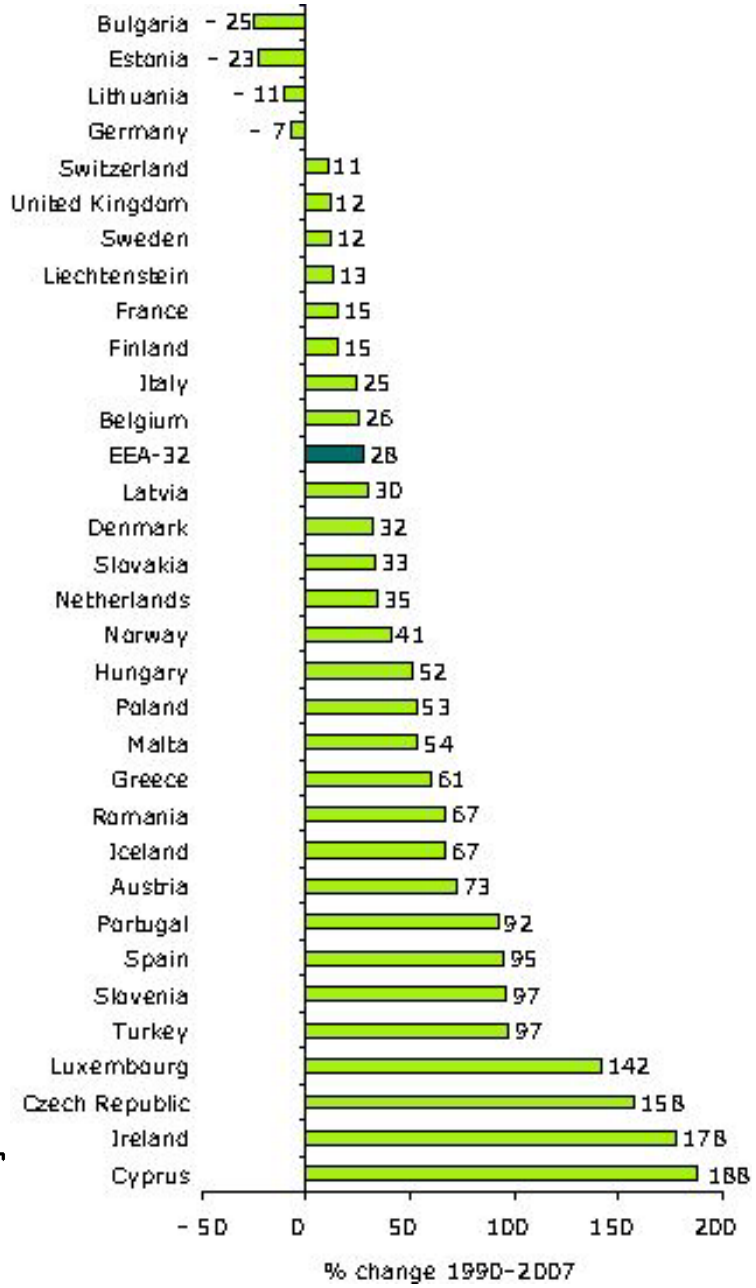


1. Why to measure with indicators?

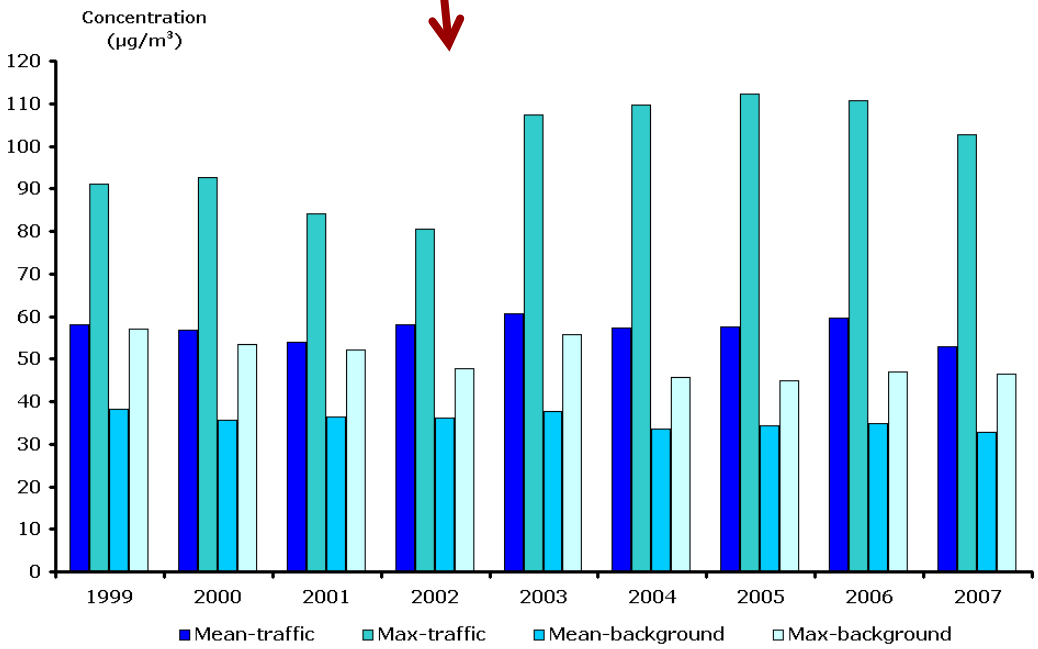
- Massive environmental impacts from transport, some growing, some reducing, some unknown, some ignored - > hardly sustainable
- Goals for 'Sustainable transport' a political priority in Europe at least since 1992
- *"Goals without indicators cannot credibly be achieved"*

  (J. Dernbach, 2002)
- Need for a better representation of sustainability concerns in transport decision making, in all areas, and at all levels
- A need to reduce complexity of information
- No full model to predict effects > Indicators (approximations) are necessary

Trends in GHG emissions from transport 1990-2007 (EEA 2010)



Traffic contribution to NO_2 concentrations In major European cities (EEA 2010)



What do we mean by indicators?

- ***Variables***, that
  - represent a phenomenon of interest
  - can be measured and populated with data values
  - can inform a variety of assessment functions
  - are often repeatable and regularly reportable
  - are always construered and selected!

COST 356 definitions

- An indicator is a variable, based on measurements, representing as accurately as possible and necessary a phenomenon of interest

- An indicator of e*nvironmental sustainability in transport* is a variable, based on measurements, which represents potential or actual impacts on the environment - or factors that may cause such impacts - due to transport, as accurately as possible and necessary

Typical functions of indicators

Focus function – What is important?

Describing the situation – What is going on ?

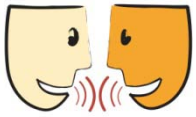
Assessing the situation – How are we doing?

Diagnosing the situation – Why are we here?

Prioritizing – What should we do?

Accountability function – Who is responsible?

Improving – How can we do better?



Communicating – How can it be shown?

2. What to measure with indicators?

- ’Sustainable transport’ is a term generally used for a transport component of Sustainable Development

- Often described with ’3 E’s’ Environment, Equity, and Economy

- ST is not a well defined concept, because,
  - Different general sustainability paradigms (weak, strong)
  - Sector is not independent from the other sectors
  - ST limits focus within sector, while intervention may be needed outside transport to make it sustainable

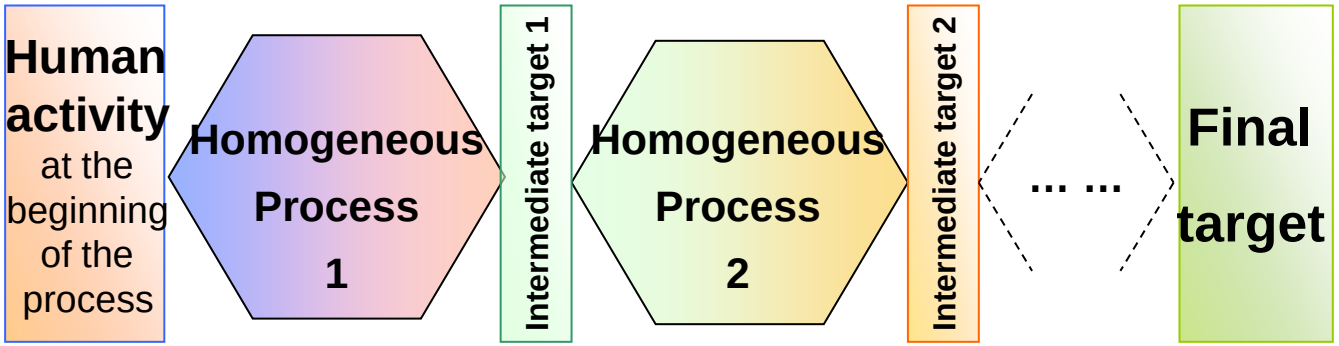
- Highly complex, ill-defined or contested phenomena (like ‘sustainable transport’) are particularly at risk of generating indicators that may arbitrarily misguide or legitimize, rather than, inform actions

Focus on *environmental impacts*

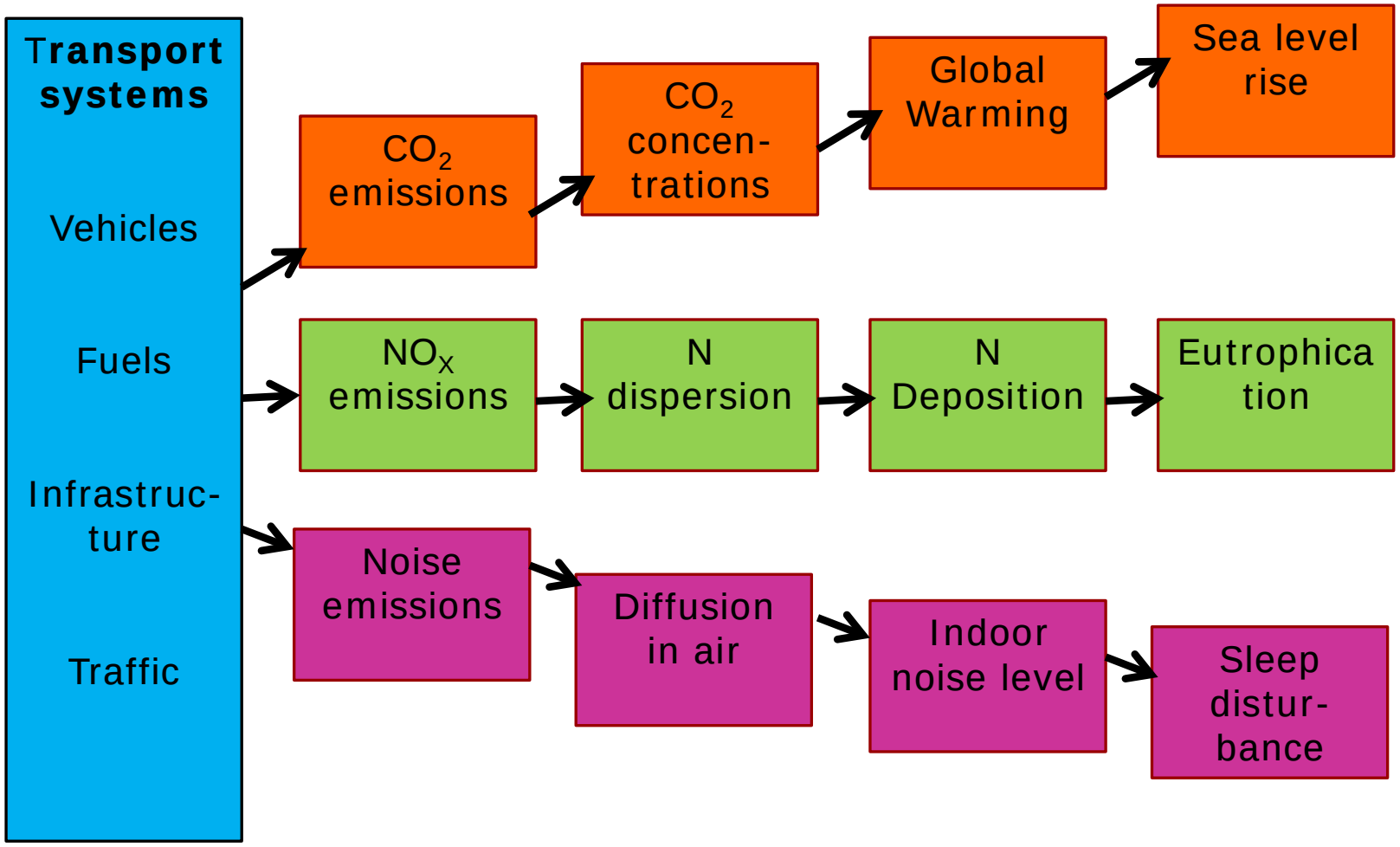
<table>
<tr><th colspan="3">COST 356 IMPACT AREAS</th></tr>
<tr><td rowspan="2">Nature</td><td>Resources
Minerals, fossils</td><td rowspan="4">”Earth”
(uinity of all areas)</td></tr>
<tr><td>Ecosystems
Living and abiotic elements</td></tr>
<tr><td rowspan="2">Humans</td><td>Health
Acute and chronic damage</td></tr>
<tr><td>Quality of Life</td></tr>
<tr><td colspan="2">Cultural Heritage
Buildings, monuments and surroundings</td></tr>
</table>

’Chain of causalities’ approach to impacts

- Comprehsensive review of ‘impacts’ literature
- Impact lists often heterogeneous in literature => need for systemic approach; indicators mix ‘cause’ and effect’ indicators’
- **Chain of causalities** = homogeneous process or series of homogeneous processes between the transport system and a final target of the impacts on the environment



Cause - - - - - - - (chain) - - - - - - - Impact



49 chains, 27 aggregated chains, 8 groups

Noise and vibrations

- Noise (4 chains)
- Vibration (1 chain)

Safety

- Traffic Safety (1 chain)
- Biota collision (1 chain)

Air pollution

- Sensitive air pollution (3 chains)
- Direct toxicity of air pollutants (2 chains)
- Photo-chemical pollution (4 chains)
- Acidification (2 chains)
- Eutrophication (1 chain)
- Dimming (1 chain)
- Ozone depletion (2 chains)

Soil and water pollution

- Pollution of soil, surface water, groundwater (3)
- Maritime pollution (3 chains)
- Hydraulic changes and risks (2 chains)

Impacts on land

- Land take (4 chains)
- Habitat fragmentation (2 chains)
- Soil erosion (1 chain)
- Visual qualities of land / townscape (1 ch.)

Non-renewable resource use and waste handling

- Non-renewable resource use (1 chain)
- Non-recyclable waste (1 chain)
- Direct waste from vehicles (1 chain)

Greenhouse effect (1 chain)

Other impacts

- Electromagnetic pollution (2 chains)
- Light pollution (1 chain)
- Introduction of invasive species (1)
- Introduction of illnesses (1 chain)
- Fire risk (1 chain)
- Technological hazards (1 chain)

RJ09

3. How to measure with indicators?

Main steps:

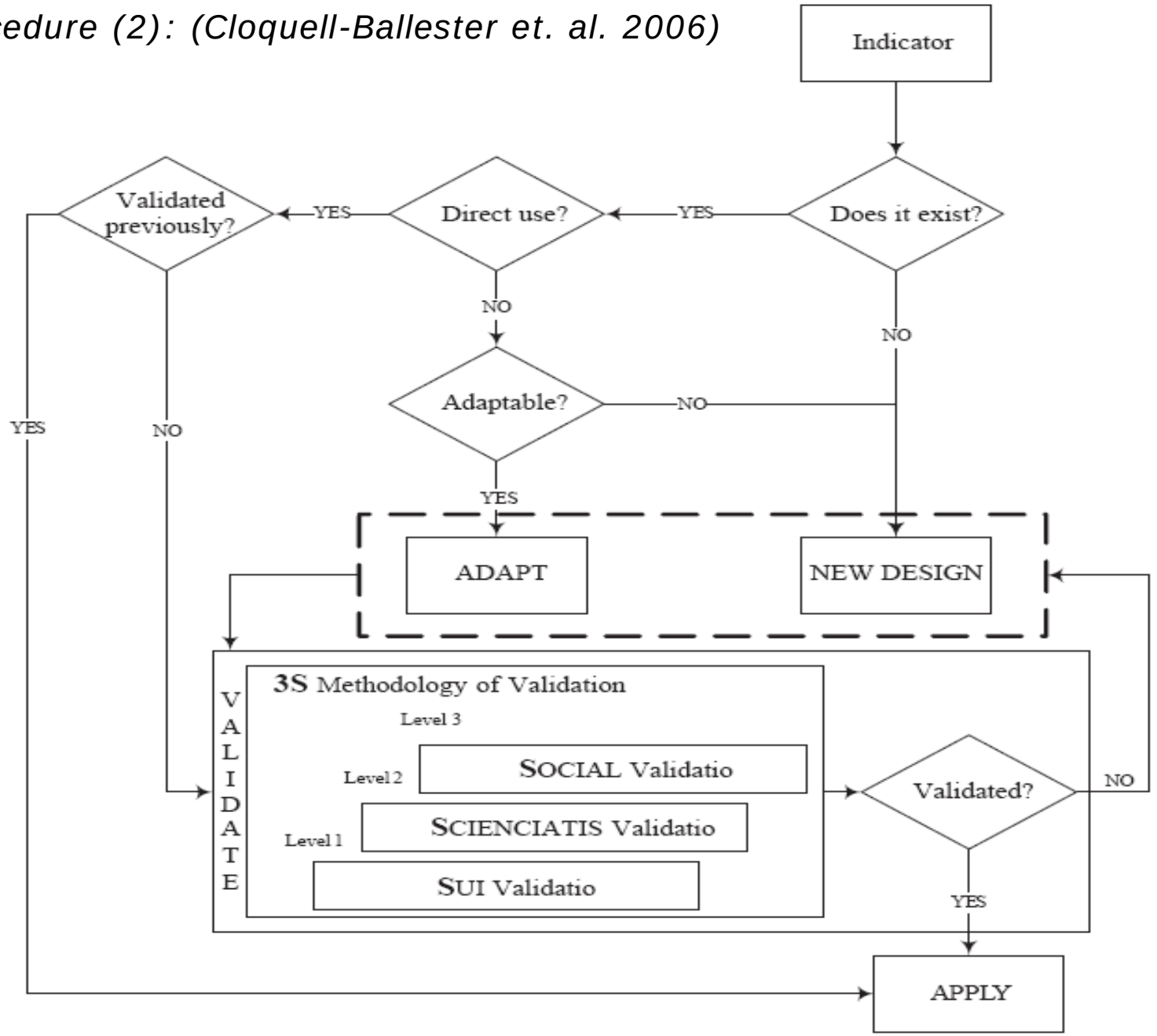
- Delimitation of systems, impacts and purpose (context)
- Criteria and procedures for ’validation’ of indicators
- Identification of ’candidate’ indicators
- Assessment of indicators per impact
- (Assessment of aggregation methods across impacts)

Validation of indicators

Example procedure 1 (Rice & Rochet 2005)

1. Determine user needs
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

Example procedure (2): (Cloquell-Ballester et. al. 2006)

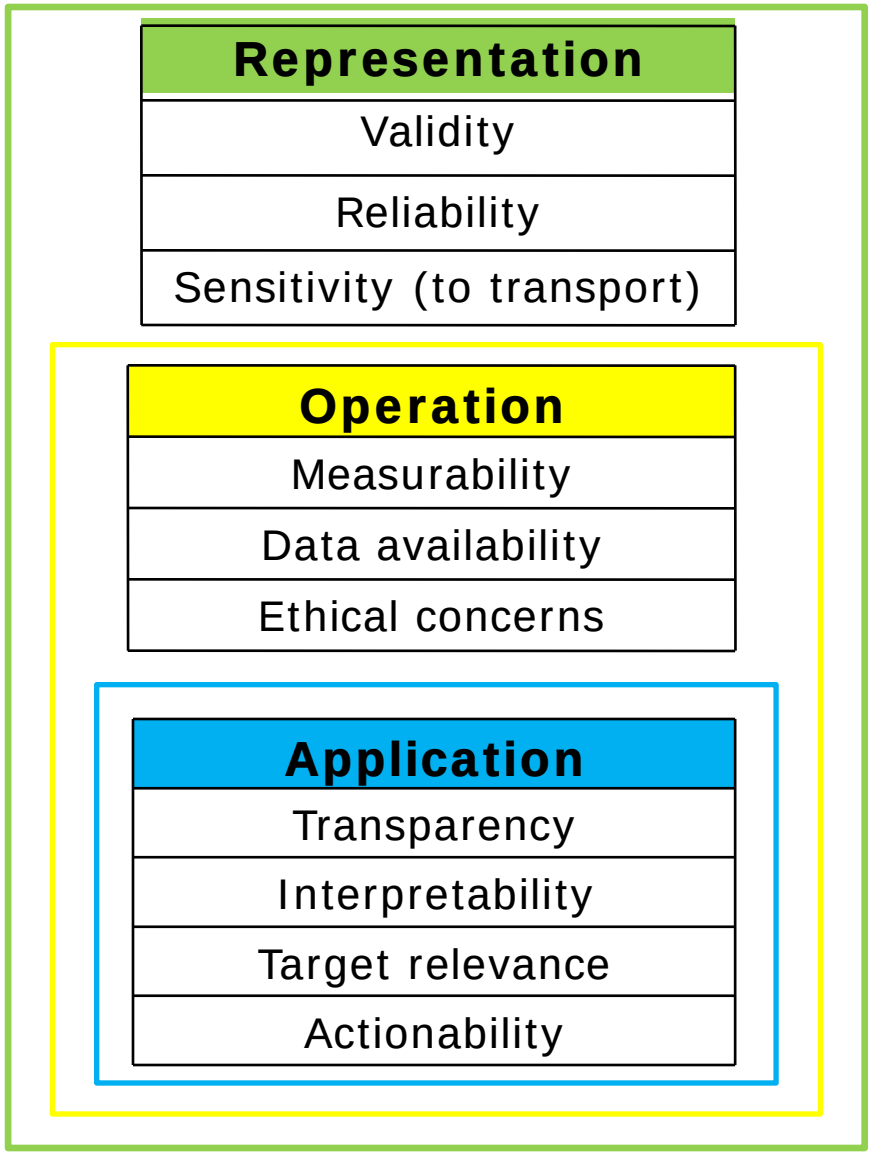


Criteria for validation of indicators

- Literature provides lists of 4-30 criteria
- Some consensus about many criteria across domains
- ‘Sustainable transport’ references mention similar criteria as others, but
  - criteria to idenitify transport ‘share’ of an impact
  - more focus on decision support than pure measurement
- Limited agreement on specific definitions of each criteria
- Very low agreement of an overall categorisation => no common logic as to purpose of each criterion

Ten criteria for indicator assessment

- Measurement related criteria: Indicators assessed with regard to accurate representation of an impact (as accurate as possible and necessary)
- Monitoring related criteria: Indicators assessed with regard to how operational they are for practical and continued monitoring
- Management related criteria: Indicators assessed for their pertinence to and usefulness for policy and decision making



Representation criteria

Validity	A valid indicator must actually measure the issue or factor it is supposed to measure	+ GWP for emission impact on climate - '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	+ Modern thermometer for air temprerature - Air temperature for road ice warning
Sensitivity (to factor transport)	A sensitive indicator must be able to reveal important changes in the factor of interest	+ Quick steering adjustments for driver fatigue - VMT for 'sustainable transport'
		+ example fulfilling criterion - example not fulfilling criterion

Operation criteria

Measura-bility	A measurable indicator should be straight-forward and relatively inexpensive to measure	+ Auto registrations, for vehicle number - 'Average satisfaction' with Public Transport
Data availability	Data available indicators are based on (input) data that should be readily available or at reasonable cost and time	+ Avarege length of cycle lanes for 32 European cities - TERM 39 'Uptake of environmental management systems for transport companies
Ethical accepta-bility	An indicator must comply with fundamental human rights and must require only data that are consistent with morals, beliefs or values of the population	+ Anonymised travel survey data - Blood alcohol data from autopsies
		+ example fulfilling criterion - example not fulfilling criterion

Application criteria

Transpa-rency	A transparent indicator is one which is feasible to understand and possible to reproduce for intended users	+ Transparency through stakeholder involvement in indicator selection - Benefits of transfer of goods from road to rail (Norway)
Interpre-tability	An interpretable indicator allows an intuitive and unambiguous reading.	+ Number of people killed in traffic - Air pollution indicator shown as decreasing function of concentrations
Target relevance	A target relevant indicator must measure performance with regard to articulated goals, objectives, targets or thresholds	+ European Road Safety Observatory reporting road fatalities/year - Lacking targets for all-cause mortality and child poverty in *Healthy People* (US)
Actiona-bility	An actionable indicator is one which measures factors that can be changed or influenced directly by management or policy action	+ Number of Ecosystem Initiatives implemented (US) - Weather conditions contributing to explain accidents

Indicator assessment for 7 impacts

- noise as annoyance,
- direct toxicity of air pollutants,
- loss of cultural heritage due to land take,
- natural habitat fragmentation,
- non renewable resource use,
- waste,
- greenhouse effect

- 90 indicators assessed / 10 criteria / by one or several experts (‘SUI’)

- Example chain **'non-renewable resource use’**

x=poor; xx=limited; xxx=good; xxxx=excellent		Category of criteria									
		Representation			Operation			Application			
Chain	Indicator	Validity	Reliability	Sensitivity	Measurability	Data availability	Ethical concerns	Transparency	Interpretability	Target relevance	Actionability
Non-renewable resource (chain 39)	Indicators based on energy and mass	x	xx	x	xxx	xxx	xxxx	n.a.	xx	x	x
	Indicators based on the relationship between use and deposits	xx	xx	xx	xx	xxx	xxxx	n.a.	xx	x	x
	Indicators based on the future consequences of resource extractions	xxx	xx	xxx	xx	xxx	xxxx	n.a.	xx	x	x
	Indicators based on exergy consumption and entropy production	xx	xx	xx	xx	xxx	xxxx	n.a.	x	x	x
	Indicators based on the marginal increase in costs due to the extraction of a resource	xx	xx	xx	xx	xxx	xxxx	n.a.	xx	x	x

Summary assessment of 7 chains

Representation	
Validity	Low scores often given
Reliability	High scores often given
Sensitivity	Poor to excellent

Operation	
Measurability	Low scores often given
Data availability	Low scores often given
Ethical concerns	For all but one chain, all indicators excellent

Policy application	
Transparency	High scores often given
Interpretability	High scores often given
Target relevance	Low scores often given
Actionability	Low scores often given

Selected conclusions

- The concept of chains of causalities provides a framework to evaluate the impacts of transport on the natural environment, on humans (health and well being), and man made heritage

- Criteria for selecting indicators were organized in a systematic way and could be applied to a range of impacts

- Criteria based scoring can help improve transparency of indicator selection, but does not eliminate subjective elements (even among experts)

- Indicators of environmental impact or environmental sustainability vary greatly in quality as assessed against 10 criteria

- Validity, data availability, and actionability are often low; there are limits to representation, operation, and policy application of EST indicators

Selected recommendations

- Continue critical review and development of indicators of individual impacts as well as methods for joint consideration of indicators
- From ‘sui’, to ‘scientific’ and ‘sociatel’ validation; Strenghten the participatory elements in the process
- Build an institutional basis for continued work for structured exchanges between researchers and practicionners
- Establish similar approaches for economic and social impacts
- Invent – and critique - ‘eye opening’ ways to represent transport and environmental impacts
- Research what makes indicators accepted and used by decision makers and the public in reality

Some discussion points

- Are environmental impacts of transport less important outside Europe?
- Are similar or other environmental impacts relevant outside Europe?
- Are the criteria for selecting indicators relevant elsewhere, and who could be involved in the selection process?
- Do institutions exist that could be ’natural’ basis for indicator development and assessment in the area of transport and sustainability?

Selected references

Joumard R. and Gudmundsson H. (eds) (2010). Indicators of environmental sustainability in transport: an interdisciplinary approach to methods. INRETS report, Recherches R282, Bron, France, 422 p. http://hal.archives-ouvertes.fr/hal-00492823/fr/

Joumard R.; Gudmundsson H. Folkesson, L: Framework for assessing indicators of environmental impacts in the transport sector. Forthcoming in: Transportation Research Records

Cloquell-Ballester V-A., Cloquell-Ballester V-A., Monterde-Dıaz R. and Santamarina- Siuranaet M-C., 2006. Indicators validation for the improvement of environmental and social impact quantitative assessment. Environ. ImpactAssessm. Rev., 26, 79-105

EEA (2010): Towards a resource-efficient transport system. TERM 2009: indicators tracking transport and environment in the European Union. Copenhagen: EEA. URL: http://www.eea.europa.eu/publications/towards-a-resource-efficient-transport-system

Gudmundsson, H. (2004). Sustainable Transport and Performance Indicators. In: Hester, R.E. & Harrison, R.M. (Eds.). Issues in Environmental Science and Technology. 20: pp. 35-63

Joumard R. and Nicolas J.P. (2010). Transport project evaluation methodology within the framework of sustainable development. Ecological Indicators, vol. 10, n° 2, 136-142. http://dx.doi.org/10.1016/j.ecolind.2009.04.002

Pei, Y. L., A. A. Amekudzi, M. D. Meyer, E. M. Barrella, and C. L. Ross (2010). Performance Measurement Frameworks and the Development of Effective Sustainable Transport Strategies and Indicators. Georgia Tech University. Presented at the 89th Annual Meeting of the Transportation Research Board, 2010

Rice J.C. and Rochet M.J., (2005). A framework for selecting a suite of indicators for fisheries management. ICES J. Marine Sci., 62, 516-527

Technical University of Denmark

DTU

Thank you for your attention!

Contact:

Henrik Gudmundsson
hgu@transport.dtu.dk or *hgu@plan.cv.titech.ac.jp*