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IN-DEPTH REPORT:

Indicators for Sustainable Cities

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Erratum notice

This In-Depth Report was revised and updated in **March 2018**, to include new information about the European Green Capital and Green Leaf Awards, the Covenant of Mayors, the DGNB Certification Scheme and the SDEWES Index, and to update weblinks.

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EXECUTIVE SUMMARY

Urban indicators for sustainable cities

Urban sustainability indicators are tools that allow city planners, city managers and policymakers to gauge the socio-economic and environmental impact of, for example, current urban designs, infrastructures, policies, waste disposal systems, pollution and access to services by citizens. They allow for the diagnosis of problems and pressures, and thus the identification of areas that would profit from being addressed through good governance and science-based responses. They also allow cities to monitor the success and impact of sustainability interventions.

A myriad of indicator tools have been advanced and tested in real cities by various organisations and research groups. These tools are available for implementation by others, and usually include aspects of sustainable development beyond environmental dimensions only, such as public health and services, governance, income, business opportunities, and transport.

The challenge for urban authorities is deciding which tool best addresses the needs and goals of a particular city, which would be easy to implement and which are worth the financial and human effort. In some cases, a selection of different tools may be desirable for a city home to a small population; in others, a large city may want to join an established global programme of indicators.

This report aims to provide local government actors and stakeholders with a concise guide to the best currently available indicator tools for sustainable cities, focusing on the environmental dimension. The tools summarised herein were chosen based on scalability and ease of use, and the positive and negative aspects of each for different situations of cities are addressed, along with real-world case studies that demonstrate how they can be implemented.

In Chapter 1 and Chapter 2, the concept of urban metabolism is clarified in the context of environmental, social and economic sustainability, and information on how to choose an appropriate indicator set is provided. Chapter 3 reviews simple, scalable indicator tools, and other useful indicator programmes and approaches are covered in Chapter 4.

It is important to note that an exhaustive list of all available tools, and a comprehensive evaluation of each is beyond the scope of this report. However, as far as possible, further reading suggestions and contact details of the relevant organisations that could assist with implementation or information is provided.

1.Introduction

1.1 Urban metabolism

Animals convert food, water and oxygen into energy and waste products like urine and carbon dioxide. The energy produced may be used to perform activities like moving, breathing or thinking, or it may be stored for later. These processes form part of the animal's metabolism — to stay alive and functioning, it requires resources and it generates waste products.

In much the same way, cities need energy, materials, water and nutrients to provide sustenance and shelter to its citizens, to produce goods and services, to grow and to eliminate waste and pollution (Kennedy, Cuddihy & Engel-Yan, 2007).

And, in the same way that an animal's metabolism is the result of cooperation between the brain, organs and enzymes, urban metabolism is facilitated by the city's governance policies, its infrastructure, and its citizens.

More and more of the world's people are moving to cities, which must expand at a rapid rate to accommodate the influx (Kötter & Friesecke, 2011). Bigger cities demand more food, water and fuel which in turn causes an increase in emissions, refuse and wastewater production (Kennedy, Cuddihy & Engel-Yan, 2007). Unfortunately, this means that while urban systems depend on ecosystem services (Millennium Ecosystem Assessment, 2005) to thrive, they also threaten those same ecosystems through resource-use, land encroachment and pollution.

In fact, the modern urban metabolic cycle drives environmental change on a local-to-global scale, affecting land-use and cover, biodiversity, hydrosystems, biogeochemical cycles and climate (Grimm *et al.*, 2008).
Many of these environmental consequences lead to new large-scale problems that impact on economic activity and public health. Population density increases, socio-economic disparities may be exacerbated and infrastructure problems could arise (Kötter & Friesecke, 2011). As such, researchers emphasise the value of understanding efficient urban metabolism in the context of sustainable city planning (Chrysoulakis, de Castro & Moors, 2014).

1.2 Urban sustainability

The main challenge for today's cities is to manage the heavy dependence on ecosystem services, which results in the depletion of natural resources and biodiversity and the efforts to mitigate and adapt to climate change, while prioritising public health and quality of life.

According to Kennedy *et al.* (2007), a sustainable city can only be one for which the inflow of material and energy resources, and the disposal of wastes, do not exceed the capacity of the city's surrounding environment. In other words, for achieving environmental sustainability urban consumption must match or be below what the natural environment — such as forests, soil and water bodies— can provide, and the resulting pollutants must not overwhelm the environment's ability to provide resources to humans and other members of the ecosystem.

Based on the reports summarised in later chapters of this report, researchers agree that sustainability depends on social, economic, environmental and governance factors.

For example, economic productivity depends on healthy, happy citizens, who need easy access to education, healthcare, security, food, water, transport, clean air and electricity.

Such an ideal situation can be created when cities build efficient waste disposal systems, green spaces and green buildings, public transport and attract employers producing green products from local resources for regional markets. Here, the behaviours and lifestyle of city-dwellers plays a role.

It is also important that cities reduce natural resource consumption (including water and materials like stone and gravel) and waste production footprints, and that they improve land-use efficiencies (especially the reuse of greyfield and brownfield land) so that negative environmental impacts are minimised.

In addition, urban system stakeholders must consider how resources get into the city. How far away are the farms that supply meat and fresh produce? What mode of transport is used to carry materials? Must water be pumped into the city from a low-lying area?

Finally, an integrated approach to urban governance that extends past urban limits to the surrounding area is essential to promote a sustainable dynamic relationship between humans and their environment, ensuring that both quality of life and eco-friendly businesses are promoted, which also sustains economic prosperity in the long run.

The European Environment Agency (EEA) uses the 'DPSIR' (Driving forces, Pressures, States, Impacts, Responses) framework (Gabrielsen & Bosch, 2003) to structure and classify environmental indicators along the causal chain from socio-economic causes to political and societal responses. However, this approach has its limits when it comes to representing the complex interplay between environmental, socio-economic and governance factors — for example, discrepancies have been found in the definition of DPSIR's information categories (Gari et al., 2015; Cooper, 2012). It cannot therefore be deemed suitable to provide the base structure for sustainability indicators.

A widely accepted venn diagram, depicting environmental, social and economic aspects of sustainability (see Figure 1, adapted from Tanguay, 2009) illustrates the necessary integration. Other depictions might set these elements in concentric circles; economic inside social inside environmental. Yet others (Adams, 2006) would emphasise that the environmental elements need to expand in order to match the size of the other two circles. All, however, show that the practical realisation of sustainability can only happen in the overlap — the dynamic — between the 3 fundamental elements.

1.3 How are sustainable cities created?

In other words, to create a sustainable urban environment, it is crucial to measure and assess policies, infrastructure, socio-economic factors, resource use, emissions and any other processes that contribute to and profit from the city's metabolism, prosperity and quality of life. This will allow city planning authorities officials, and governments in general, to identify areas of opportunity as well as concern, and to respond by developing realistic sustainability goals with a long-term perspective.

The following chapters of this In-depth Report provide an overview of a number of established urban sustainability indicators that would be relatively simple to implement by urban planning authorities. The tools and systems presented were selected based on scalability (in terms of city size and access to resources), ease-of-use and support for implementation.

The results of suitable urban sustainability indicators, in combination with models, case studies and other research can inform urban policies geared toward reaching sustainability goals, and further use of indicators allow for ongoing assessments of interventions. That is to say indicators are a key tool for driving science-based urban planning and management.

Figure 1. Venn diagram representing the standard dimensions of sustainable development. Adapted from Tanguay, 2009, and referencing concepts proposed in WCED, 1987.

2. Choosing appropriate urban sustainability indicators

Definitions

Parameter: a property that is measured or observed.

Variable: an element, feature, or factor that is liable to vary or change

Data set: a collection of parameters that have been measured; usually the source of the specific data used by indicators.

Indicator: a parameter, or a value derived from parameters, which points to, provides information about, and/or describes the state of a phenomenon/environment/area, with a significance extending beyond that directly associated with a parameter value.

Analysis framework: a basic structure underlying a system, concept, or text, used to characterise the major issues to be monitored using indicators. Examples include the Pressure-State-Response (PSR) and the Driving forces, Pressure, State, Impact, Response (DPSIR) frameworks for environmental policies.

Index: a set of aggregated or weighted parameters or indicators.

Indicator set: an agreement that defines the overall objectives and outputs that are measured using a selection of indicators.

In this report the term 'tools' is often used as an umbrella term for the definitions above. (Gabrielsen & Bosch, 2003; Organisation for Economic Co-operation and Development, 2003)

According to the Food and Agriculture Organization of the United Nations, indicators allow for the measurement of change in a system:

> "Indicators are selected to provide information about the functioning of a specific system, for a specific purpose — to support decision-making and management. An indicator quantifies and aggregates data that can be measured and monitored to determine whether change is taking place. But in order to understand the process of change, the indicator needs to help decision-makers understand why change is taking place."
>
> (Indicators – what are they?, FAO, 2002)

Policymakers and city managers are today faced with a great array of available sustainability indicator frameworks. These vary in their fundamental purpose, their approach to measuring sustainability, their scale, and of course, their selection of indicators. The common ground to

be found is this: all of these frameworks endeavour to promote sustainable urban development by aggregating diverse information into focussed and applicable knowledge (Hiremath *et al.*, 2013). Indicator frameworks achieve this by reducing the data required to illustrate urban sustainability, and allow communication of that information with diverse audiences (Keirstead, 2007).

It is important that decision-makers trust in and understand the indicators that inform policies. The sheer number and diversity of indicator frameworks can, however, be overwhelming (Zavadskas *et al.*, 2007), and there are significant differences in methodology, conceptual framework or even general approach to the topic (Hammond *et al.*, 1995; Ramos, Caeiro & de Melo, 2004; Moreno Pires, Fidélis & Ramos, 2014).

How, then, to choose between these frameworks? Perhaps the most useful way to start is by understanding the various purposes for which indicators can be used. Fundamentally, they can be applied in three ways: as explanatory tools, pilot tools, or performance assessment tools (Shen *et al.*, 2011).

The European Green Capital Award (EGCA; Berrini & Bono, 2011) is an example of an explanatory tool: where a well-defined set of indicators has been collated in order to evaluate the current state of the environmental dimension of sustainability in a city or urban area. In doing so, the EGCA highlights good practices in order to promote them. As such, the EGCA also falls into the category of pilot tools, which refers to indicators chosen specifically to assist policymaking. Other examples of pilot tools include City Blueprints (van Leeuwen *et al.*, 2012), Urban Sustainability Indicators (Mega & Pedersen, 1998).

The last use-category is by far the most populated, and in fact, performance assessment is widely regarded as the most important role for sustainability indicators (Hiremath *et al.*, 2013). The frameworks that fall into this category are too many to mention, but notable examples include the Global City Indicators Programme (http://www.citiesalliance.org/node/2529), and the Reference Framework for Sustainable Cities (http://rfsc.eu/), a toolkit based on the characteristics of cities.

The next challenge in selecting an indicator framework is in agreeing what constitutes a representative indicator set or index, or even the categories that are most important when measuring progress towards sustainable development. There is some consensus that the four dimensions, or 'pillars', of sustainable development are environmental, economic, social, and governance (Hiremath *et al.*,

Important considerations for using indicators

- Without good data, based on monitoring, it is not possible to develop indicators.
- Performance measures imply that targets need to be set (i.e. against which performance can be compared).
- Different people living in different places have different values. Indicators must therefore be able to take into account different locations, people, cultures and institutions.
- Sets of indicators evolve over time.
- Sets of indicators are seldom, if ever, complete.
- Measurement of indicators tends to reduce uncertainty, but does not eliminate it.
- Indicators can play an important role in how human activities influence the environment — changing the indicators will most likely also change the system.

Source: Food and Agriculture Organization of the United Nations, 2002

2013). Some researchers have observed that EU indicator systems put little focus on social and governance aspects of sustainable development (Adelle & Pallemaerts, 2009), while others say that social and economic considerations are under-represented (Lynch *et al.*, 2011). Almost all indicator sets and indices place an emphasis on the environmental aspect of sustainability, sometimes to the detriment of the other categories (Shen *et al.*, 2011). Generally speaking, and importantly, most indicator sets do not capture how the pillars of sustainability are linked (Adinyira, Oteng-seifah & Adjei-kumi, 2007).

Less fundamental issues faced when choosing an indicator set include standardisation and data availability. As performance assessment is one of the main purposes for using sustainability indicators, it is important to be able to compare performance between similar urban areas. In this way, indicator sets can be validated and improved, shedding light on complex and abstract policy issues (Yigitcanlar & Lönnqvist, 2013).

Standardisation also contributes to improved collaboration and knowledge sharing within and between local governments (Moreno Pires, Fidélis & Ramos, 2014).

It must be noted however that the standardisation of indicators between cities remains an issue, and this raises the question of what precisely constitutes a city? The answer is unfortunately beyond the scope of this discussion.

Data availability is another important aspect to consider when selecting an indicator system. These frameworks are designed by a range of groups and individuals, such as government agencies, non-governmental organisations and universities, to name a few (Sébastien & Bauler, 2013). The result is that there is often little or no consideration of what data is readily available when the indicator set is proposed. City Blueprints is a classic example: despite explicitly planning the indicator set around publically available data, they struggled to obtain the data required to complete the assessment of Rotterdam's water sustainability (van Leeuwen *et al.*, 2012). Pires *et al.* (2014) cite unsuitable or unavailable data sources as one of the most common failings of indicator systems.

It would perhaps be valuable at this point to discuss what aspects of indicator systems are desirable. One thing that is widely agreed upon is that indicator sets need to be locally-relevant — they need to work at the scale (size, physical lay-out, and organisational structure) of the city or municipality (Campbell, 1996; Camagni, 2002). The indicator framework chosen must reflect the geographical

and social context of the urban area in question (Moreno Pires, Fidélis & Ramos, 2014; Hiremath *et al.*, 2013).

Another important observation is that indicators with broad political support have been more successful than those proposed by academic institutions or non-government agencies (Hiremath *et al.*, 2013). Logically, this is because indicators are selected to inform policies that are defined by policymakers; the argument is that policymakers, along with those who are affected by these policies, are in the best position to predict the potential success and sustainability of new regulations and interventions.

Proceeding to the more technical aspects of these frameworks, several lists of desirable qualities for indicators have been put forward. Mega and Pedersen (1998) suggested that indicators should be clear, simple, scientifically sound, and reproducible. Cash *et al.* (2003) define three criteria for the usability of any given indicator: salience, credibility and legitimacy. Zavadskas *et al.* (2007) in turn suggest that a set should be

"well-founded, limited in number, broad in coverage of Agenda 211 goals, obtainable at a reasonable cost–benefit ratio, using data published officially, and must be able to reflect every aspect of urban development." Finally, Hiremath *et al.* (2013) suggest that indicators should be "policy relevant, scientifically founded, readily implantable, and useful for planning purposes."

Taken together, these give a clear indication of the theoretical strengths of an indicator system. Most importantly, though, is that an indicator system needs to address the sustainability needs of the city where it is being implemented (Shen *et al.*, 2011).

Providing a comprehensive guide to choosing an indicator system is beyond the scope of this report. However, the above points cover the most pertinent aspects of how a policymaker could go about selecting an appropriate framework for a given urban area. The following chapters provide some indication of which tools are available, easy to scale and relatively simple to apply.

3. Scalable, easy-to-use indicator frameworks

A number of indicator tools are described below. They are discussed in alphabetical order, as per Table 1, and each summary includes a description of where the tool is relevant, its pros and cons for different situations and goals of cities, how easy it is to apply, how scalable it is, and any other unique information. In addition, links to online resources and tools are provided, and many include case studies that demonstrate the application of the tool. Most tools originate in Europe and were designed for European cities. Where this is not the case, it is indicated in the text.

Indicator/Toolkit:	Organisation:	Read More:
China Urban Sustainability Index	Urban China Initiative	http://www.urbanchinainitiative.org/en/resources/report.html
City Blueprint	Waternet Amsterdam; KWR Water Cycle Research Institute	https://www.kwrwater.nl/en/tools-producten/city-blueprint/
EEA Urban Metabolism Framework	European Environment Agency	http://ideas.climatecon.tu-berlin.de/documents/wpaper/CLIMATECON-2011-01.pdf
European Green Capital Award	European Commission	http://ec.europa.eu/environment/europeangreencapital/about-the-award/
European Green City Tool	European Union	http://ec.europa.eu/environment/urban/tool.htm
European Green City Index	Economist Intelligence Unit; Siemens	http://www.siemens.com/press/pool/de/events/corporate/2009-12-Cop15/European_Green_City_Index.pdf
European Green Leaf Award	European Union	http://ec.europa.eu/environment/europeangreencapital/europeangreenleaf/
Global City Indicators Program	Global City Indicators Facility	http://www.citiesalliance.org/node/2529
Indicators for Sustainability	Sustainable Cities International	http://sustainablecities.net/
Reference Framework for Sustainable Cities (RFSC)	RFSC	http://www.rfsc.eu/
STAR Community Rating System	Sustainability Tools for Assessing and Rating Communities (STAR)	http://www.starcommunities.org/rating-system/
Urban Audit Cities Statistics	Eurostat	http://ec.europa.eu/eurostat/web/cities
Urban Ecosystem Europe - Informed Cities	International Council for Local Environmental Initiatives (ICLEI); Ambiente Italia	http://informedcities.eu/
Urban Sustainability Indicators	European Foundation for the Improvement of Living and Working Conditions.	https://www.eurofound.europa.eu/sites/default/files/ef_files/pubdocs/1998/07/en/1/ef9807en.pdf

Table 1: Scalable, easy-to-use indicator frameworks, sets and tools.

China Urban Sustainability Index

The China Urban Sustainability Index (Li *et al.*, 2014), funded by the Urban China Initiative, is a report into the sustainability of nearly 200 Chinese cities.

The indicator set was developed from the 2011 China Sustainability Index as well as the China Urbanisation Index, using the indicator framework set out in the 2011 CSI. It is an extremely scalable tool, as it was developed for cities ranging in size from 200 000 people to 20 million people.

Emphasis is placed on society and environmental indicators through a weighting system. The strength of the CSI Indicator set is that it is a tool to quantify urban growth and development, rather than a static benchmarking tool. However, the report is not clear on what data was used for the evaluation.

The report can be downloaded at http://www. urbanchinainitiative.org/en/resources/index.html.
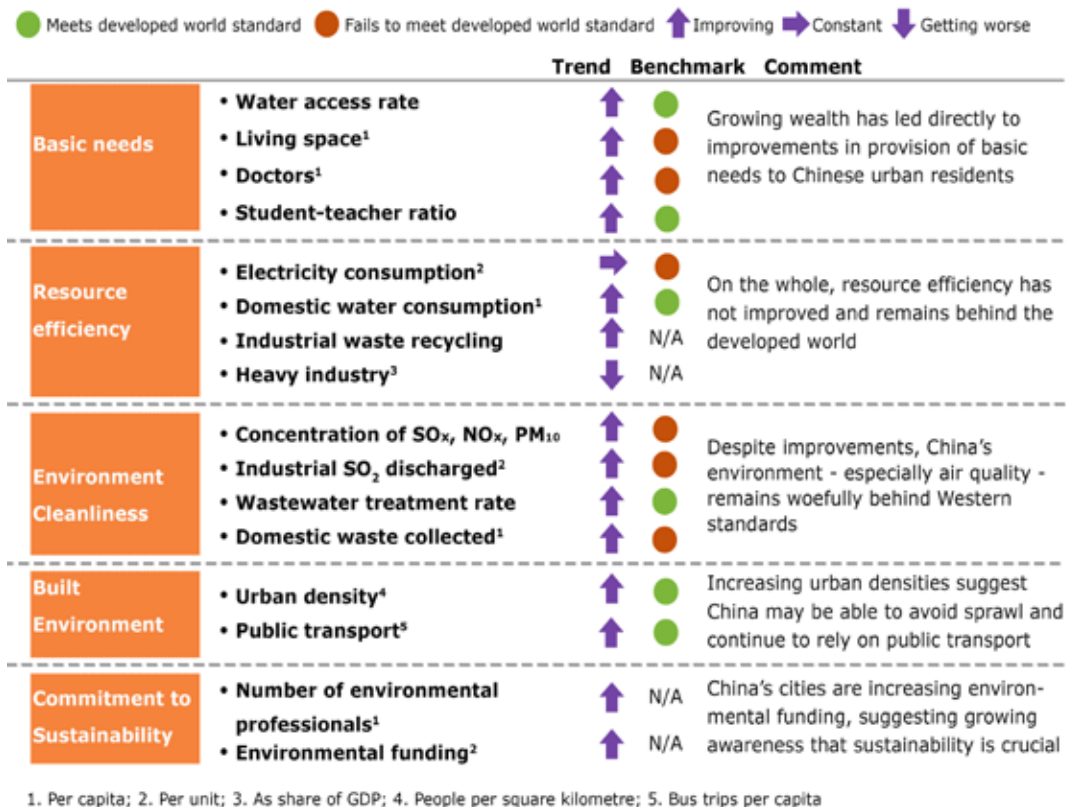

Figure 2:
China Urban Sustainability Index

A summary of China's urban sustainability compared to developed world standards, based on data from 185 Chinese cities. Little emphasis is placed on governance.

City Blueprints

City Blueprints is a tool developed by Waternet Amsterdam and the KWR Water Cycle Research Institute to provide a quick scan and baseline assessment of water sustainability in a city. The overall aim is to provide European city managers and other stakeholders with the base knowledge to implement integrated urban water management and thereby contribute to overall sustainability.

The tool consists of 24 indicators, subdivided into eight broad categories: (1) water security following the water footprint approach developed by Hoekstra and Chapagain (2007), (2) water quality, which includes surface water and groundwater, (3) drinking water, (4) sanitation, (5) infrastructure, (6) climate robustness, (7) biodiversity and attractiveness and (8) governance.

Indicators were selected for ease of use: calculation and scoring is easy, and they aimed to base the indicators on easily accessible public data. The City Blueprints indicator set places its focus on resource use and waste and

pollution (not including air pollution), with less attention paid to governance and long-term sustainability. The set does incorporate some indicators of health, but only uses indicators that are related to water (such as water quality and sanitation.)

City Blueprints attaches a score of 0–10 to each indicator, where 0 indicates poor performance and 10 indicates excellent performance requiring no further attention. This simplified approach also allows for easy comparison between cities.

The output of the tool is a spider-web diagram that clearly indicates regions of good performance and concern. The indicators were tested in a case study in three Netherlands cities, namely Rotterdam, Maastricht, and Venlo (van Leeuwen *et al.*, 2012). This paper also contains brief guidelines for stakeholders on how the findings of a City Blueprints assessment could be implemented.
To implement the tool in your city, visit the website at https://www.kwrwater.nl/en/tools-producten/city-blueprint/.

No.	Description	Dimension
H1	Per capita CO_2 emissions from energy consumption	Urban Flows
H2	Energy efficiency of transport	Urban Flows
H3	Efficiency of residential energy use	Urban Flows
H4	Efficiency of urban water use	Urban Flows
H5	Waste intensity	Urban Flows
H6	Recycling	Urban Flows
H7	Urban land take	Urban Flows
H8	Green space access	Urban Quality
H9	NO_2 concentrations	Urban Quality
H10	PM_{10} concentrations	Urban Quality
H11	Unemployment rate	Urban Quality
H12	Land use efficiency	Urban Patterns
H13	Public transport network length	Urban Patterns
H14	Registered cars	Urban Drivers
H15	GDP per capita	Urban Drivers

Table 2: Headline indicator set proposed by the European Environmental Agency

EEA Urban Metabolism Framework

The European Environmental Agency has studied the possibility of developing an Urban Metabolism indicator system. This is a way to evaluate the sustainability of a city based in metabolic flows rather than performance or current status.

measure of how sustainable a city is. It is informative at a European level rather than at an individual-city level. Implementation of this indicator system will require contacting the EEA (http://www.eea.europa.eu/).

The report (Minx *et al.*, 2010) collated a wide range of indicators from various frameworks such as Urban Ecosystem Europe, all of which are based on publically available municipal datasets (the authors of the report chose to use existing data to make the indicator set easier to implement). From this, they have generated a headline data set of 15 indicators, which were chosen to be representative of the larger set.

This set provides low-cost, continuous monitoring of urban metabolism in European cities. In addition, the report proposes a scaling framework to allow the tool to be used in cities of various sizes.

The strength of this framework is in its simplicity and its use of readily available data sources; however it does not provide the most comprehensive
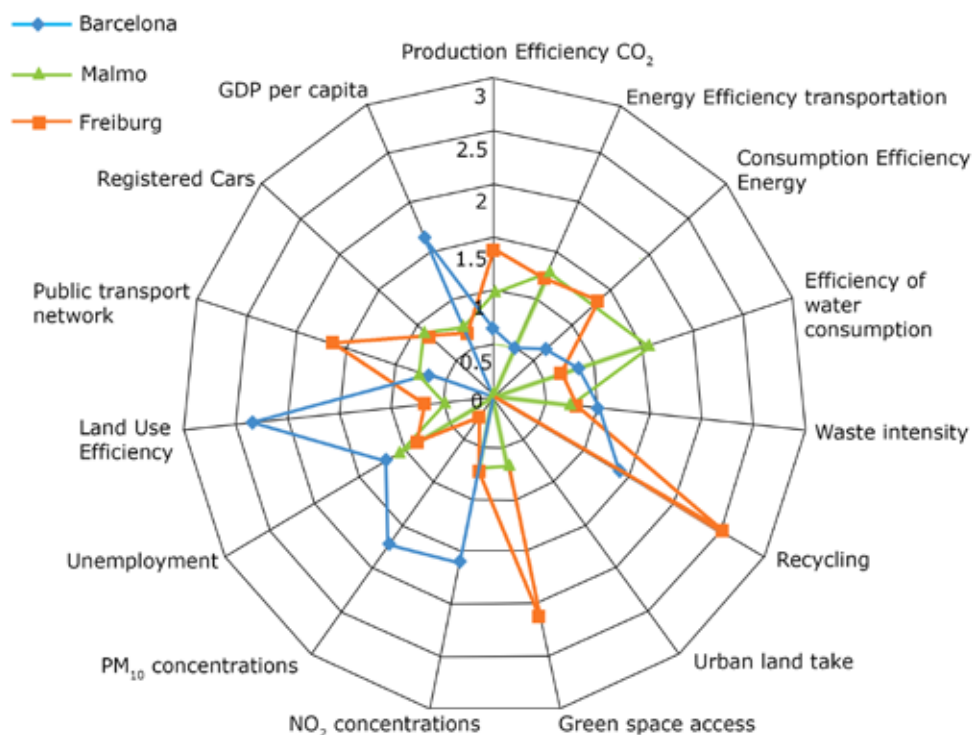

Figure 3: The Urban Metabolism Framework. The Urban Metabolism Framework was tested on three representative cities: Barcelona, Freiburg, and Malmo. This spider diagram shows how each of them compare based on 15 indicators of sustainability. This visualisation makes comparing cities easy and straightforward.

European Green Capital Award

The European Green Capital Award is an annual award that recognises an outstanding commitment to environmental practices in one European city (Berrini & Bono, 2011). Cities are required to have at least 100 000 inhabitants to participate, but there is no upper limit.

Participating cities are judged on an evolving indicator set: 12 indicator areas that cover environmental categories of urban environmental sustainability such as waste and water management, land use, air quality and climate change adaptation and mitigation. The tool is less focussed on economic measures of sustainability. Emphasis is placed long-term strategies for the cities' future, and concrete strategies that have been prepared in a holistic way with all stakeholders and departments involved.

For the 2021 award cycle, these 12 environmental indicators are:
1. Climate Change: Mitigation
2. Climate Change: Adaptation
3. Sustainable Urban Mobility
4. Sustainable Land Use
5. Nature and Biodiversity
6. Air Quality
7. Noise
8. Waste
9. Water
10. Green Growth and Eco-innovation
11. Energy Performance
12. Governance

The European Green Capital Award has run since 2008 with the first winner of the title in 2010. Every year, several reports are issued, such as the technical assessment of each applicant city per indicator area, and a selection of good practices to inspire other cities.

Detailed information on how shortlisted cities were assessed as well as on the award in general is available here: http://ec.europa.eu/environment/europeangreencapital/

European Green City Tool

This self-assessment tool looks at city governance (so it represents yes/no answers about the approach a city is taking and is not about quantitative, scalar indicators) in the 12 indicator areas covered by the European Green Capital Award. The intention of this tool is to be accessible for cities with different levels of knowledge and experience in assessing the environmental performance of their city. It is aimed at both those who have little knowledge as well as those who have taken strides to improve their performance. The data will not be shared and full confidentiality is guaranteed for user cities, other than the collection of generic data for benchmarking. The tool will also offer guidance, and suggest policy actions that other EU cities (in similar situations) have taken.
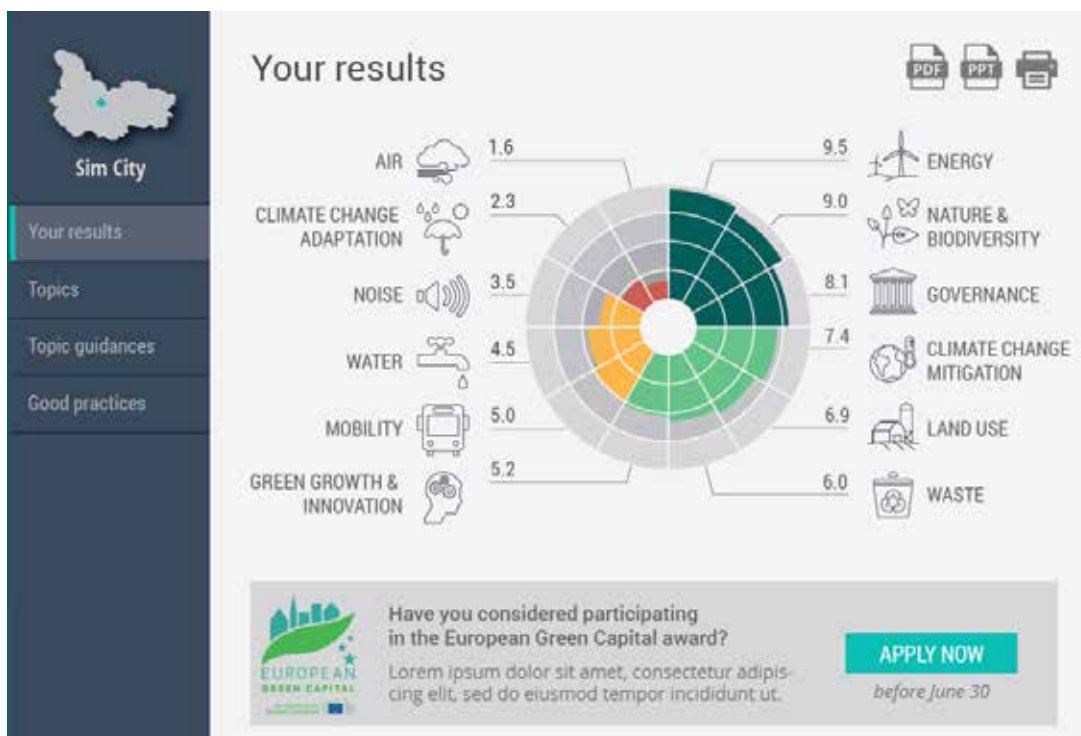
Cities should be able to use the results in communication with citizens, investors or other stakeholders if they wish.

Figure 4: Green City Tool Draft Interface.

European Green City Index

The European Green City Index is an evaluation of the environmental sustainability of 30 European cities ranging in size from less than 1 million people to more than 3 million people (Watson, 2009).

As part of the evaluation (conducted by the Economist Intelligence Unit in cooperation with Siemens), an expert panel developed a set of 30 indicators to compare these cities. The indicator set comprehensively covers all major areas of urban environmental sustainability, with a particular emphasis on energy and CO_2 emissions. Little attention, however, is paid to measures of health, happiness and quality-of-life. The indicators are divided into quantitative indicators, which measure the cities' current performance, and qualitative indicators which cover the aspirations and commitments of a city to sustainable practices.

The indicator set is structured to use publically available data (with the notable exception of CO_2 emissions, which are not well-reported in many European cities), and each indicator is normalised to allow comparison between cities.

This indicator system was not intended for widespread use, but could easily be adapted to the task of evaluating other cities.

To learn more, go to https://www.siemens.com/press/pool/de/events/corporate/2009-12-Cop15/European_Green_City_Index.pdf.

Figure 5: The European Green City Index
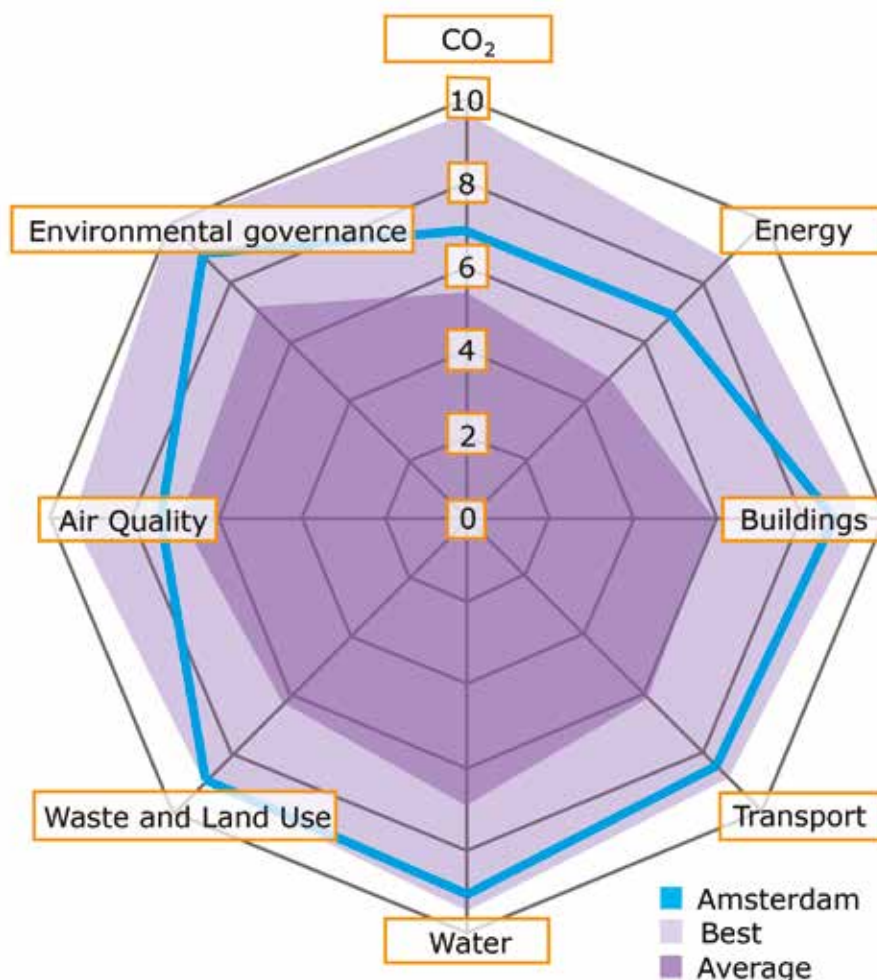
The European Green City Index report presents a fact sheet or profile for each city. This approach highlights the successes and shortcomings of environmental sustainable development in each of the 30 cities in the Index. Here we can see how Amsterdam compares to other cities in an easy-to-read spider diagram — it is clearly doing fairly well in reaching its sustainability goals.

European Green Leaf Award

Inspired by the success of the Green Capital Award, the European Commission launched the European Green Leaf Award in 2015, which is a similar competition, but for smaller cities, i.e. with populations of between 20,000 and 100,000 people. The European Green Leaf recognises the cities and towns which are most committed to green growth and a better environment.

Applicant cities are ranked based on their performance in these 6 topic areas:
• Climate Change and Energy Performance;
• Sustainable Urban Mobility;
• Nature, Biodiversity and Land Use;
• Air Quality and Noise;

• Waste and Circular Economy;
• Water.

The Spanish city of Mollet del Vallès and the Portuguese city of Torres Vedras were the winners of the inaugural European Green Leaf Award 2015 and the Irish city of Galway is European Green Leaf City 2017. The Belgian city of Leuven and the Swedish city of Växjö are the joint winners of the European Green Leaf Awards 2018.

For more information see: http://ec.europa.eu/environment/europeangreencapital/europeangreenleaf/

Global City Indicators Facility

The Global City Indicators Facility (GCIF) has developed and implemented a standardised global indicator set that allows for performance evaluation on an international scale (Global Cities Institute, 2007). See http://www.citiesalliance.org/node/2529.

The tool covers all aspects of urban life, with an emphasis on economic and social measures of sustainability. It does not measure pollution or air quality and there is little mention of renewable energy sources. However, the tool is well-established, and there are already hundreds of cities that are GCIF Members.

A notable strength of the GCIF system is that it is easy to implement.

Indicators for Sustainability

The Indicators for Sustainability report (Dekker *et al.*, 2012) from Sustainable Cities International took a different approach to the development of an indicator set compared to the other frameworks mentioned so far.

It began with case studies of several international cities of varying size. From this information they chose indicators that were common to several cities, easy to understand and implement, and covered multiple related sustainability goals.

The result is a core indicator set that is flexible, easy to implement and relevant to cities regardless of size or location (see facing page). The indicators cover a broad range of sustainability targets. Little weight is given to indicators of health and governance, however.

The report itself (http://sustainablecities.net/) incorporates the indicator list into an easy-to-use Toolkit for Cities. This includes guidelines for evaluating the needs of a specific city and establishing baseline targets, as well as best practices gleaned from case studies.

Reference Framework for Sustainable Cities

The Reference Framework for Sustainable Cities (RFSC) is a toolkit to help European cities implement the sustainability goals of the Leipzig Charter on Sustainable European Cities. It is a freely-accessible and flexible way for cities to stimulate sustainable and integrated urban development in line with Europe 2020 guidelines and objectives (van Dijken, Dorenbos & Kamphof, 2012).

The tool provides practical materials and instruments for cities for this purpose, but also functions as a checklist or planning instrument for future sustainability initiatives.

The indicator set consists of 16 key indicators as well as over 300 supplementary indicators, covering economy, society, environment and governance. The tool places particular emphasis on sustainable governance and economic activity.

Due to the large number of supplementary indicators, the RFSC indicator set is extremely flexible.

Implementation is also straightforward: once a user has registered on the website (http://app.rfsc.eu/), they are guided through the process of generating a unique indicator set depending on the needs and aims of the particular city.

The tool was tested out in more than 80 cities in nearly all EU Member States, ranging from very small to very large. Feedback from that exercise was used to develop the tool into a web-based portal.

Sector	Indicator	Measures
Economy	Unemployment rates/ Jobs	Underemployment/employment/ vunemployment rates; Percentage of green jobs in the local economy; Average professional education years of labour force
	Economic growth	Annual GDP growth rate; Annual GNP growth rate; Net Export Growth rates (% increase of country's total exports minus the value of its total imports per annum; Foreign Direct Investments (Capital/Earnings accrued from listed FDI's per annum)
Environment	Green spaces	Percentage of preserved areas/ reservoirs/ waterways/parks in relation to total land area; Percentage of trees in the city in relation to city area and/or population size
	Reduce greenhouse gases/ Energy efficiency	Total amount of GHG emissions per city and per capita; Percentage of total energy consumed in the city that comes from renewable sources
	Mobility	Transportation mode split (Percentage of each mode of transportation, i.e. private, public, bicycles, pedestrians); Average commute time and cost
	Water quality/ Availability	Total amount of water availability; Water quality index/score; Proportion of population with access to adequate and safe drinking water
	Air quality	Levels of Particulate Matter (PM_{10} – mg/m³); Levels of Particulate Matter ($PM_{2.5}$ – mg/m³)
	Waste/ Reuse/ Recycle	Recycling rate (Percentage diverted from waste stream); Volume of solid waste generated
Social	Complete neighbourhood/ Compact city	Access to local/ neighbourhood services within a short distance; Crime rates; Measures of income distribution and inequality
	Housing	Percentage of social/ affordable/ priority housing; Breakdown of housing sector by property type (owner occupied/ rental, single occupant/couples/family/multifamily etc.)
	Quality public space	Percentage of roadways in good condition; Percentage of green space (public parks) coverage in relation to city area and/or population size
	Education	Number of schools with environmental education programs; Adult literacy rate
	Sanitation	Percentage of population with access to water-borne or alternative (and effective) sanitary sewage infrastructure
	Health	Mortality rate/ Life expectancy; Percentage of population with access to health care services

Table 3: Sustainable Cities International's Indicators for Sustainability list

STAR Community Rating System

The Sustainability Tools for Assessing and Rating Communities (STAR) Community Rating System is a toolbox developed for community leaders in the USA to assess the sustainability of their community, set targets for the future, and measure progress along the way (Lynch *et al.*, 2011).

The indicators were developed over time by a number of technical advisory committees, and will continue to be adjusted as necessary. The tool includes economic, environmental and social aspects of sustainability, and consists of a number of goals, objectives, and evaluation measures.

Human wellbeing and quality of life is highlighted, while less focus is placed on waste management and transport aspects.

The tool is freely accessible at www.starcommunities. org. It provides options for communities to conduct an initial assessment, as well as the possibility to be rated and certified based on the overall score achieved.

No official case studies have been published, but the pilot programme was tested in 34 cities in the USA. Thirteen of those have since achieved STAR Certification. Some examples of successful implementation can be found at www.STARcommunities.org/communities.

Urban Audit Cities Statistics

The Urban Audit, run by Eurostat, is currently the largest urban data collection effort in the EU (Eurostat is the Directorate-General of the European Commission responsible for collecting and distributing statistics for the European Union, as well as harmonising data collection efforts across EU member states). The Urban Audit is comprised of hundreds of variables maintained in an Urban Audit database (Manninen *et al.*, 2004). It is thus not in itself an indicator system, but many of the variables could become indicators if they were integrated in a set dedicated to providing information on a specific issue.

Since 1999, data has been collected every 3 years from hundreds of cities and urban zones. Cities included in the Audit range in size from 50 000 to 10 million people.

The data set covers all aspects of city life in great detail, and, as mentioned, it could be easily adjusted to suit the needs of a specific city or urban centre simply by selecting a subset of the available variables that could function as indicators. In

addition, all data submitted to Eurostat undergoes a quality check before being included in the Urban Audit.

Participation in the Urban Audit is voluntary, and cities can join the audit by contacting Eurostat (http://ec.europa. eu/eurostat/web/cities). One important consideration is that although the Urban Audit variables are well-defined, the database has not necessarily been well-populated by countries that have not been obligated to participate; in some cases, there is no data available for the cities of certain countries.

Further information on each of the indicators is available in the Urban Audit Reference Guide (http:// ec.europa.eu/eurostat/documents/3859598/5902753/ KS-RA-07-016-EN.PDF/23b5af3c-3348-4155-bab9- f79b89c44dd6?version=1.0).

To access Urban Audit data, go to http://ec.europa.eu/ eurostat/web/cities/data/database.

Urban Ecosystem Europe

The Urban Ecosystem Europe (UEE) Report is an assessment of 32 European cities by the research institute Ambiente Italia, and forms part of the International Council for Local Environmental Initiatives (ICLEI).
As part of the report, researchers developed set of indicators specific to the purpose. They took several other indicator systems into consideration when developing the methodology for the UEE project.

The indicators were chosen to reflect a city's progress towards the Aarlborg Commitments for sustainable cities.

The focus is on local governance and quality of life, but the indicators manage to touch on almost all aspects of urban sustainability.

The cities evaluated ranged in size from 150 000 people to more than 2 million, showing that the indicator set is scalable to both large and small cities. A main output of the UEE report is a series of city profiles that show a city's standing terms of sustainable development.

This is a representative graph (facing page) showing the type of output produced by the Urban Ecosystem Europe Report, 2007. The graph compares annual particulate matter (PM_{10}) concentrations (a common indicator of air quality) for 30 large, medium and small European cities. The report also discusses each indicator result in some depth.
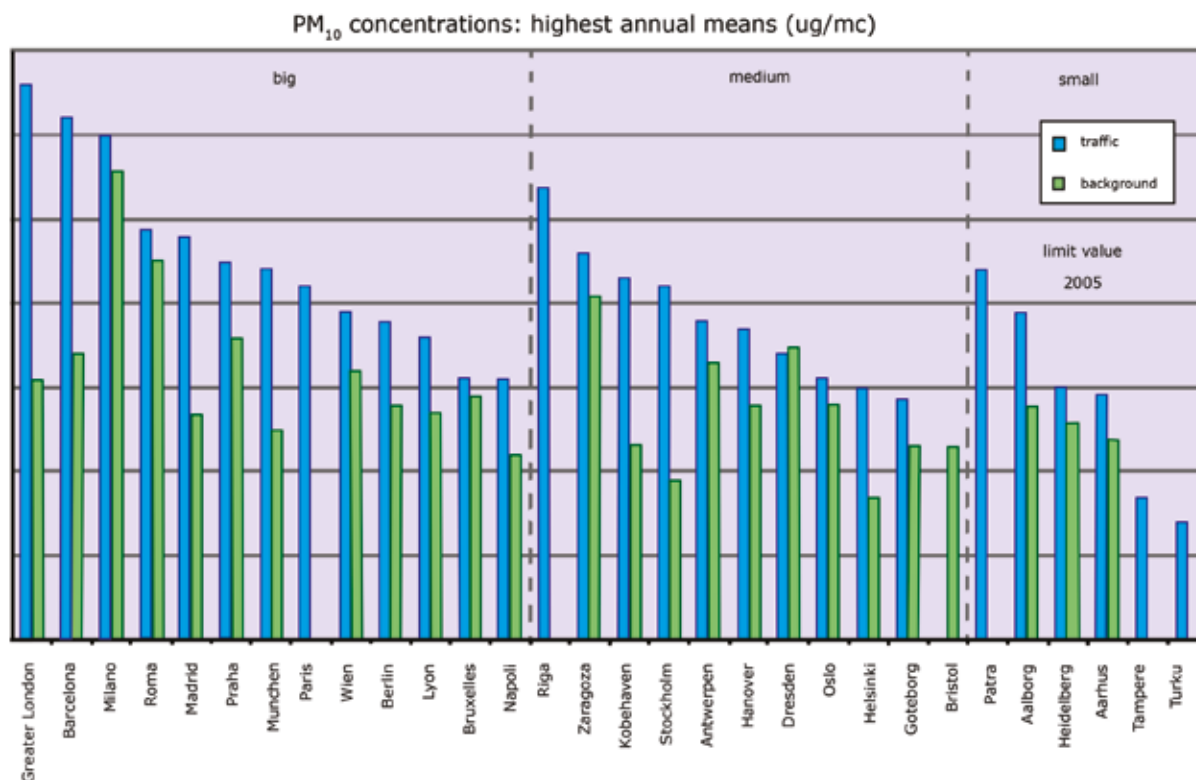
Figure 6: Urban Ecosystem Europe.

Urban Sustainability Indicators

The Urban Sustainability Indicator framework was developed by the European Foundation for the Improvement of Living and Working Conditions from the commitments laid out in the Charter of European Sustainable Cities and Towns, also known as the Aarlborg Commitments (Mega & Pedersen, 1998).

Indicators were assigned to each policy theme identified in the charter, ensuring a brief but highly significant indicator set. The selected indicators effectively cover all aspects of urban sustainability, with a special focus on measures of environmental health. The set was tested on a number of European cities.

Notably, the system includes a 'Unique Sustainability' category, which endeavours to quantify certain sustainable practices or features that are unique to a specific city.

Implementing this indicator system can be achieved using the report (available at https://www.eurofound.europa.eu/sites/default/files/ef_files/pubdocs/1998/07/en/1/ef9807en.pdf), which offers detailed accounts of how to apply and measure each aspect, as well as more general guidelines for city managers.

Indicator	Data components/measure
Global climate	Emitted total CO_2, CH_4, N_2O and CFCs and halons
Air quality	Number of days per year on which alarm levels are exceeded and traffic circulation is stopped
Acidification	Deposition of SO_2, NO_2 and NH_3 per hectare
Ecosystem toxification	Sum of emitted quantities of cadmium, polyaromatic hydrocarbons, mercury, dioxin, epoxyethane, fluorides and copper, and radioactive substances, weighted according to their toxicity and their residence time in the environment
Urban mobility/clean transport	Total number of trips (and their length) by private car and number of trips, (and their length) for commuting and basic needs/inhabitant/year
Waste management	Tonnes of waste disposed of per inhabitant and per year (building and demolition waste, industrial waste, domestic waste, retail and service waste)

Indicator	Data components/measure
Energy consumption	Tonnes of oil equivalent per inhabitant per year for domestic use, industrial use, the tertiary sector and public spaces
Water consumption	Metres^3 per inhabitant per year (total water extracted minus water from recycling and water used for maintenance of public and green spaces)
Nuisance	Percentage of the population affected by noise, odour or visual pollution
Social justice	Percentage of the population affected by poverty, unemployment, lack of access to education, information, training and leisure
Housing quality	Percentage of the population affected by lack of housing or poor housing environments
Urban safety	Total percentage of the population affected seriously by crime or traffic accidents
Economic urban sustainability	Total individual incomes in city minus: city fiscal deficit, environmental expenditure and pollution damage per inhabitant per year
Green, public space and heritage	Percentage of green or public spaces and local heritage in need of improvement
Citizen participation	Total percentage of the population participating in local elections or as active members in associations for urban improvement and quality of life
Unique sustainability	To be defined by cities — this indicator should represent the degree to which unique factors or events lead to urban sustainability with its environmental, social and economic dimensions

Table 4: The European Foundation for the Improvement of Living and Working Conditions' Urban Sustainability Indicators

4. Other potentially useful tools

Here follows a list of tools that may not be as scalable and easy to implement as those mentioned in the previous chapter, nor as comprehensive, but are worth looking into for any city looking at developing indicator tools or taking part in established programmes.

Indicator/Toolkit:	Organisation:	Read More:
BREEAM Communities	Building Research Establishment Environmental Assessment Methodology (BREEAM)	https://www.breeam.com/
Climate+ Development Program	Clinton Foundation; US Green Building Council	http://www.c40.org/other/climate-positive-development-program
Covenant of Mayors	Covenant of Mayors	http://www.covenantofmayors.eu/
DGNB Certification System	German Sustainable Building Council	http://www.dgnb.de/en/
Eco^2 Cities Initiative	World Bank	http://siteresources.worldbank.org/INTURBANDEVELOPMENT/Resources/336387-1270074782769/Eco2CitiesBookWeb.pdf
Eurostat Sustainable Development Indicators	Eurostat	http://ec.europa.eu/eurostat/web/sdi/sustainable-cities-and-communities
Green Cities Programme	OECD	http://www.oecd.org/regional/greening-cities-regions/46811501.pdf

Indicator/Toolkit:	Organisation	Read More:
Green Star	Green Building Council of Australia	http://www.gbca.org.au/green-star/
LEED for Neighbourhood Development (LEED-ND)	Leadership in Energy and Environmental Design (LEED)	https://www.nrdc.org/cities/smartgrowth/files/citizens_guide_LEED-ND.pdf
National Australian Built Environment Rating System (NABERS)	Government of Australia	https://www.nabers.gov.au/public/WebPages/Home.aspx
SDEWES Index	International Centre for Sustainable Development of Energy, Water and Environment Systems (SDEWES) Index	http://www.piran2016.sdewes.org/sdewes_index.php
SynCity	Imperial College London	https://workspace.imperial.ac.uk/urbanenergysystems/public/urs_keirstead2009.pdf
Urban Indicators Guidelines	UN Human Settlements Programme	https://unhabitat.org/urban-indicators-guidelines-monitoring-the-habitat-agenda-and-the-millennium-development-goals/

Table 5: A list of other applicable tools.

BREEAM Communities

Building Research Establishment Environmental Assessment Methodology (BREEAM) Communities is the most widely-used international tool for evaluating the sustainability of large developments and communities (Joss, 2012). It promotes developments that are good for the environment, pleasant to live in and economically feasible. To read more, go to https://www.breeam.com/.

Climate + Development Programme

The Climate Positive Development Programme is a framework to promote practices contributing to sustainable development in the USA (Clinton Foundation, 2011). The programme rewards a range of behaviours and activities that reduce emissions and promote carbon-positive buildings and communities. Read more about the Climate+ Development Programme here: http://climatepositivedevelopment.org/download/attachments/294975/ClimatePositiveFramework+v1.0+2011+.pdf?version=1&modificationDate=1331574106709.

Covenant of Mayors

The Covenant of Mayors for Climate & Energy brings together thousands of local and regional authorities voluntarily committed to implementing EU climate and energy objectives on their territory. This movement started in 2008 (with the support of the European Commission), in which signatory local authorities share a vision for making cities decarbonised and resilient, and for citizens to have access to secure, sustainable and affordable energy. The Covenant of Mayors offers a facilitated self-assessment and peer-to-peer exchange through a common monitoring and reporting template, a flexible reference framework for action, which is adaptable to local needs as well as enhanced cooperation. More information can be found here: http://www.covenantofmayors.eu/.

DGNB Certification System

The German Sustainable Building Council (DGNB) is a registered non-profit organisation and its certification system provides an assessment of the sustainability of buildings and urban districts, using up to 50 sustainability criteria. Buildings are assessed over their entire life cycle. The certification system can be tailored to different possible uses of a building as well as to country-specific requirements. It can be applied internationally. The DGNB certificates exist in bronze, silver, gold and platinum and there is even the possibility of a pre-certification during the planning phase. More information can be found here: http://www.dgnb.de/en/.

The Eco² Cities Initiative

The Eco² Cities Initiative is a World Bank Programme that has developed a framework for analysing economic and ecological sustainability of developing cities around the world (Moffatt, Suzuki & Iizuka, 2012). It uses the Global City Indicators Facility indicator set (mentioned earlier in this report) for initial analysis and provides advice and a decision-support system for developing cities. All of this information can be found in the book Eco2 Cities: Ecological Cities as Economical Cities (http://siteresources.worldbank.org/INTURBANDEVELOPMENT/Resources/336387-1270074782769/Eco2CitiesBookWeb.pdf).

Eurostat Sustainable Development Indicators

This EU indicator set is used by Eurostat for biennial monitoring of the EU Sustainable Development Strategy on an EU and national level. These indicators are intended to give an overall picture of whether the European Union has achieved progress towards sustainable development in terms of the objectives and targets defined in the strategy. They are presented in ten themes; more information can be found at: http://ec.europa.eu/eurostat/documents/2995521/5168890/8-12122013-CP-EN.PDF/be0127a8-69c5-414d-b1ba-e9d025fa54c1.

Green Cities Programme (OECD)

This is a promising international project that has developed its own set of indicators for evaluation of policies in cities and urban areas. However, the project is still in progress and the indicator sets are not publically available. Further information can be found here: http://www.oecd.org/gov/regional-policy/49318965.pdf.

Green Star

Green Star is primarily a tool for rating energy efficiency of existing buildings. It was first developed in Australia, but is also recognised in several other countries, including New Zealand and South Africa (Joss, 2012). For more information, visit http://www.gbca.org.au/green-star/. A comparison of the energy performance assessment between the LEED, BREEAM and Green Star programmes has been done by Roderick *et al.* (2009).

LEED for Neighbourhood Development

Leadership in Energy and Environmental Design for Neighbourhood Development (LEED-ND) is a sustainability certification for neighbourhoods and small communities (Welch, Benfield & Raimi, 2010). It builds on the LEED sustainability certification for buildings (founded in the USA), and aims to reduce vehicle travel, create local jobs and services, and promote green building and infrastructure. For more information, see https://www.nrdc.org/cities/smartgrowth/files/citizens_guide_LEED-ND.pdf.

NABERS

The National Australian Built Environment Rating System (NABERS) is a tool created by the Australian government to evaluate the environmental performance of various types of building (such as houses, office blocks or shopping centres). Greenhouse gas emissions, energy efficiency, water efficiency, waste efficiency and indoor environment quality are all taken into account (Joss, 2012). For more information, go to http://www.nabers.gov.au/public/WebPages/Home.aspx.

SDEWES Index

This index has been developed to evaluate cities' performances and to allow a comparison of best practices. Cities are benchmarked according to 7 dimensions, 35 indicators and close to 20 sub-indicators. Based on the wide scope of the index, the final ranking favours those cities that have above -average performances in as many dimensions as possible. The 7 dimensions are Energy Consumption and Climate; Penetration of Energy and CO2 Saving Measures; Renewable Energy Potential and Utilisation; Water and Environmental Quality; CO2 Emissions and Industrial Profile;,City Planning and Social Welfare; R&D; and Innovation and Sustainability Policy. More information can be found here: http://www.piran2016.sdewes.org/sdewes_index.php.

SynCity

SynCity is a generalised modelling tool for integrated urban energy management, with a focus on sustainability (Keirstead, Samsatli & Shah, 2009). It uses an indicator set as data input for a software model that can be used in the planning stages of an urban development. The tool is described here: https://workspace.imperial.ac.uk/urbanenergysystems/public/urs_keirstead2009.pdf.

Urban Indicators Guidelines

The Urban Indicator Guidelines (United Nations Human Settlements Programme, 2004) set developed by the United Nations Human Settlements Programme focuses on quality of life, with little attention paid to sustainability goals. These indicators were developed to monitor global progress towards the Millennium Development Goals and the Habitat Agenda. An introduction to the Urban Indicator Guidelines can be found on the UN Habitat website: https://unhabitat.org/urban-indicators-guidelines-monitoring-the-habitat-agenda-and-the-millennium-development-goals/.

5. Summary

Sustainability indicators are a proven method for driving sustainable urban development, and hundreds of different sets and frameworks exist. As cities vary greatly in terms of available resources, population size and urban metabolic processes, this wealth of tools is useful. However, choosing appropriate sustainability indicators can be difficult. The advantages, disadvantages and applicability of some of the more successful indicator tools that have been established and validated all over the world have been presented in this report to help simplify the selection process for city planning authorities.

The research reviewed in the preceding chapters shows that efficient governance informed by science-driven policies is a critical component of sustainable development. As progress-measurement tools or static sustainability diagnostics, urban sustainability indicators provide the simple, measurable evidence needed to create and maintain cities that are not just environmentally-friendly, but that promote long-term economic productivity, as well as the health and well-being of their citizens.

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