






Sustainability Assessment of Urban Systems

(ENV-461) – BS 170

6: Indicators for Urban Sustainability

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Sustainability Assessment of Urban Systems

Laboratory on Human-Environment Relations in Urban Systems

Program of the course

Binder & Heinrich

Lectures : BS 170 on Wednesdays, 13:15 – 16:00 (Lecture + Exercise)

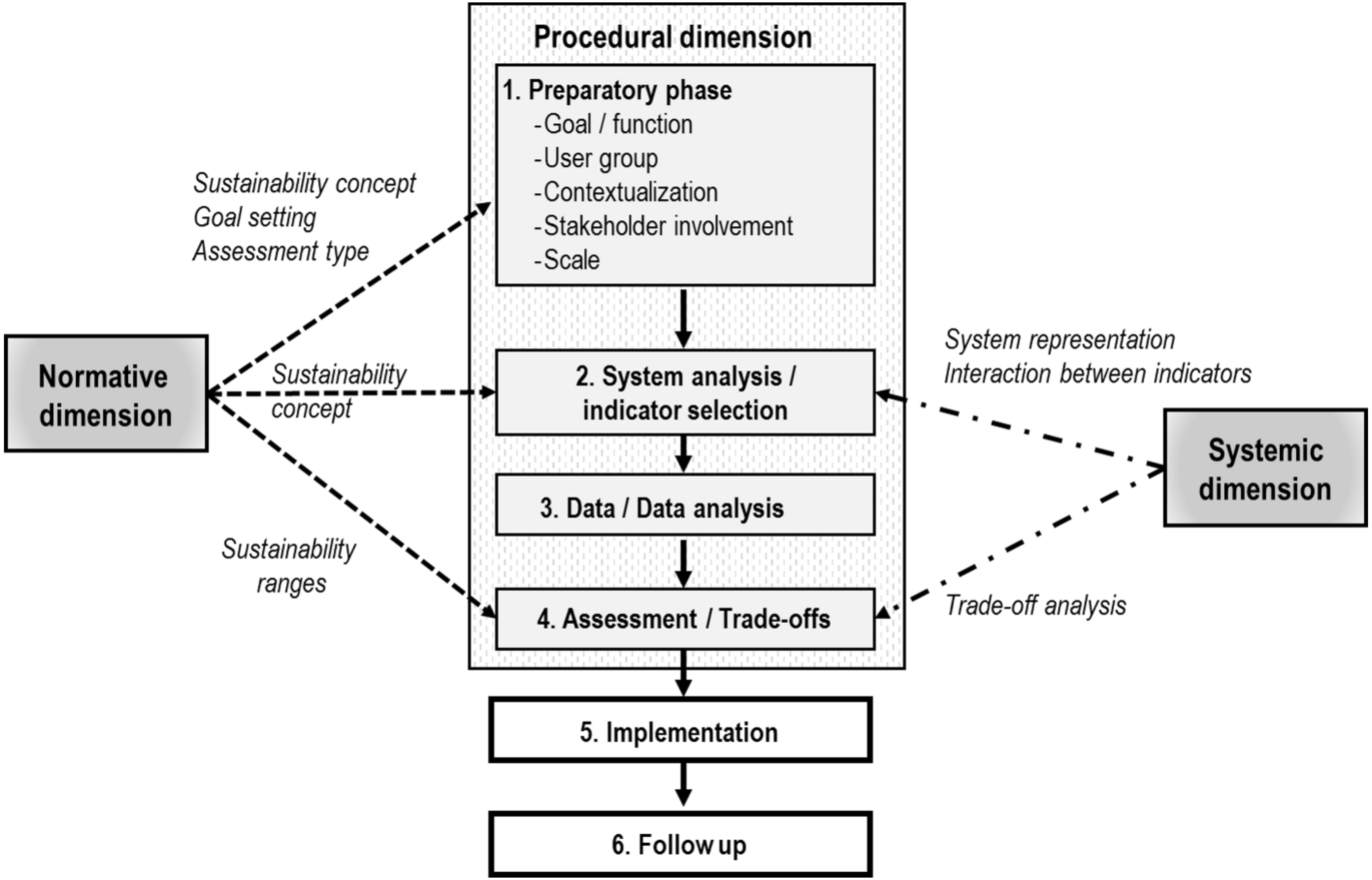
n°	Date	Session	Milestones Project
1	19/02/2025	**Introduction** into sustainability and SA	
2	26/02/2025	**Sustainability issues** in **urban systems**	
3	05/03/2025	**Key steps in SA #1**: SSP, normative dimension, frameworks	**Groups formed**
4	12/03/2025	**Key steps in SA #2**: Systemic dimension	
5	19/03/2025	**Key steps in SA #3**: Participatory dimension	**Submission - Outline 19.03**
6	26/03/2025	**Deriving indicators (1/2)**	
7	02/04/2025	**Deriving indicators (2/2)**	
8	09/04/2025	**Influence matrix**	
9	16/04/2025	**Multi-Criteria Analysis**	
	23/04/2025	**Easter break**	
10	30/04/2025	**Deriving policy recommendations**	
11	07/05/2025	**Policy implications**	
12	14/05/2025	**Sustainability Assessment in practice**	
13	21/05/2025	**Exam**	
14	28/05/2025	**Presentation of semester work_2**	

* May be updated depending on the number of students enrolled

Goals of the lecture

- Understand **what an indicator is** and what it is made of
- Learn how to **choose the most suitable indicators** for a sustainability assessment with the help of **selection criteria**
- Getting to know **sustainability indicator systems in Switzerland**: the case of MONET and "Cercle Indicateurs" (Anne Boesch OFS-EPFL)

Last week recap



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Review

Indicators for urban sustainability: Key lessons from a systematic analysis of 67 measurement initiatives

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ABSTRACT

Today, the centrality of cities in the global sustainability challenge is widely acknowledged, and numerous initiatives have been developed worldwide for monitoring and comparing the sustainability performance of urban areas. However, the escalating abundance of indicators makes it difficult to understand what really counts in urban sustainability and how to properly select the most suitable indicators. By methodically collecting and mapping the diversity of available indicators, our work aims to elucidate the emphases, as well as the gaps, that exist in the way urban sustainability is currently translated into metrics, and to draw instructive lessons to support the development of future indicator sets. Representing the most comprehensive study ever performed in the field, this analysis relies on both an innovative research approach entailing multi- and cross-typological systematic analysis of indicators and an extensive data sample comprising 67 indicator sets (for a total of 2847 indicators) from academia and practice. The findings highlight the most frequent indicators in urban sustainability measurement initiatives, and demonstrate the prominence of social issues (e.g., quality of life, access to services, consumer behaviour, employment) and to a lesser extent, of environmental stakes. In contrast, urban sustainability indicator sets generally pay marginal attention to political questions (e.g., participation, policies, institutional settings), gender issues and distributional concerns. From a systemic point of view, the analysis reveals the strong emphasis placed on the status of actual and potential resources as well as the satisfaction of current needs. The study further highlights seven key lessons on how to deal with three typical tensions faced during indicator selection processes: (i) parsimony vs. comprehensiveness; (ii) context-specificity vs. general comparability; and (iii) complexity vs. simplicity. The directly implementable recommendations proposed herein will support both scholars and practitioners in the design of future urban sustainability measurement initiatives.

1. Introduction

During the last decades, the concept of sustainability has increasingly captured public attention by highlighting the difficult reconciliation between global population needs and the burden that those needs place on the environment. The concept has also been firmly positioned at centre stage in international policy at least since the United Nations' (UN) adoption of Agenda 21 in 1992. Given advancing urbanization worldwide, the sustainability of cities and their surroundings constitutes a major component of the general global sustainability challenge. Urban areas hosted 55% of the world's population in 2018, and according to the projections of the United Nations (UN, 2019), this figure will reach 68% by 2050. Meanwhile, studies estimate urban areas to be responsible for approximately 80% of the global gross domestic product (GDP) and 75% of energy-related CO_2 emissions (IPCC, 2014; GEA, 2012).

By now, the centrality of cities in the global sustainability challenge is widely acknowledged in the political sphere. For example, one of the UN's Sustainable Development Goals (SDG 11 - Make cities and human settlements inclusive, safe, resilient and sustainable) is specifically dedicated to cities and communities, and the 167 countries participating in the UN's Habitat III conference in 2016 elaborated the New Urban Agenda (UN, 2017b) as a global guideline for urban development. Beyond national governments, cities are also emerging as significant actors in their own right, and city networks such as the C40 Cities Climate Leadership Group and ICLEI (Local Governments for Sustainability) are providing a platform for international policy diffusion for urban sustainability.

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What is an indicator?

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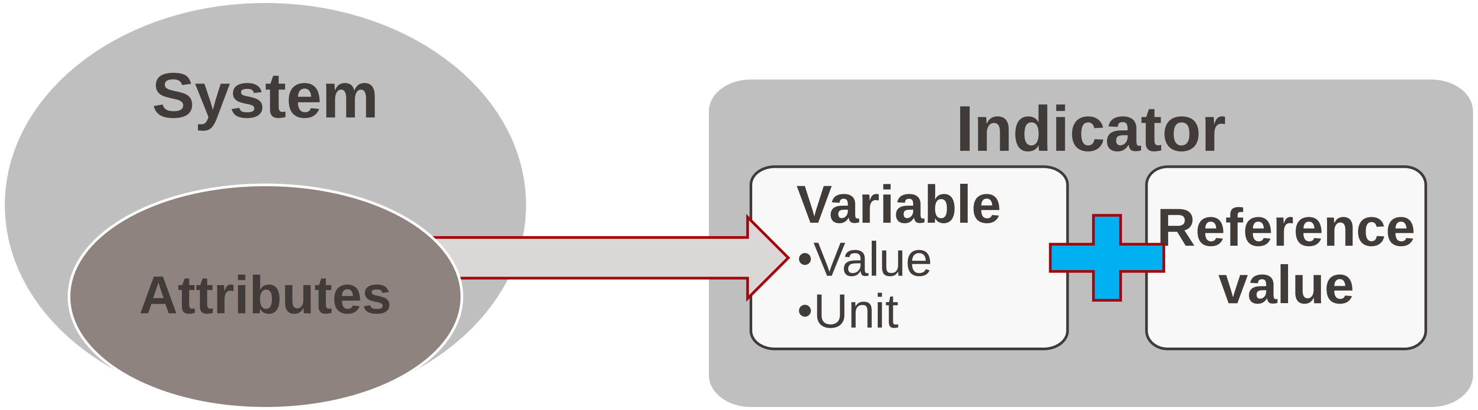
Indicators - Purposes

What are the purposes of indicators for sustainability assessment?

- Information challenge
  - Structure complexity and communicate information
  - Identify knowledge and data gaps
- Interpretation challenge
  - Express and operationalise sustainability
- Influence challenge
  - Encourage accountability and benchmarking
  - Social learning

Source: Waas et al., 2014

What is an indicator?



- **An indicator is…**
  - a representation of an attribute of a given system
  - by a quantitative or qualitative variable, including its value related to a reference value
- **An indicator can be either…**
  - Descriptive or normative
  - Quantitative or qualitative
  - Objective or subjective
  - Community or expert-defined

Source: Waas et al., 2014

What is an indicator?

An indicator is **an instrument that provides an indication**, generally used **to describe** and/or **give an order of magnitude** to a given condition

In our daily life we continuously use indicators to understand and interpret the world, mostly without actually realizing it…!

Illustration: How is your health?

Age

Weight

Stress

Cholesterol

Sports

Healthy food

Drugs

Smoke

Exposure to chemicals

Respiratory capacity

Previous health issues

Alcohol

Genetic predisposition

Headaches

Illustration: What's my house worth?

Bedrooms

View

Property taxes

Character

Floor area

Location

Energy efficiency

Nearest shop

Garden

Bathrooms

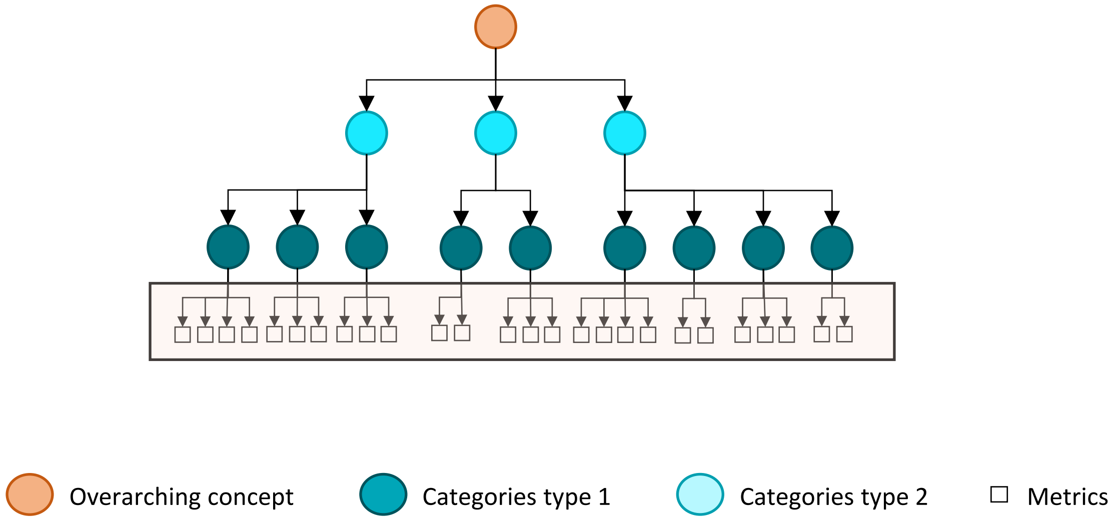
Fire place

Garage

What is an indicator?

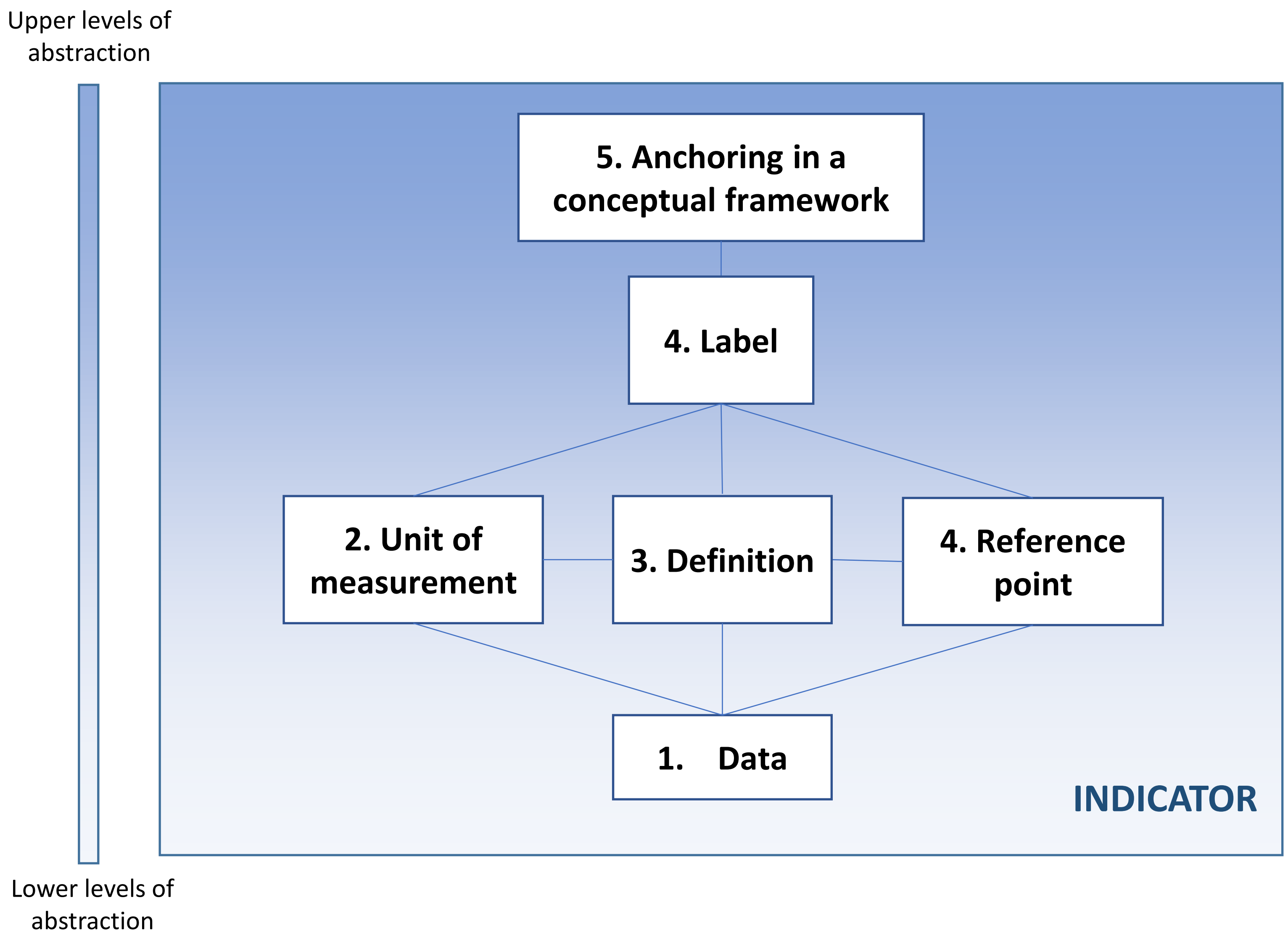
"We understand indicators as **allegorical representations** through which an issue of larger and usually **complex significance is broken down into specific and comprehensible features**".

Urban Sustainability



Merino-Saum et al. 2021

What are indicators made of?



Merino-Saum et al. 2021

1. Data

- Data gaps are the rule, not the exception!

OECD | 60 Data › Français Search for OECD data

Indicators

- Water withdrawals
- Wastewater treatment

Water withdrawals Total, Million m3, 2010 – 2018 Source: Water: Freshwater abstractions

Show: Chart Map Table fullscreen share download My pinboard

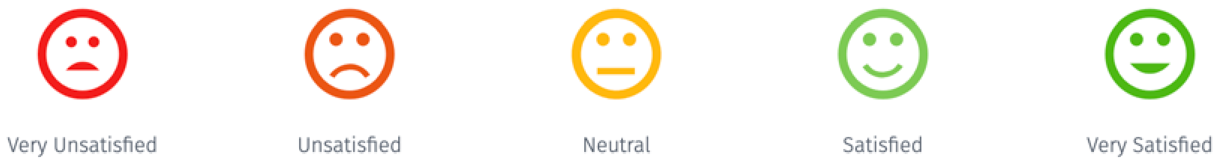
Location	2010	2011	2012	2013	2014	2015	2016	2017	2018
Latvia	200.4	176.2	187.1	180.1	168.4	176.6	185.7	181.0	205.5
Lithuania	741.3	612.1	668.7	443.1	388.6	410.5	340.1	291.6	286.0
Luxembourg	47.6	46.3	44.6	43.1	46.0	45.3	45.0	..	..
Mexico	80 213.5	81 588.1	82 733.7	81 651.2	84 928.8	85 664.3	86 576.8	87 841.5	..
Netherlands	10 931.2	10 188.1	10 738.8	10 638.9	9 408.1	8 410.8	7 988.7	7 916.4	8 093.4
New Zealand	5 200.5	..	..	..	9 874.3	..	..	..	..
Poland	11 644.9	11 910.8	11 478.5	11 242.7	11 308.5	11 093.5	11 152.9	10 652.0	10 333.7
Portugal	..	..	..	..	..	..	..	4 836.9	..
Russia	72 685.0	68 652.0	66 296.0	65 104.0	64 807.0	62 163.0	63 000.0	62 648.0	..
Slovak Republic	600.7	593.1	665.3	637.4	559.3	573.6	555.3	578.6	573.1
Slovenia	925.5	850.3	781.3	893.3	978.2	895.1	885.1	929.6	957.4
Spain	35 310.0	35 069.4	34 309.0	32 346.2	32 916.4	31 556.2	31 259.8	..	..
Sweden	2 811.0	..	..	..	..	2 375.0	..	..	..

More on data collection next week

1. Data

- Qualitative / quantitative

  - Satisfaction of local stakeholders with their **involvement in local planning** and decision-making
  - People who feel **safe** walking alone in local area during the day
  - Percentage of people who have **trust** in the political system



  - Implementation of **risk and vulnerability assessments** for disaster mitigation.

    (i) plans present and adequate;
    (ii) plans present and inadequate;
    (iii) plans do not exist.

1. Data and which indicators to select

"if we guide our decisions only by quantitative indicators and not qualitative ones, we will produce a world of quantity without quality. Many of our social and personal problems arise from the fact that we are well on our way of doing exactly that"

"Indicators arise from values (we measure what we care about) and they create values (we care about what we measure)"

(Meadows cited in Waas et al., 2014)

2. Unit of Measurement

2019 SDG Index and Dashboards Report

EUROPEAN CITIES

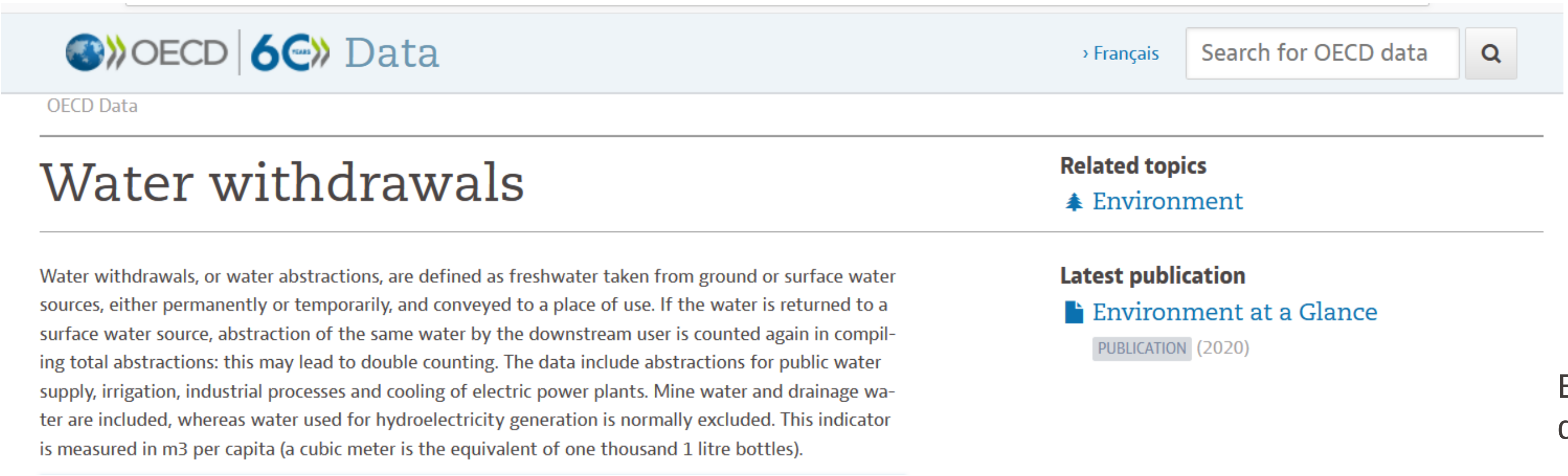
PROTOTYPE VERSION

SDG	INDICATOR	LEVEL	SESCRIPTION
4	Adults with upper secondary education (% 25-64)	Nuts2	The percentage of the population aged 25 to 64 having attained at least upper secondary education or post-secondary non-tertiary education (ISCED levels 3 and 4) .
8	GDP per capita (€/capita)	City	The indicator is calculated as the ratio of real GDP to the average population of a specific year. GDP measures the value of total final output of goods and services produced by an economy within a certain period of time. It is a measure of economic activity and is also used as a proxy for the development in a country's material living standards. However, it is a limited measure of economic welfare.
11	Emission of nitrogen oxides (kg/km2)	City	Annual mean concentrations of nitrogen oxides. Excessive levels of the oxides of nitrogen, particularly nitrogen dioxide (NO2), can cause death in plants and roots and damage the leaves of many agricultural crops. NO2 is the damaging component of photochemical smog. Breathing high levels of oxides of nitrogen can cause rapid burning, spasms and swelling of tissues in the throat and upper respiratory tract, reduced oxygenation of tissues, and a build up of fluid in the lungs.
11	Satisfaction affordable housing (%)	City	The percentage of people who somewhat or strongly agree that it is easy to find good housing at a reasonable price in their city.
12	Municipal waste (kg/capita)	Nuts2	Amount of waste generated by households and businesses standardized per capita.

3. Definition

- A clear definition describes what an indicator means, thereby **preventing misunderstandings** and misuse by its potential users

- An indicator might be considered as being clearly defined when its definition is **easily and coherently understood by its target audience/users**


OECD 60 Data
› Français
Search for OECD data
OECD Data

Water withdrawals

Related topics
Environment

Water withdrawals, or water abstractions, are defined as freshwater taken from ground or surface water sources, either permanently or temporarily, and conveyed to a place of use. If the water is returned to a surface water source, abstraction of the same water by the downstream user is counted again in compiling total abstractions: this may lead to double counting. The data include abstractions for public water supply, irrigation, industrial processes and cooling of electric power plants. Mine water and drainage water are included, whereas water used for hydroelectricity generation is normally excluded. This indicator is measured in m3 per capita (a cubic meter is the equivalent of one thousand 1 litre bottles).

Latest publication
Environment at a Glance
PUBLICATION (2020)

Example of an indicator definition, OECD Data

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4. Reference point

- Reference points clarify the gap existing between the current situation and an either appropriate, optimal or critical level of sustainability
- **They help users to properly interpret the indicator at hand**

- Reference points can be either **absolute** (e.g., thresholds, targets set by the relevant governmental entity) or **relative** (e.g., initial value, average)

- In some cases, a **simple orientation** (↑ ↓) expressing the desired evolution for sustainability is enough

5. Label

▸ Labels help indicators **to be easily and immediately grasped** by any end user, independently from their knowledge and experience

- GINI coefficient

Income inequality

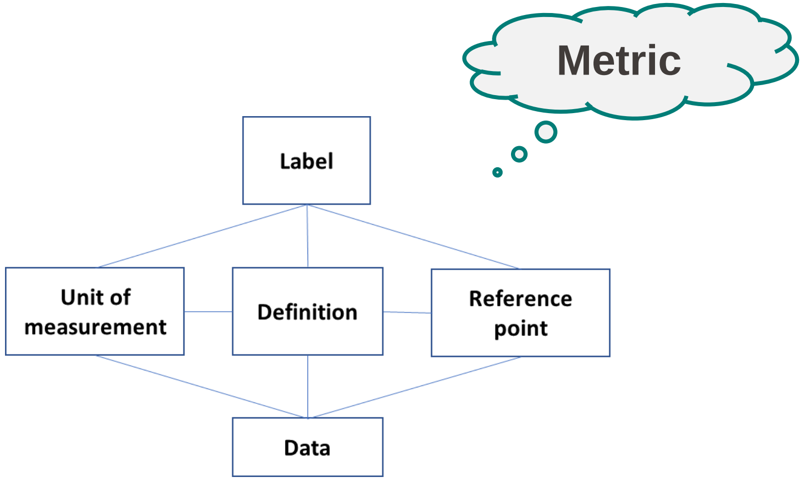
- AROPE rate

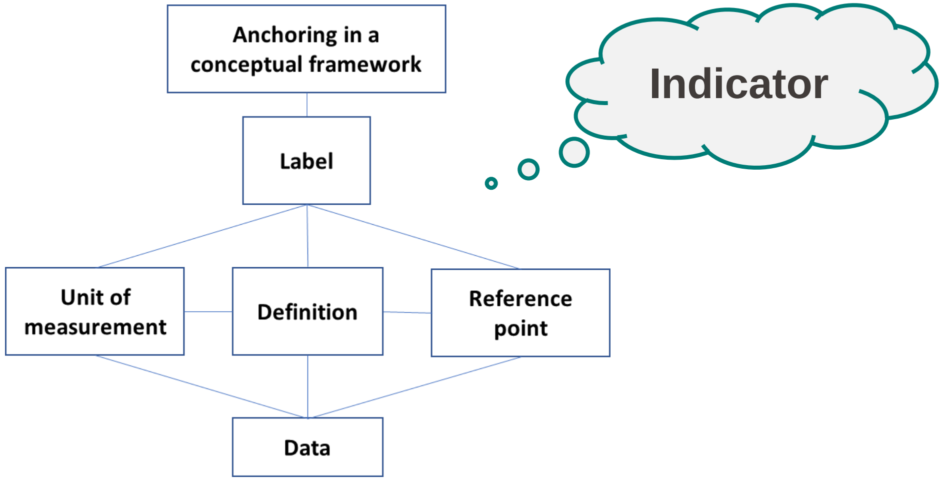
At **R**isk **O**f **P**overty or social **E**xclusion

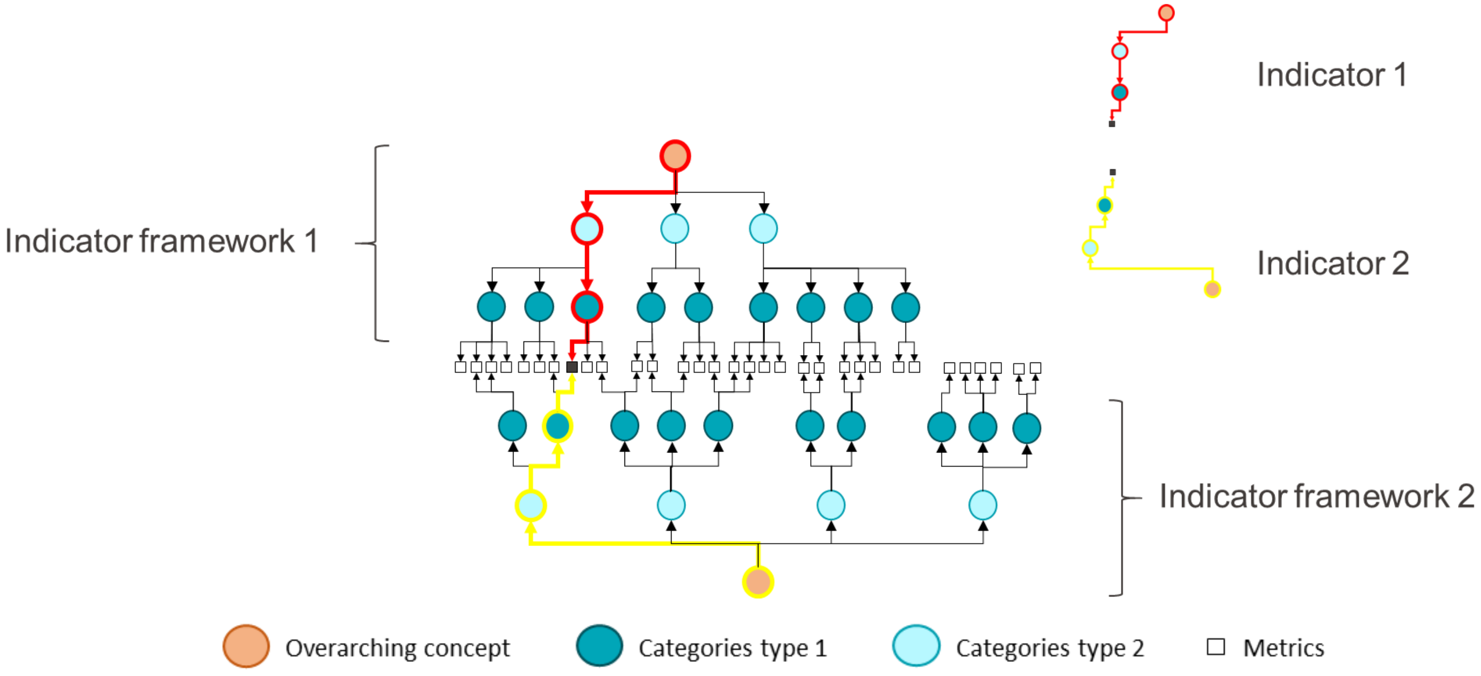
Air pollution

- **Air Quality Index** (Particulate matter (PM2.5) , NO2 (nitrogen dioxide), SO2 (sulphur dioxide), and, O3 (ozone).
- **Satisfaction with air quality** (10-point scale; 1='very dissatisfied' to 10='very satisfied')
- **Percentage of days/year on which standards are met** (%)
- **Annual percentage change in toxic chemicals released into air from production-related waste** (%)

6. Anchoring in a conceptual framework







Example from Lecture 3

Local food production (%)

How should indicators be presented in your report?

An example: indicator framework

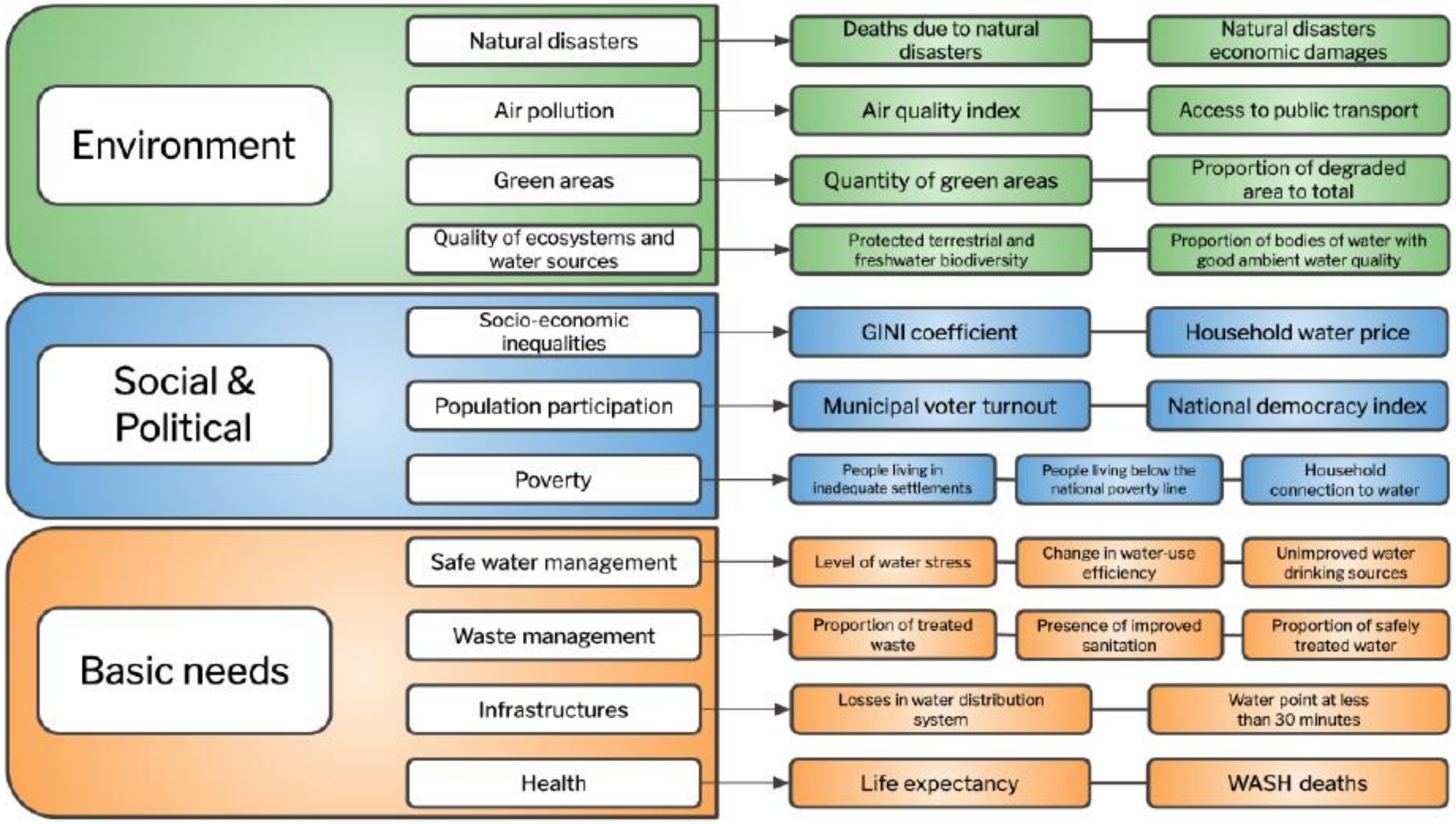


Figure 8: Indicator framework

Source:
Sustainability assessment of 4 cities struggling with a lack of access to water
Charlotte Jianoux, Wei Yin, Nicola Santacroce, Matthieu Souttre, Melanie Droogleever Fortuyn

How should indicators be presented in your report?

An example: indicator table

N°	DOMAIN	THEME	INDICATOR NAME	LABEL	UNIT	DEFINITION	DESIRED TREND
1	Environmental	Natural Disasters	Death caused by natural disasters	ENV-ND-1	death/year	Number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 population	Decrease
2	Environmental	Air Pollution	Air quality index	ENV-AP-1	[-]	Coefficient measuring air quality based on a set of factors	Decrease
3	Environmental	Air Pollution	Access to public transport	ENV-AP-2	%	Proportion of population that has convenient access to public transport	Increase
4	Environmental	Green areas	Quantity of green areas	ENV-GA-1	m2/capita	Square meters of green area per person	Increase
5	Environmental	Green areas	Proportion of degraded area to toal	ENV-GA-2	%	Proportion of land that is degraded over total land area	Decrease
6	Environmental	Quality of ecosystems and water sources	Proportion of protected terrestrial and freshwater biodiversity to total	ENV-QE-1	%	Proportion of important sites for terrestrial and freshwater biodiversity that are covered by protected areas, by ecosystem type	Increase
7	Environmental	Quality of ecosystems and water sources	Water quality	ENV-QE-2	MPN/100ml	Contamination level of water bodies with fecal coliform	Decrease
8	Socio-political	Socio-economical inequalities	GINI coefficient	SP-SE-1	[-]	Coefficient measuring inequality in terms of income over the population	Decrease

+ Data sources

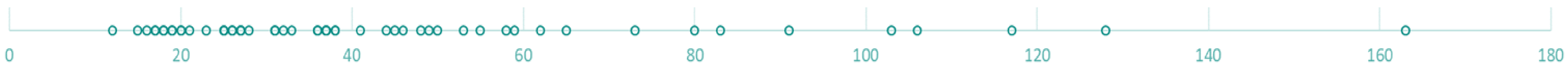
Source:
Sustainability assessment of 4 cities struggling with a lack of access to water
Charlotte Jianoux, Wei Yin, Nicola Santacroce, Matthieu Soutre, Melanie Droogleever Fortuyn

How should indicators be presented in your report?

Conceptual category(ies)	Social; to reduce inequalities	Environment; to improve soft mobility
Label	GINI Coefficient	Length of bicycle network
Units	Index (0-1)	Kms
Data source	OECD	Eurostat
Reference point	Decrease	Increase
Definition	The Gini coefficient is based on the comparison of cumulative proportions of the population against cumulative proportions of income they receive, and it ranges between 0 in the case of perfect equality and 1 in the case of perfect inequality.	Includes both dedicated cycle tracks and cycle lanes. Cycle lanes are part of a carriageway designated for cycles and distinguished from the rest of the carriageway by longitudinal road markings. Cycle tracks are independent roads or part of a road designated for cycles and sign-posted as such.

How many indicators should we include in our set?

➢ There is no optimal and fit-to-all size!



Size (number of indicators); sample: 55 indicator sets

- Min: 12; Max: 163
- Average: 45
- Median: 36

Based on Merino-Saum et al. 2021

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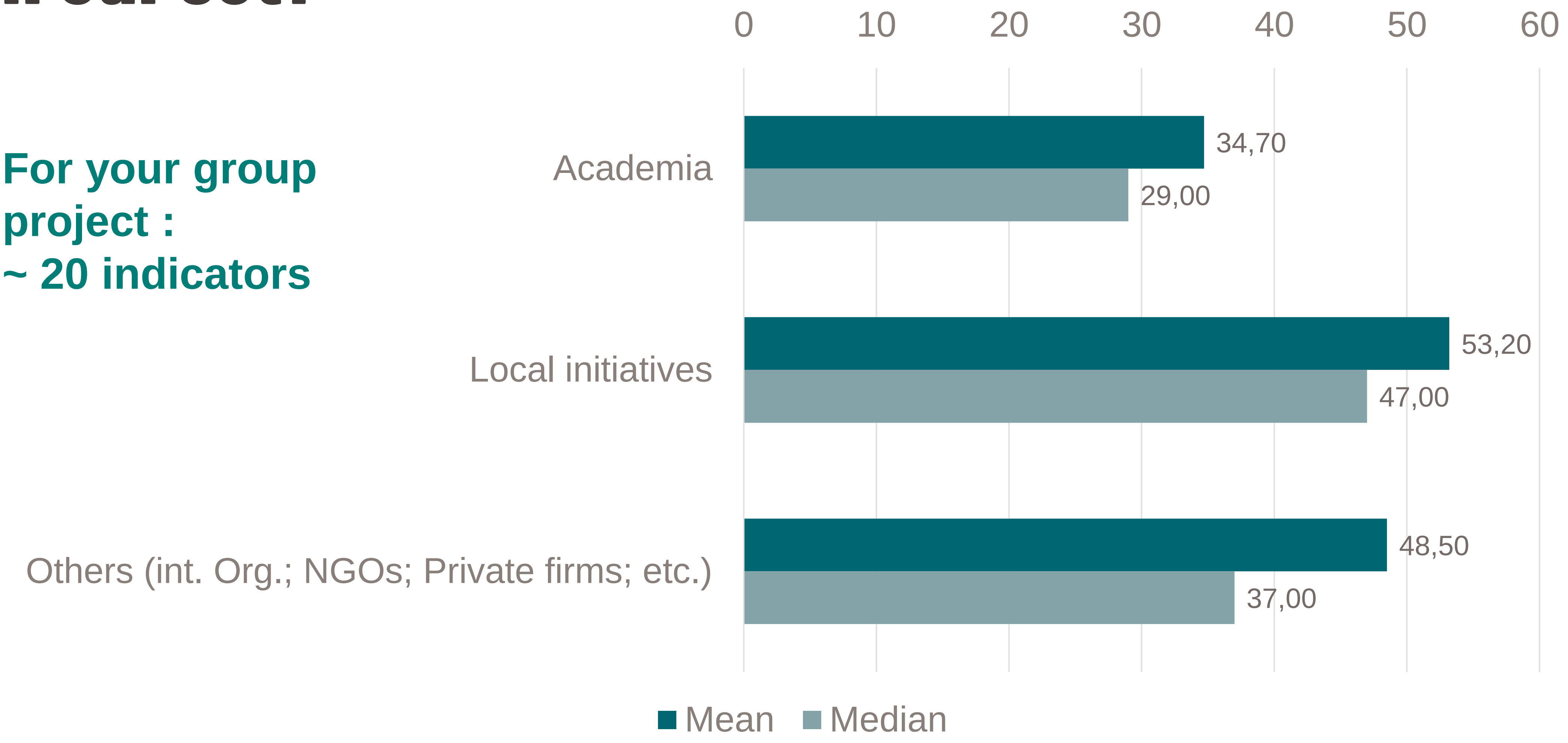
How many indicators should we include in our set?

For your group project :
~ 20 indicators



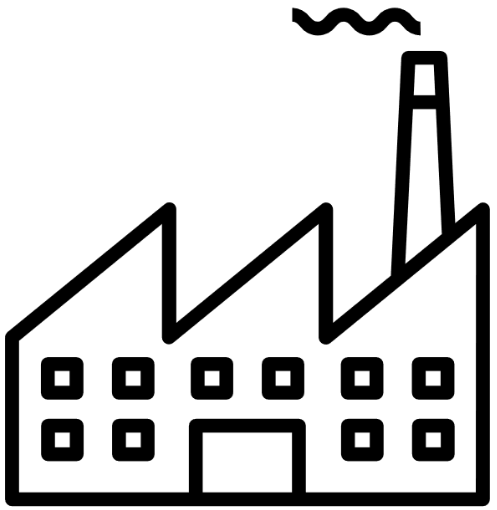
Based on Merino-Saum et al. 2021

How to choose most suitable indicators?

Conceptual categories → List of candidate indicators → Final set based on selection criteria

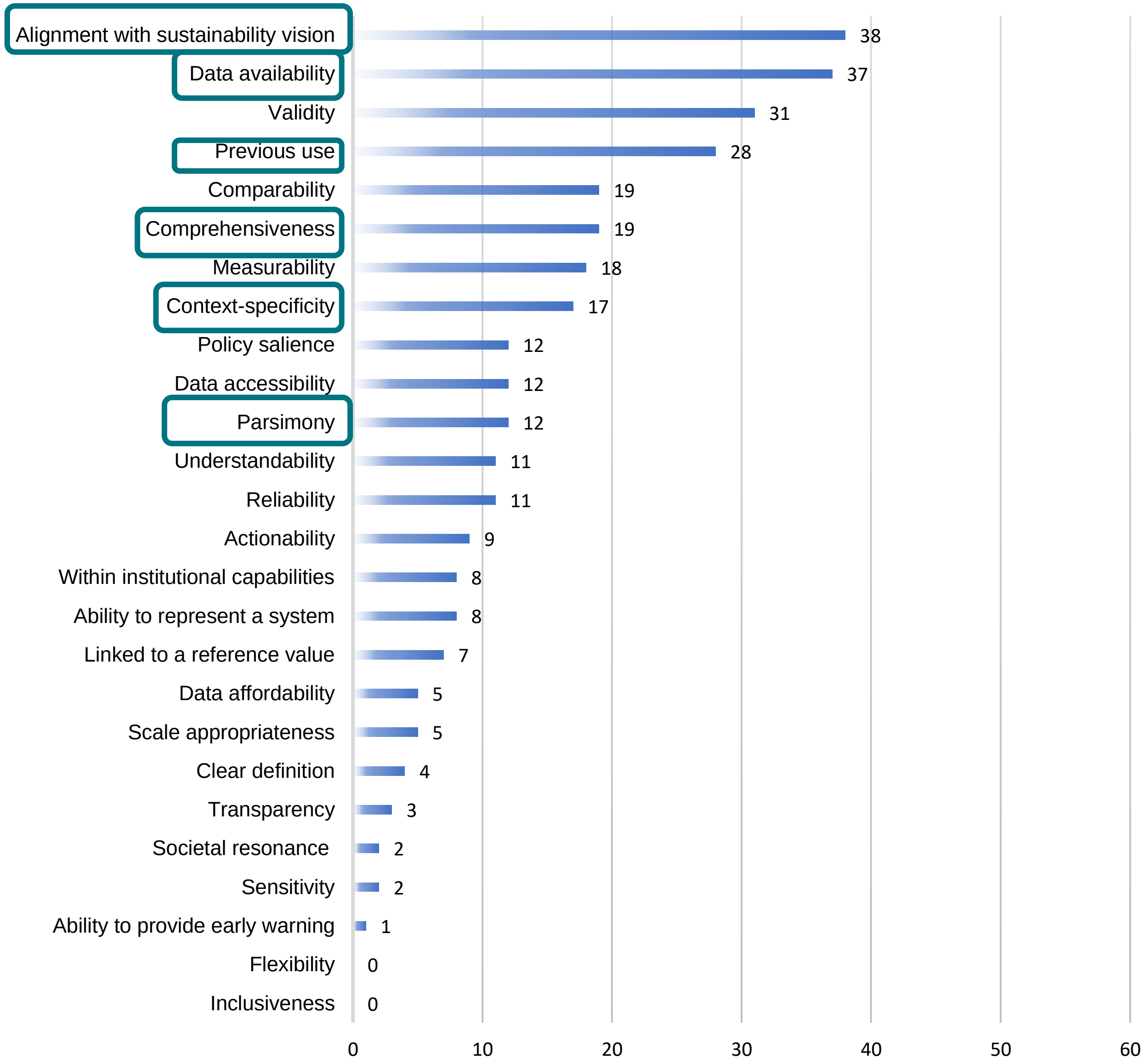
Indicator selection

- **Indicator selection** ineluctably **influences the results** of any measurement initiative (Niemeijer & de Groot 2008; Fiksel et al. 2012; Dale et al. 2015; etc.)
- Indicator selection processes unavoidably **implicate subjectivity** (McCool & Stankey 2004; Rametsteiner et al. 2011; Huang et al. 2015; etc.)
- Given that (i) indicator selection processes influence results and that (ii) they are inherently subjective, they **must be well-defined and transparently reported** (Tanguay et al. 2010; Lebacq et al. 2013; de Olde et al. 2017; etc.)



Indicator «industry»
2 847 indicators for urban sustainability collected from both practice and academia
(Merino-Saum et al. 2021)

How are indicators most often selected?



Selection criteria identified in the sample (by frequency of appearance)

Based on a review of 67 indicator sets, see Merino-Saum et al. 2021

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1. Alignment with sustainability vision

► An indicator is aligned with a vision of sustainability when the former is coherently articulated with both the **overarching concept** to be measured and the underlying **narrative** carried by the indicator set as a whole.

- Illustration **1**: weak/strong sustainability ⇨ • **Incommensurability**
- Illustration **2**: sustainability pillars/interfaces ⇨ • **Multidimensionality**
- Illustration **3**: pro-growth/growth agnostic ⇨ • **Transformative perspective**

Economic growth — Well-being

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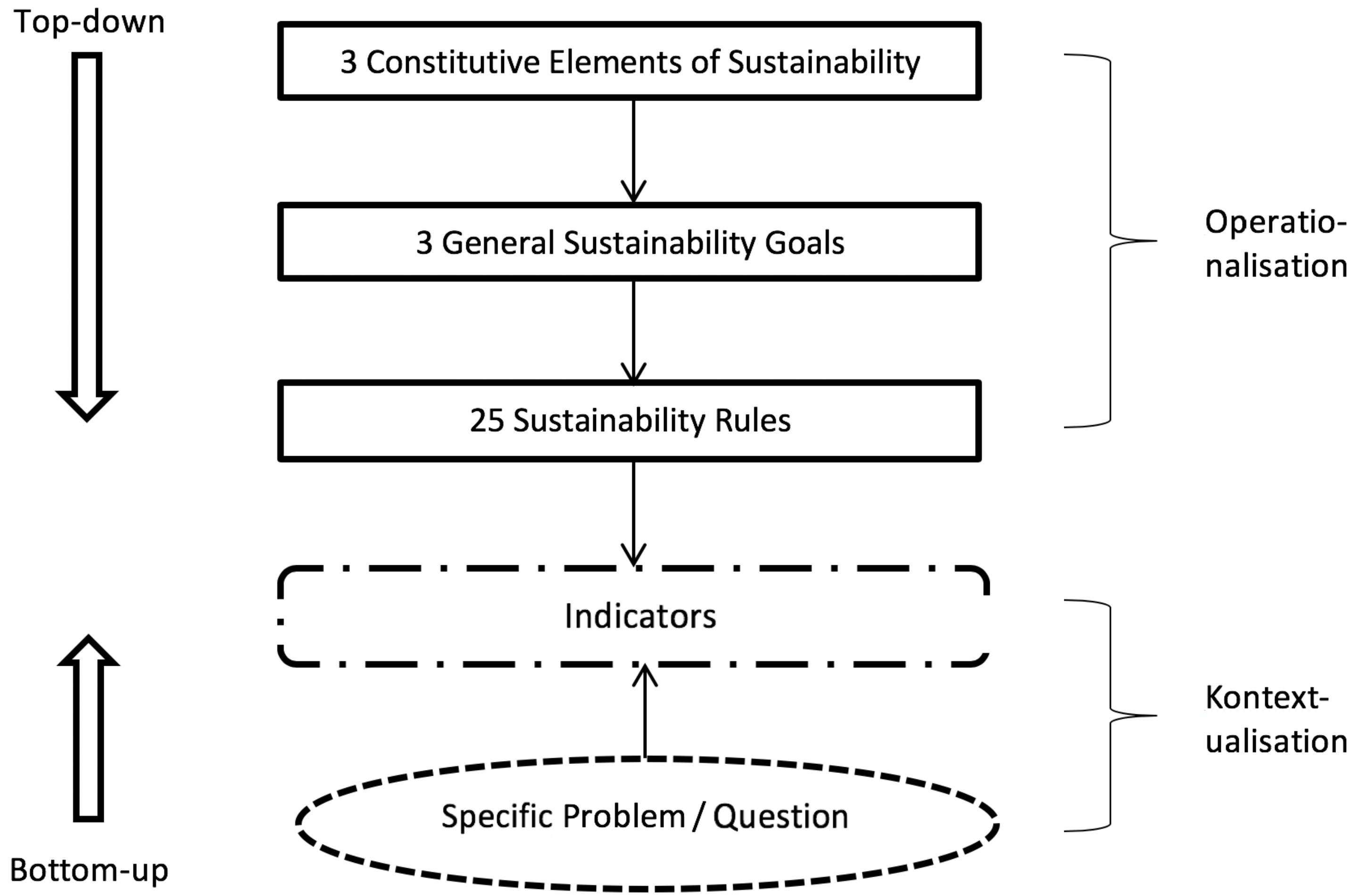
(Halla & Merino-Saum 2022; forthcoming)

1. Alignment with sustainability vision
Procedure to derive indicators (KIT approach)



Source: Stelzer and Kopfmüller, 2019

1. Alignment with sustainability vision: The 25 sustainability rules

Substantial Rules		
Securing human existence	Maintaining society's productive potential	Preserving society's options for development and action
S1. Protection of human health S2. Satisfaction of basic needs S3. Autonomous subsistence based on income from own work S4. Just distribution of opportunities to use natural resources S5. Reduction of extreme income and wealth inequality	S6. Sustainable use of renewable resources S7. Sustainable use of non-renewable resources S8. Sustainable use of the environment as a sink for waste and emissions S9. Avoidance of technical risks with potentially catastrophic impacts S10. Sustainable development of man-made, human, and knowledge capital	S11. Equal access for all to information, education, and occupation S12 Participation in societal decision-making processes S13. Conservation of cultural heritage and cultural diversity S14. Conservation of the cultural function of nature S15. Conservation of social resources

Instrumental Rules	
I1. Internalization of external social and ecological costs I2. Adequate discounting I3. Limitation of public debt I4. Fair international economic framework conditions I5. Promotion of international co-operation	I6. Society's ability to respond I7. Society's ability of reflexivity I8. Society's capability of government I9. Society's ability of self-organization I10. Balance of power between societal actors

Source: Stelzer and Kopfmüller, 2019

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Example of energy system in Chile

Source: Stelzer and Kopfmüller, 2019

Substantial Rules	
Securing human existence	Maintaining society's productive potential
S1. Protection of human health S2. Satisfaction of basic needs S3. Autonomous subsistence based on income from own work S4. Just distribution of opportunities to use natural resources S5. Reduction of extreme income and wealth inequality	S6. Sustainable use of renewable resources S7. Sustainable use of non-renewable resources S8. Sustainable use of the environment as a sink for waste and emissions S9. Avoidance of technical risks with potentially catastrophic impacts S10. Sustainable development of man-made, human, and knowledge capital
I3. Limitation of public debt	I10. Balance of power between societal actors

2. Data availability

▶ Data availability refers to the **factual existence** of the **data** on which an indicator relies.

- Data **availability** ➡ Does data exist (timeliness, regularity, etc.?)
- Data **accessibility** ➡ Is the data easily collectable for any potential end-user independently from her/his professional position, socio-economic status, etc.?
- Data **affordability** ➡ Is the data usable at a reasonable price?

(Reed et al. 2006; Uhlmann et al. 2014)

3. Previous use

► Developers of indicator sets often prioritize indicators that have been:

(i) either particularly **frequently used** in the past;

Frequency

(ii) or included in initiatives with **similar** thematic and/or geographical scopes;

Similarity

(iii) or still previously selected by **notorious institutions** and/or **widely-cited scholars**.

Notoriety

(Tanguay et al. 2013)

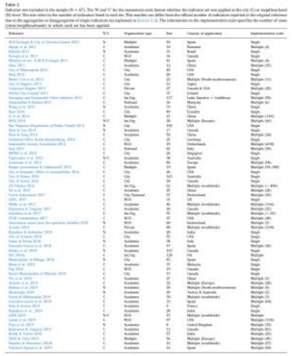
3. Previous use

- Scientific literature

Scopus

https://www.scopus.com/

- Previous sets



Overview of 67 sets in Merino-Saum et al. 2021

- International data bases

eurostat

OECD Data

- Cities

Which is most frequently used in the 67 indicators sets analyzed?

- Unemployment rate (% of population)
- Green areas (m^2/capita)
- Energy consumption (kwh/capita/year)

3. Previous use

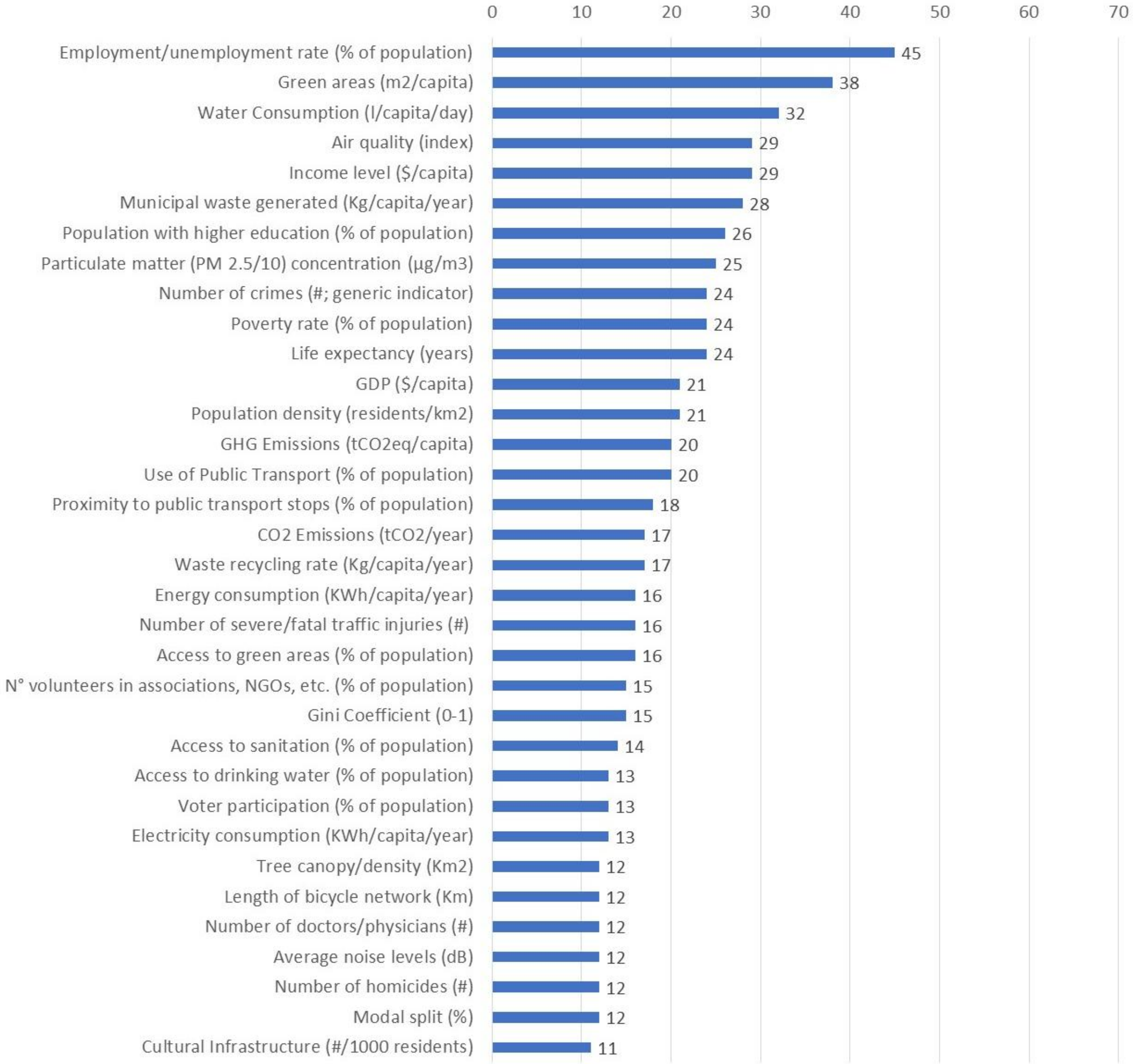


Fig. 4. Most frequent (net) indicators ranked by the number of indicator sets in which they appear. Brackets enclose exemplified measurement units for each indicator based on the most frequent unit used in the indicator sets.

Consistency over time; comparability; legitimacy;

Might perpetuate existing gaps; unsuitable coverage of emergent issues;

(Merino-Saum et al. 2021)

4. Comprehensiveness / Sufficiency

► Generally speaking, something is comprehensive when it is complete and includes **everything that is necessary**.

In the particular context of sustainability indicators, comprehensiveness refers to both:

- the **components** or properties that are inherent to the system at hand
- the **values** that concerned actors convey

… comprehensiveness requires us to **identify blind spots** in the indicator set

… considers the **whole indicator set**

4. Comprehensiveness / Sufficiency

Illustration: Sustainable Development Goals (SDGs)

- Which SDG receives the greatest attention in the 67 indicator sets analyzed?
- Which are the blind spots?

2030 Agenda for Sustainable Development UN (2015)

4. Comprehensiveness / Sufficiency

- Which SDG receives the greatest attention in the indicator sets analyzed?

Climate action

Gender equality

Zero hunger

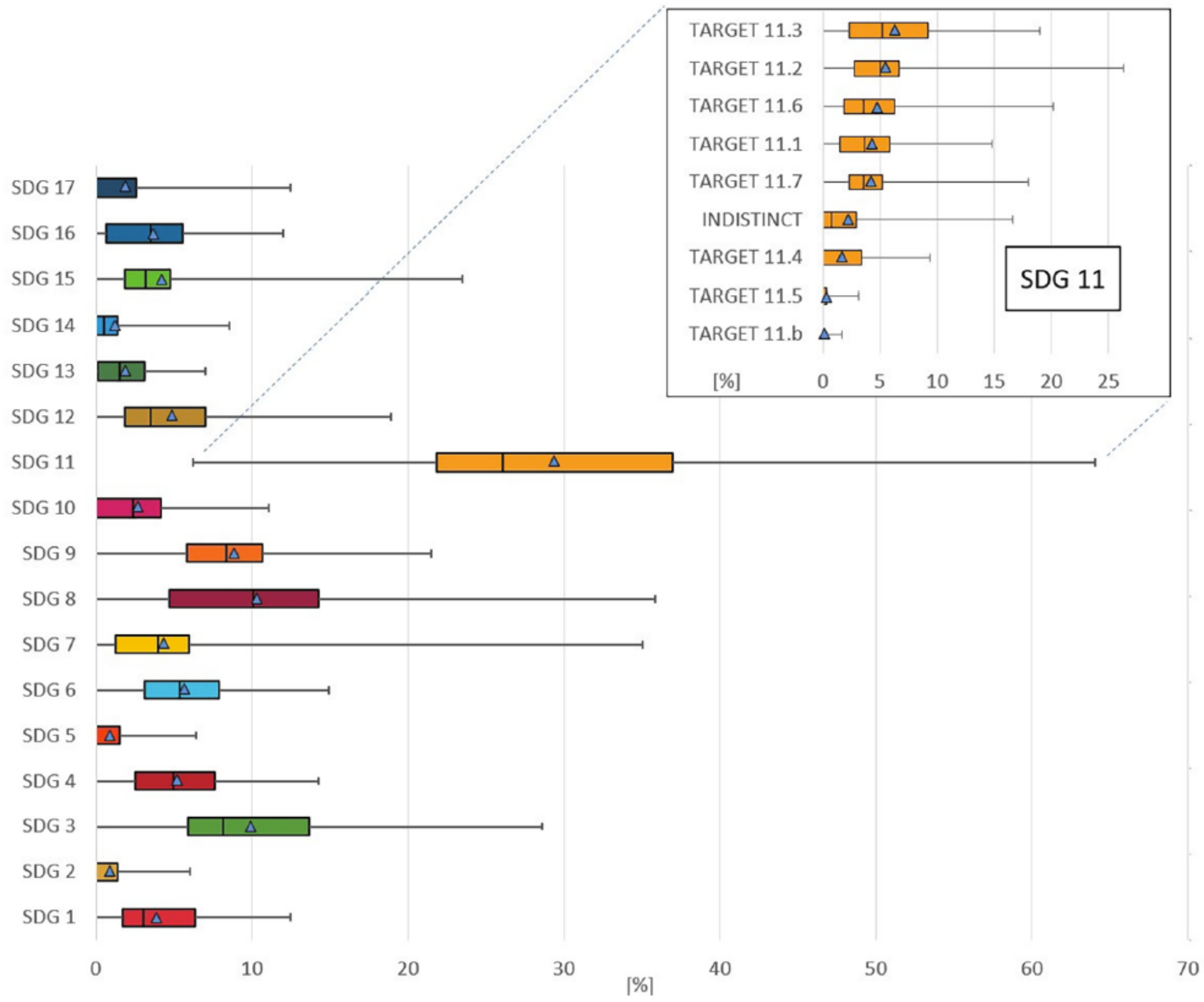


Fig. 5. Relative importance given to each SDG by the analyzed indicator sets.

(Merino-Saum et al. 2021)

5. Context-specificity

► An indicator is context-specific if it is able to explicitly **address an issue or concern that is characteristic of the city** (or the group of cities) under study

- **Context-specificity** ➡ Refers to specific features (e.g. geographical, cultural, environmental, political, socio-economic) that differentiate a city or a group of cities
- Scale-appropriateness ➡ Refers to generic spatial scales (e.g. neighborhood; city; agglomeration; canton; etc.)

(Astleithner et al. 2004; Rydin 2007)

5. Context-specificity

Sustainable water management

Aragón (Spain)

- Water Stress
- Water availability
- Freshwater withdrawals

Bretagne (France)

- Drinking water quality
- Trophic status (nutrient pollution)
- Phosphorus concentration

Las Vegas (USA)

- Average amount of water consumed per person per day
- Average annual hours of water service interruptions per household

6. Parsimony

► A parsimonious indicator set represents the system under study with **as much simplicity as possible** and **just enough indicators as needed**

… Parsimony generally requires to identify **potential redundancies** within a set, thus minimizing overlap between indicators

…considers the whole indicator set

(Spangenberg et al. 2002; Binder et al. 2010)

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6. Parsimony

indicators	condensation suggested by the research team	suggested indicators
• GHG Emissions • CO2 Emissions	select only one of them	• GHG Emissions
• Total Employment • Unemployment rate (by sex, age and persons with disabilities)	select only one of them	• Unemployment rate (by sex, age and persons with disabilities)
• Climate change adaptation frameworks • Implementation of National Strategy for Sustainable Development and Action plan	select only one of them	• Climate change adaptation frameworks
• Expansion and implementation of environmental sectors • Green growth contribution to economic growth • Green Investment (finance/capital/incentives/subsidies)	select only one of them	• Expansion and implementation of environmental sectors

Case study: Green Economy Measurement Framework in South Africa (Merino-Saum 2019)

Indicator selection another view

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I: Criteria for indicator selection (Bossel, 1999)

Knowledge about and perception of the total system. What is our model of the total system? What is the organization and interconnection of subsystems?

Perception of subsystems and their interrelationships. What are the parts and processes of subsystems? How do they interact?

Scenarios of future developments. Which developments are possible; which are likely?

Time horizon. How far should we try to look ahead?

Systemic horizon. Should only essential systems be observed, or should nonessential systems be included, like rare species without economic value?

Interests of the observer/manager. What information is of interest for various reasons? What information is needed for management?

General scheme for identifying indicators of viability (Bossel, 1999)

H: **Ratio** of full-time employed people
S: **Ratio** of investment/depreciation rate
N: **Rate** of change of species diversity

H: **Rate** of change of life expectancy
S: **Rate** of change in Nr. of farms
N: **Fraction** of life support originating in region

basic orientor	viability of affecting system	contribution to affected system
effectiveness	Is it effective and efficient?	Does it contribute to the efficient and effective operation of the total system?
freedom of action	Does it have the necessary freedom to respond and react as needed?	Does it contribute to the freedom of action of the total system?
security	Is it secure, safe and stable?	Does it contribute to the security, safety and stability of the total system?
adaptability	Can it adapt to new challenges?	Does it contribute to the flexibility and adaptability of the total system?
coexistence	Is it compatible with interacting subsystems?	Does it contribute to the compatibility of the total system with its partner systems?
psychological needs*	Is it compatible with psychological needs and culture?	Does it contribute to the psychological well-being of people?

* *only for systems with sentient beings*

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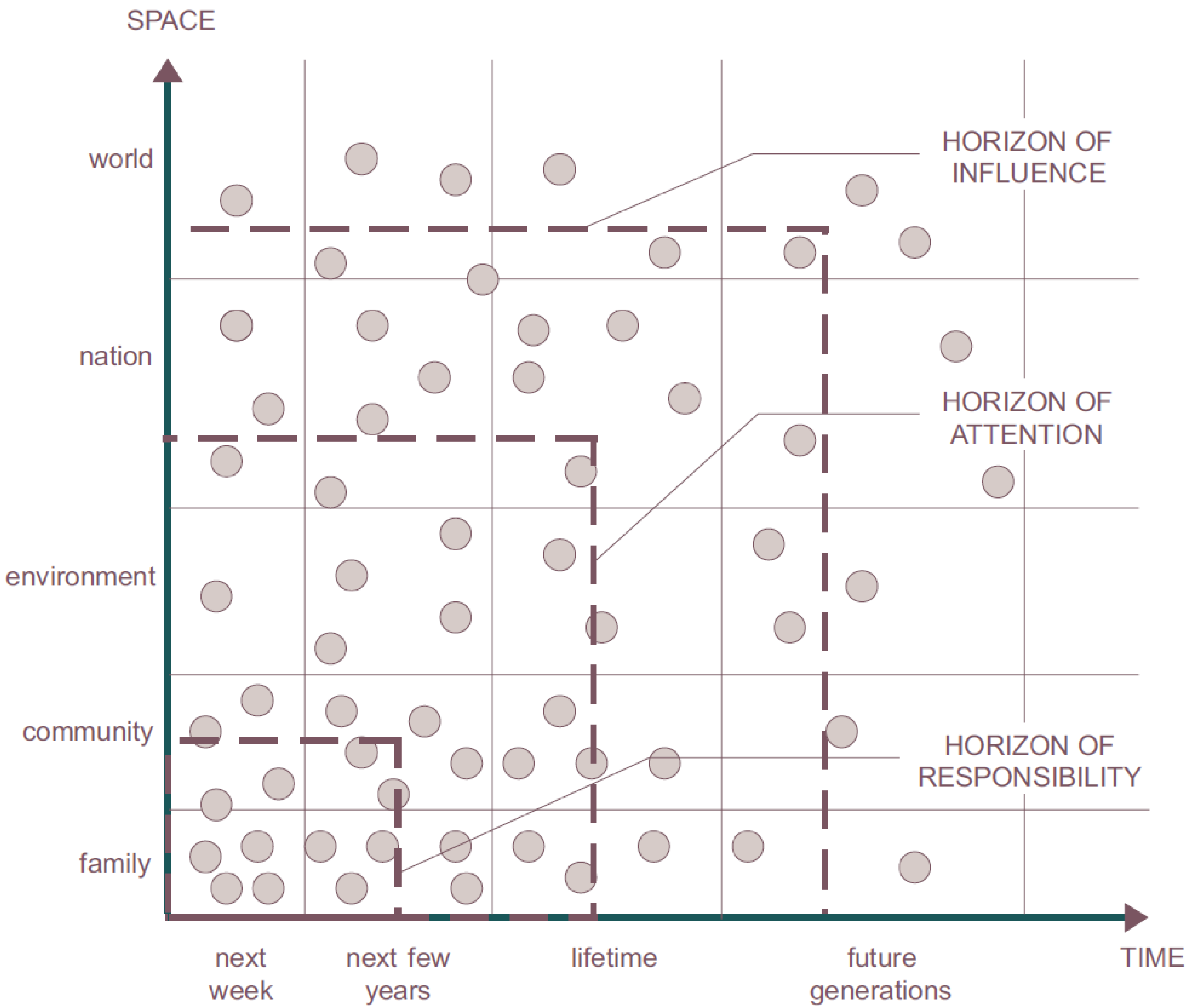
H: Human
S: Support
N: Natural

Horizons of influence, attention and responsibility



Bossel, 1999

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Ways for reducing your indicator set

Reducing the number of indictaors

- **Aggregation**. Use the highest level of aggregation possible.

- **Condensation.** Locate an appropriate indicator representing the **ultimate cause** of a particular problem, without bothering with indicators for intermediate systems.

E.g., using fossil fuel consumption as an indicator for threats to global climate and viability of the global system.

- **Basket average**. If several indicators representing somewhat different aspects of a question should all be considered, define an **index** that provides an average reading of the situation.

E.g., *using the representative **basket of consumer goods** for economic statistics*.

- **Basket minimum**. If a particular aspect depends on the acceptable state of each of several indicators, **adopt the one with the currently worst performance** as representative indicator.

E.g. *farmers representation in parliament*

6. Parsimony / Condensation

indicators	condensation suggested by the research team	suggested indicators
• GHG Emissions • CO2 Emissions	select only one of them	• GHG Emissions
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Case study: Green Economy Measurement Framework in South Africa (Merino-Saum 2019)

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Reducing the number of indicators

- **Weakest-link approach**. Identify the weakest links in the system and define appropriate indicators. Do not bother with other components that may be vital but pose no viability threats under fore- seeable circumstances.

For example, using availability of water in savanna agriculture as a weakest link, not nutrients, labour or farm machinery.

- **Representative indicator**. Identify a variable that provides a reliable information characteristic of a whole complex situation.

E.g., *using the occurrence of lichen as indicator of air pollution*. Note: when using a representative indicator, it is particularly **important to state clearly what it is supposed to represent**.

Wrap-up

- An indicator is:
  - Made of data, a unit of measurement, a definition, a reference point, a label
  - Anchored in a conceptual framework (e.g. goals/dimensions)

- Selection of indicators **influences the results** of any measurement initiative & **involves subjectivity**
- Rationale guiding the selection of indicators needs to be **transparently reported**
  - Possible selection criteria are: data availability, previous use, validity, comprehensiveness, parsimony, context-specificity, …
  - Some selection criteria focus on the individual indicator (e.g. validity), others consider the whole indicator system (e.g. parsimony)

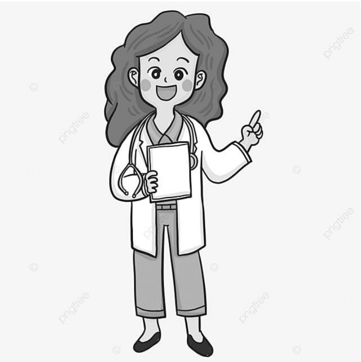
Appendix: additional indicator selection criteria

Validity

► A valid indicator is one that is **conclusively representative of the construct** it is intended to characterize.

To be valid, an indicator must tell us something **significant** (pertinent) about the construct it purports to measure; it must pertinently reflect it (even if it simplifies it).

Health status?



Healthy food

Genetic predisposition

Exposure to chemicals

~~**Highest diploma**~~

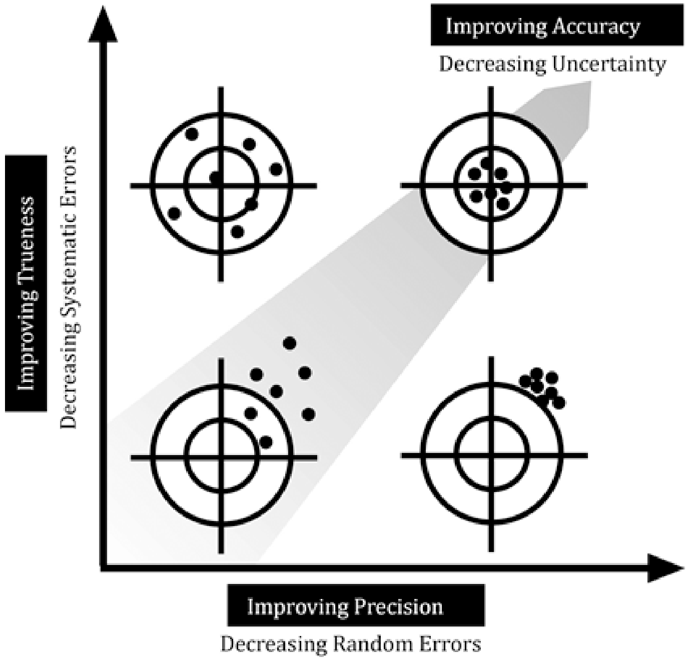
~~**Carbon footprint**~~

(Bossel 1999; Hak et al. 2012)

Validity

• ***Conceptual* validity**: a valid indicator provides a pertinent **symbol** of the construct it refers to

• ***Empirical* validity**: a valid indicator is one that is **accurate** enough to provide a correct estimation of the construct at hand



(Bossel 1999; Hak et al. 2012)

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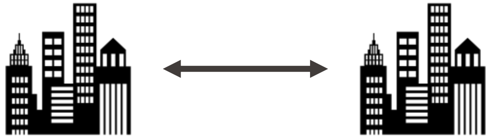
Comparability

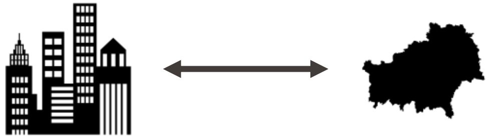
► A comparable indicator is one that is **similar to (or at least compatible with)** at least another indicator either used in another measurement initiative or included in common databases

… Having comparable indicators allows for both:

- comparisons between different urban areas - ***horizontal* comparability**.



- comparisons across dissimilar geographical scales, for instance, between a city and the region it belongs to - ***vertical* comparability**.



(Pinter et al. 2005; Uhlmann et al. 2014)

Measurability

► An indicator satisfies the measurability criterion when it is able **to suitably translate an abstract construct into an either nominal, ordinal or cardinal scale**

We further differentiate:

- ***strong* measurability** (an abstract construct is translated into a cardinal scale)
- ***weak* measurability** (any kind of scale is accepted).

(Bauler et al. 2007; Joung et al. 2012)

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Scientific credibility

Sustainability indicators should (OECD 2001):

(i) be theoretically **well founded** in technical and scientific terms;

(ii) be based on international standards and international **consensus about its validity**;

(iii) lend itself to being **linked to** economic **models**, forecasting and information systems.

Indicators must be at best **widely acknowledged by the scientific community** (Spangenberg et al. 2002).

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Legitimacy

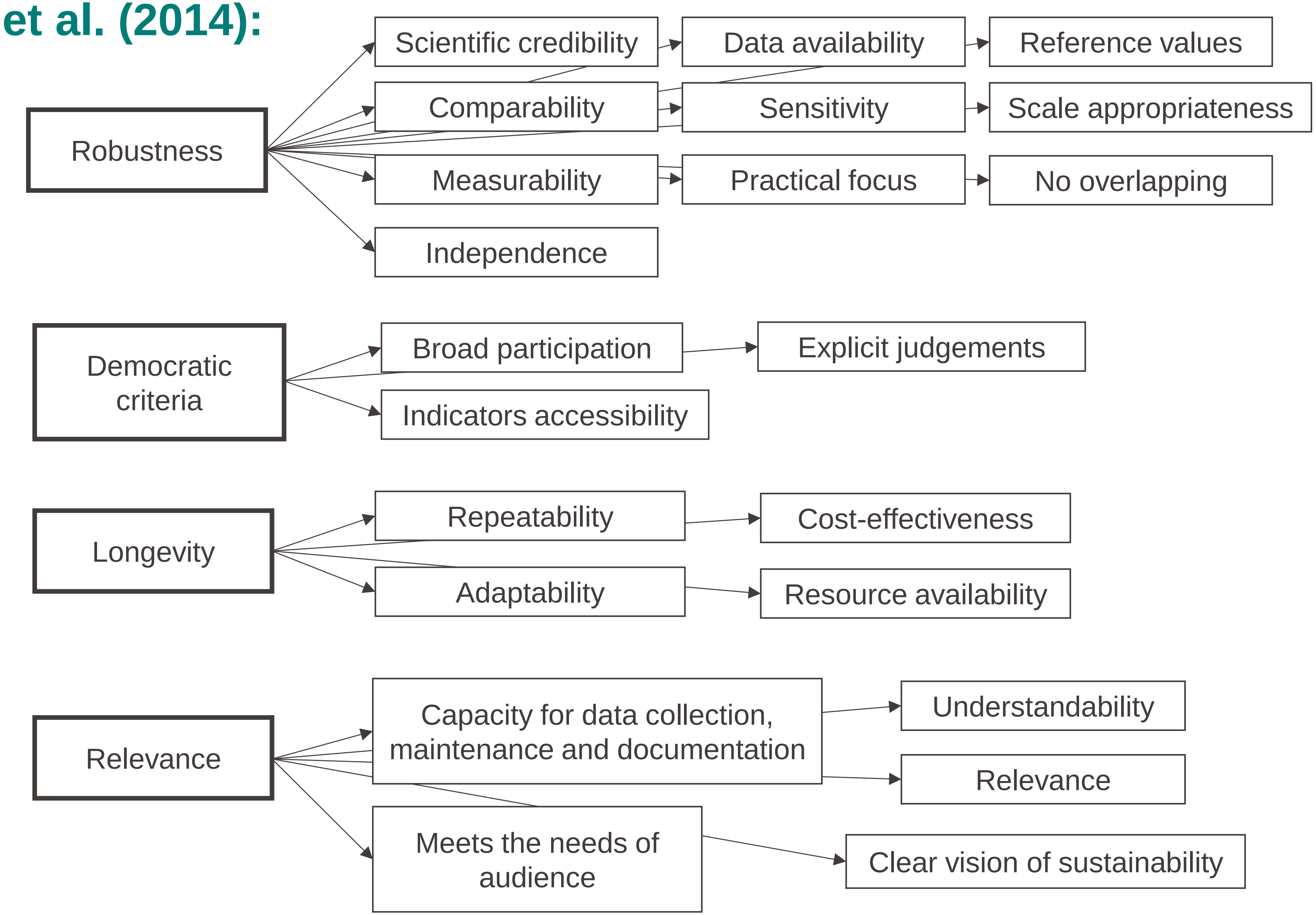
Legitimacy refers to the perception that the indicator set is **respectful of stakeholders' divergent values and beliefs**, unbiased, and fair in its treatment of opposing views and interests (Parris & Kates 2003).

The strength of an indicator depends on its **broad acceptance by major stakeholders** (e.g. growers, policy-makers, scientists, customers) (Moller & MacLeod 2013).

Indicators must measure what is important to stakeholders; they **must have social appeal and resonance** (Reed et al. 2006).

Other typologies of selection criteria

Waas et al. (2014):



Other typologies of selection criteria

Reed et al. (2006):