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*Article*

# Applying the SDGs to cities: business as usual or new dawn?

**Roland Zinkernagel [1,2]*, James Evans[3] and Lena Neij[1]**

[1] International Institute for Industrial Environmental Economics, Lund University, P.O. Box 196, 22100 Lund, Sweden; roland.zinkernagel@iiiee.lu.se
[2] City of Malmö, Environment Department, 20580 Malmö, Sweden; roland.zinkernagel@malmo.se
[3] Department of Geography, University of Manchester; Oxford Rd, Manchester, M13 9PL, UK; james.z.evans@manchester.ac.uk
* Correspondence: roland.zinkernagel@iiiee.lu.se; Tel.: +46-708-120227

**Abstract:** With growing urbanisation the sustainability of cities has become increasingly important. Although cities have been using indicators for a long time it is only in the last decades that attempts have been made to collate indicators into indicator sets with the aim of reflecting the many different aspects that need to be covered to assess the sustainability of a city. The aim of this paper is to review how indicators for monitoring sustainable urban development have evolved over time and compare them to the indicators suggested by the UN Sustainable Development Goals (SDGs). The review reveals that previous indicator sets emphasised environmental sustainability, health and economic growth. It is also shown that indicator sets that pre-date the SDGs lacked dimensions such as gender equality and reduced inequalities. In all, the SDG indicators provide the possibility of a more balanced and integrated approach to urban sustainability monitoring. At the same time, a methodology is needed to facilitate the adaptation process of localising the SDGS, targets and indicators. Challenges of local application include their large number, their generic characteristics and the need to complement them with specific indicators that are more relevant at the city level.

**Keywords:** sustainable development goals, urban sustainable development, indicators, evolution of sustainability assessment

## 1. Introduction

Cities have become an important agent for sustainability. Agenda 21, adopted at the 1992 Rio Earth conference, enshrined the active involvement of local stakeholders in delivering sustainable development, giving cities a key role in sustainability efforts [1–3]. In more recent years, cities have actively engaged in the UN climate negotiations, asking for and committing to greenhouse gas mitigation targets [2,4,5]. At the same time, cities are facing many challenges, such as urban sprawl [6,7], limiting greenhouse gas emissions [8,9], satisfactory and sustainable water supply, adequate waste management and improved human health [6,10,11].

Cities have a key role to play in accelerating sustainable development [3,12–14]. 66% of the world´s population is expected to live in cities by 2060 [15] and rapid urbanisation puts a huge strain on urban systems [16,17]. It has become increasingly important to monitor cites' performance in reaching sustainability. As urban systems are complex, a common way to simplify monitoring is the use of indicators [18]. An indicator can be defined as being an observable feature that is assumed to represent a state or a trend, usually an unobservable one, at a certain point in time [19,20]. Cities have been and are using indicators to a larger or lesser degree to assess the development of social issues [21,22] and environmental conditions [23] as well as economic development [22]. During the last two decades there have been many attempts by international organisations and cities themselves, as well as private and interest groups, to develop indicators and indicator sets to monitor cities' sustainable development [24], accompanied by a proliferation of different monitoring methods [12,25].

In the autumn of 2015, the UN adopted the Sustainable Development Goals (SDGs) in order to provide guidance for all countries and all stakeholders to achieve a sustainable development [26]. The SDGs comprise 17 goals covering different aspects of sustainable development, as defined by the Brundtland commission [27,28]. These goals in turn consist of 168 targets and several hundred indicators (UN I-AEG on SDG indicators, 2016) to assess progress in meeting the goals[1].

Especially since the introduction of the SDGs, there is a growing body of literature that deals with various aspects, either regarding the evolution of the SDGs, historically but also forward-looking [27,31,32], as to the degree to which the SDGs themselves, or the way they are structured, can facilitate the progression to a more sustainable development [27,28,33–36], or aspects concerning the applicability of the SDGs and their associated indicators, on different levels.

There is an increasing amount of research dealing with aspects regarding the use of the SDGs in cities [3,16,37–47]. Guides on localising the SDGs are starting to be available [48,49]. Several goals directly address the local level. Yet, a number of researchers point out the fact that cities and urban activities touch upon the majority of all 17 goals [3,41,43]. Recent research has highlighted a number of challenges when implementing the SDGs at local level. The core challenges identified in the literature are summarised below:

- Availability of reliable data in cities [37,42–44,47]. The number of suggested SDG indicators makes it difficult meet the required demand on data.
- Policy relevance in the local context and political prioritisation process [3,31,39,46,50]. Several of the aspects that the SDGs take up might need to be addressed through policies at other than the local level; political prioritisation can simplify, but also jeopardise successful implementation of the SDGs.
- Covering the complexity of urban systems [12,39,42,46]. Local governments deal with many aspects that are interdependent; local implementation of the SDGs will lead to the identification of synergies but also contradictions in goal achievement.
- Dealing with out of boundary challenges and externalities [46,51–53]. Cities not only have an impact within their territories but also elsewhere, leading to challenges in allocating those impacts.
- Indicators in a multilevel and multi-actor governance structure [3,54,55]. Several aspects might need to be addressed at different levels and with different actors, depending on the form of governance structure in each country, including who is responsible for monitoring the addressing of these aspects.
- Need for capacity and skills in the academic and practitioners' field [3,31,46,54]. More knowledge and experiences needs to be gained to be able to use the SDGs in practice as a tool to achieve sustainable development.

This means that even though the SDGs offer a new opportunity to assess cities' sustainability performance at all levels, it is not clear what benefits or barriers exist with regard to implementing SDGs in cities, the extent to which the SDGs will improve the assessment of the sustainability of a city, or how cities actively contribute and get involved in the global challenge of reaching sustainability [3,56]. This paper contributes to addressing these issues.

The SDGs acknowledge the complexity and interrelatedness of development by having progressed from the established distinction of sustainability aspects into various pillars [57]. They require holistic and coordinated actions across sectors, illustrated by goal 17 itself.

The objective of this paper is to review indicator sets previously developed to evaluate the progress of sustainability in cities with the purpose of identifying (1) which are the most commonly used indicators so far, (2) the degree to which the most commonly used indicator sets cover various aspects of sustainable development and (3) how do the previously used indicator sets compare with the indicators suggested by the SDGs. The answers to these questions are then used to place the SDGs in a chronological context and to analyse and discuss the new aspects of sustainable development that the SDG indicators are introducing in evaluating sustainability in cities, whether the SDG

[1] At the time of writing, the number of SDG indicators is 232 of which nine are repeated twice or three times [30]

indicators match the challenges that cities face today, and some of the challenges they may present to cities in terms of operationalisation. The results of the study will be valuable for cities implementing the SDGs on the local level and will contribute to the emerging academic debate by outlining a detailed research agenda to facilitate the implementation of the SDGs at local level.

The remainder of this paper is organised as follows: Section 2 presents the use of indicators in general and in assessing urban sustainability, as well as an outline of the selection of indicator sets included in the analysis of this study. Section 3 analyses the data collected in order to identify trends in how sustainability monitoring has evolved over the years, how well the concept of sustainable development has been captured, and to compare previous indicators with the ones suggested by the SDGs. The paper concludes with a discussion of the challenges for cities and key areas for future research.

## 2. Seeing the forest for the trees? Indicators for sustainable urban development

### *2.1 Conceptual background on sustainability indicators in the complexity of urban systems*

The following section presents the main methodological and conceptual background for identifying and using indicators for monitoring urban sustainable development as identified in the literature. The section summarises epistemological views on indicator use as well as criteria for indicator selection contrasted with the actual selection process that cities implement.

Monitoring development through indicators is regarded as an efficient and meaningful way to condense complex system dynamics into a manageable amount of information that can be used to assess progress against stated outcomes [58]. Part of the research community argues for a selection of indicators based on conceptual frameworks describing the interrelation between human systems and ecosystems. These frameworks are meant to help with structuring the diversity of activities and interactions and thus make it possible to identify and prioritise how to monitor sustainable development [22,33,59,60] and thereby aid the decision-making process of selecting indicators [61]. Nevertheless, the use of frameworks has been criticised for having been developed mostly through a top-down and technically dominated approach, not necessarily considering practical feasibility or use, especially when aiming at monitoring sustainable development [18,22,59].

Indicators should relate to previously identified target values. Literature on indicators in general, as well as literature on indicator use in the urban context, states that sustainability indicators are used to monitor change in society and to show progress towards a given goal or objective based on observable or measurable markers (indicators) [17,20,24,62,63]. By monitoring the same indicator over time it is possible to identify trends and development directions [64]. Indicators can be used to monitor both quantitative and qualitative changes in society [62].

The setting of indicators can either be theoretical and science driving, in which case they are to be seen as a non-subjective tool where the selection of indicators is based on theoretical models. The selection of indicators can also be value driven, where the indicators can reflect current social debates and priorities. The latter practice is more often applied when indicators are used for policy-making and/or there is a need to co-produce indicators with stakeholders such as communities or residents. The reasoning is that in many cases the subject of analysis is not static but changes over time, hence there is no static relationship between the underlying theoretical model and the data being produced by the indicators based on the model [65].

When choosing indicators, it is stressed that they are specific, measurable or observable, and that data are, or could be, made available. Yet, the selection of sustainability indicators is challenging. Wilson et al. (2007) show that different understanding of sustainability will lead to different indicators being selected, and in turn differences in the resulting sustainability performance [17]. Mori and Christodoulou (2012) reviewed sustainability indicator sets that have been used by cities and conclude that none of these indicator sets satisfies the requirements necessary to monitor sustainable development, in line with the triple bottom line, in cities across the world [53].

Criteria for selecting indicators to monitor sustainable development, according to the literature, are that the total number of indicators should be limited [17,61,66–68] in order to obtain a manageable

workload and not get lost in too many details. Indicators must be policy-relevant, reliable, measurable, wide in scope and simple. In practice, however, indicators for sustainable urban development have been selected on the basis of political prioritisation, perceived importance and/or data availability [69–71]. Research stresses the importance of involving stakeholders in the process of selecting the evaluation indicators, especially when monitoring progress towards sustainable development [18,59,62,72].

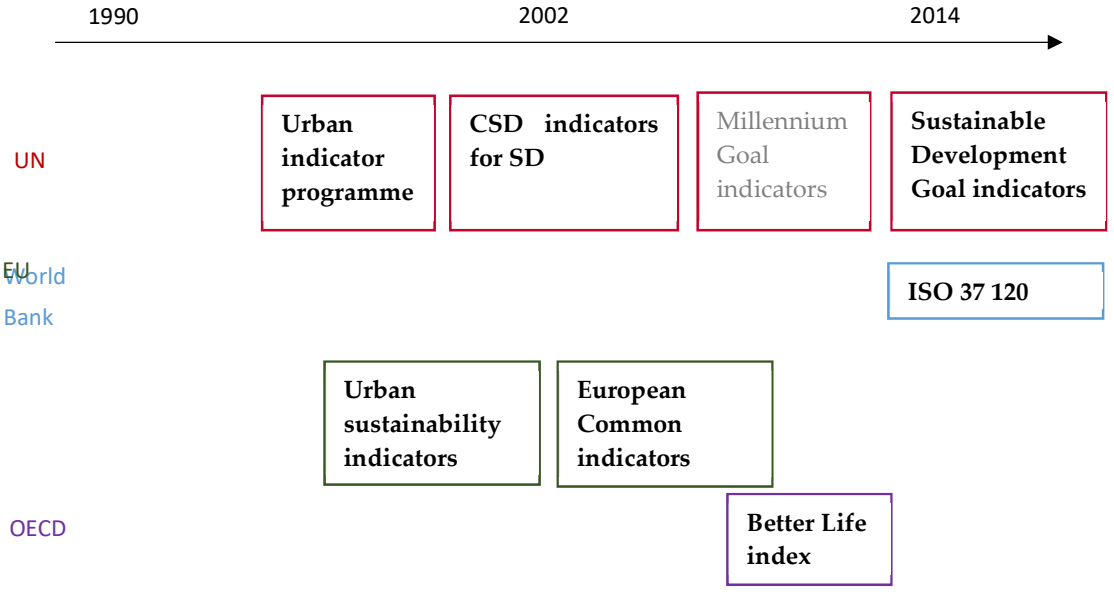
When selecting indicators, cities need to deal with the complexity of the urban system and they need to decide what is regarded as representative in order to monitor trends and developments towards the goal (i.e. be sustainable), at the same time as the goal is in fact not clearly defined. What further complicates the process of selecting and applying indicators is the fact that the base line changes; there is no constant status quo. Consequently, what is important and prioritised, and the related indicators that are most appropriate, is constantly changing.

*2.2 Data used in this study*

Since the introduction of the concept of Agenda 21 in the 1990s, several international organisations have worked on developing indicator sets to be able to monitor progress towards the Agenda's goals (see Figure 1). Indicator sets to monitor both global as well as local sustainability goals have been developed by cities [62,73–75], by private companies (e.g. Arcadis, the Economist Intelligence Unit) or in public-private collaboration (e.g. Sustainable Cities International). Sustainability indicator sets that have been developed for a more general level have also been applied in an urban context; examples of these include the Ecological Footprint, Environmental Sustainability Index, Dashboard of Sustainability, Welfare Index, Index of Sustainable Economic Welfare, City Development Index, Emergy/Exergy, Human Development Index, Environmental Vulnerability Index, Living Planet Index or Environmentally-adjusted Domestic Product [24,53,74].

Figure 1: Chronologic development of selected indicator sets by international organisations since the 1990s included in this study. The Millennium Development Goals are marked in grey as they do not make a claim to cover sustainability; however, they are an important link to the development of the Sustainable Development Goals.

In this paper, we analyse selected indicator sets introduced to monitor urban sustainability. The broader population of indicators was identified by collecting information about indicators




monitoring sustainability, monitoring urban development, and monitoring quality of life. Based on this information, indicator sets were selected on the following principles: (1) the indicator set aims to

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cover sustainability in its entirety and account for each different aspect independently; (2) the indicators were chosen on the basis that they should be developed for a wider group of interested parties and not a specific group of actors; (3) the indicators should be developed by transnational, non-private organisations to avoid country-specific bias and therefore be able to be applicable in a wide range of different contexts; and (4) the indicators should be targeting societal challenges and not be specifically developed to evaluate certain products or services. These selection criteria resulted in the indicator sets represented in *Figure 1*. Detailed information about the indicator sets can be found in Table 1.

Table 1 Summary of characteristics of each of the indicator sets analysed in this paper

| | Use-phase | Launch | Adjust-ments | Use frequency | Urban aspect |
|---|---|---|---|---|---|
| UN Habitats Urban indicator programme [76] | 1996 – date | 1993 | 1996 2001 | Different versions are used by 200+ cities | Strong urban focus |
| Commission for Sustainable Development's Sustainable Development indicators [77] | 1995 – ca 2008 | 1995 | 2001 2005 | No information on use in cities | Primarily focusing on national level reporting on sustainable development. Several aspects that are relevant at local level |
| EU's Urban sustainability indicators [78] | 1998 – ca 2002 | 1998 | | No information on use in cities | Strong urban focus |
| European Common Indicators [79] | 2000 – 2004 | 2000 | | Tested by 42 cities | Strong urban focus |
| OECD's Better Life Index [80] | 2011 – date | 2011 | frequent | Frequent reporting on national level | Focus on citizens' quality of life from a mainly national perspective; some urban aspect are included |
| ISO 37 120 indicators (Smart City Data) [81] | 2014 - date | 2014 | | 30 cities have reported at least some indicators | Strong urban focus |
| Sustainable Development Goals indicators [82] | 2015 | 2015 | | No information on use in cities yet | Sustainable development on all levels in all regards |

In the analysis, these indicator sets are assessed in relation to the SDG indicator set, which is built on the experiences and strategies of previous goals and indicators, in particular the Millennium Development Goals [27,43,83–85], acknowledging and addressing shortcomings and challenges such as the need to explicitly include all dimensions of sustainability, the need to set globally relevant goals but also to include and address local government. In particular, the recognition of the role of urban areas and local governments in facilitating sustainable development has led to the inclusion of a specific urban goal dedicated to cities and communities [43], even though many of the other 16 goals touch upon urban issues [3,41,48] and although many cities already have their own sustainability goals.

## 3. Sustainability monitoring has increased in complexity, leading to more indicators that need to be managed

The following section reviews and discusses which aspects have been most commonly monitored since the development of indicator sets for urban sustainable development started. The various indicator sets in this study are assessed with regard to the extent to which they cover sustainability and contrasted with each other as well as with the indicators suggested by the SDGs. The section concludes with an analysis of the SDG indicators and of how far they appear suitable for evaluating the sustainability in cities, both from a theoretical perspective as well as in practical terms.

*3.1 Challenges with measuring the undefined*

*Figure 2* presents the total number of indicators that each of the indicator sets of this analysis contains. It becomes apparent that, despite the recommendations of limiting the total number of indicators [66–68], there is a trend of an increasing number of indicators. This possibly reflects the fact that more indicators are needed in order to be able to display all different aspects of sustainability. At the same time, the increasing number exacerbates the challenges of data availability and reliability in cites. The higher the number of indicators, the more difficult and work-intensive it is to collect the information; voices have already been raised pointing out that only geographically relevant indicators need to be reported [26], even though the UN statistical division asks for reporting on all indicators at national level [86]. Whereas earlier indicator sets limited the total number of indicators, thus making it more feasible to collect all information that had been deemed relevant, newer indicator sets, and in particular the SDG indicators, pose big challenges (Simon et al., 2016). The number of indicators therefore needs to strike a balance between the existence of reliable data and the complexity of urban systems, ideally including aspects of boundary challenges and externalities.

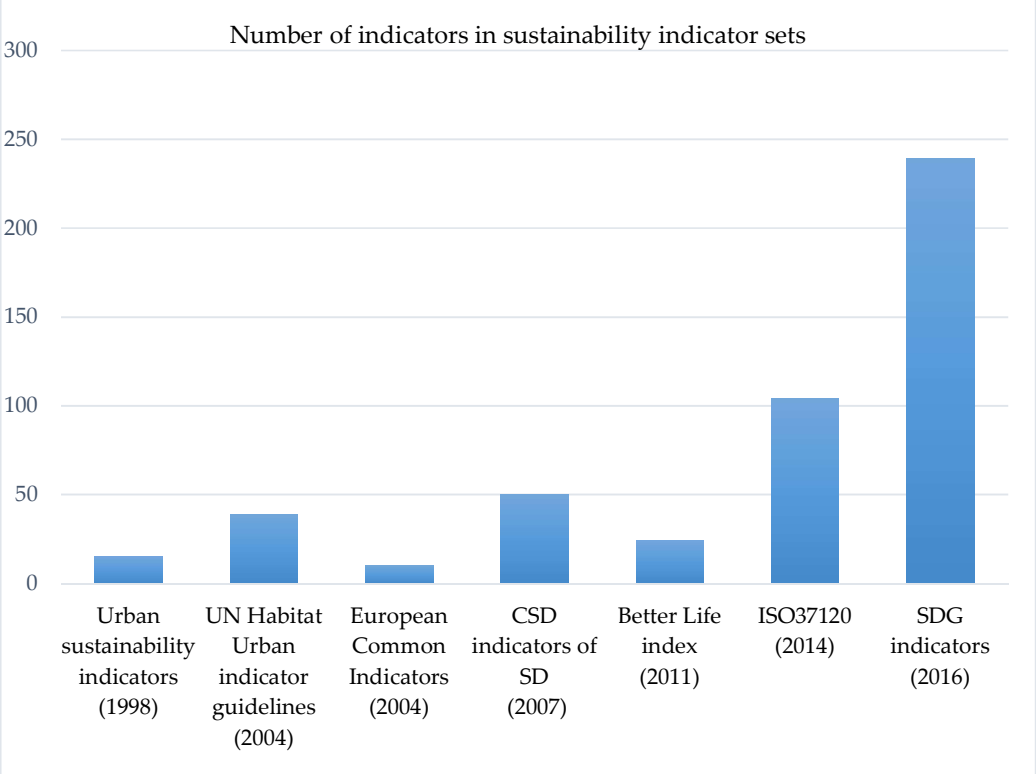


*Figure 2* Total number of indicators of sustainability assessments

Using indicators to inform policies on the local level entails a number of different challenges. Depending on local conditions and governance structure in each country and/or region, cities might have more or less capacity to influence local conditions through policy intervention [3]. The relevance of indicators from a policy intervention perspective is consequently not necessarily straightforward and is valid for any type of indicator set that has been developed for an international context. The same is the case in a regime of multi-level and multi-actor governance, a situation that is widely

considered will become more rather than less prevalent in the future [87,88]. With an increasing number of actors that either influence or are needed to be able to report indicators, it is more and more important that the choice of indicators reflects and acknowledges this trend and the associated challenges and opportunities of working with a wide range of stakeholders to monitor and report.

The risk of politically steered prioritisation of policy interventions that are not based on facts (delivered by indicators) as mentioned by Keirstead and Leach (2008) or Shen et al. (2011) is assumed to be, in principle, equally high across all indicator sets [69,70]. When coupled to the increasing total number of indicators, however, it could be argued that politically-led prioritisation increases with an increasing number of indicators as it reflects a growing desire to keep monitoring on a more manageable level. At the same time, it could also be misused and lead to a prioritisation of areas that are predominantly of special interest in political debates.

*3.2 What matters most - which are the most commonly used indicators so far?*

Table 2**Error! Reference source not found.** presents the most common aspects that are covered by indicators in the selected sets. It is worth noting that all these indicators are reflective indicators in themselves, i.e. measuring the current state. It is only by relating these to each other, i.e. the summary of the indicators, that it possible to give a bigger picture on the state of, for example, the environment in general. Interestingly, the list contains only one indicator associated with economic aspects – in total environmental and social aspects dominate. This economic indicator (unemployment rate) has, however, a very strong social implication.

Table 2 Most common indicators used in the analysed indicator sets*

| Indicators that appear most frequently | Frequency of use (n/7 indicator sets) |
|---|---|
| Education amongst children and young people | 6 |
| Air quality (particulate matter) | 6 |
| Victims of homicide | 5 |
| (Un)employment rate | 5 |
| Access to sanitation | 4 |
| Under 5 mortality rate | 4 |
| Safely managed drinking water | 4 |
| Greenhouse gas emissions | 4 |
| Access to electricity and use per capita | 4 |
| Hazardous waste generated and treated | 4 |
| Voter participation in elections | 4 |

* Urban indicator programme, CSD indicator for sustainable development, ISO 37 120, Urban sustainability indicators, European Common indicators, Better Life index, SDG indicators

The indicators on air quality and on employment/unemployment rate have been used over the longest time span. They can be found in the earliest indicator set from 1998 and have been used in most sets since then. The indicator on greenhouse gas emissions per capita has been used early on but is missing among the SDG indicators. The same is the case for the indicator on voter participation in municipal elections. Hazardous waste is one indicator where it is possible to see a clear trend indicating an increasing attention in more recent years. For other indicators in Table 2 it was not possible to determine clear chronological patterns.

The analysis of the full data set suggests that the following aspects were regarded as more important initially and as having lost in importance over the years: modal split of transportation, total water consumption per capita, housing according to building regulations, urban population growth and proportion of households with more than three persons per room. On the contrary, indicators that have gained importance over the years are: proportion of urban population living in

slums, proportion of teachers having received adequate training, passengers and freight volumes and internet connections.

It is worth noting that the use of indicators has been changing over time, in line with an increasing trend to incorporate 'New Public Management' ideals into public administration, i.e. the ideals of cost-efficiency, decentralisation, customer-orientation and empowerment. The desire towards economic efficiency is reflected in the choice and use indicators in the public sector [62,65]. In all, indicators have moved towards an approach that is more centred on the individual and quality of life. Instead of measuring total water consumption, for example, indicators intend to cover the proportion of the population that has access to safe drinking water or sanitation.

*3.3 Evolution of sustainability monitoring*

The analysis reveals that indicator sets have until now each been used only over a certain time period, after which they have been developed and adjusted. This indicates that there has been a tendency towards following new trends and shifts in (political) prioritisation over the years. This might be explained by the lack of a common definition of sustainability or sustainable cities [52].

*Figure 3* gives an overview of the total number of indicators that various indicator sets suggest, grouped according to the structure proposed by the SDGs. It becomes obvious that the number of indicators suggested to implement the SDGs is by far the highest, 232 indicators in total, going beyond other assessment tools in all but two of the 17 goals. Only the ISO 37 120 indicators surpass the number of SDG indicators on the topics of goal 7 (affordable and clean energy) and goal 11 (sustainable cities and communities). The high number of indicators with the ISO standard for goal 11 could be explained by the fact that this standard focuses on smart city data, i.e. collecting data necessary for an efficient running of a city, yet the standard is still making a claim on evaluating the sustainability of cities.

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*Figure 3* Number of indicators in different sustainability assessments according to SDG structure

Figure 3 also shows the relation between the number of indicators for the SDGs and the Millennium Development Goals (MDGs). The MDGs were developed as a global effort to improve the quality of life of people especially in the developing world. Although they did not specifically make any claim to cover all aspects of sustainable development, the process of developing the MDGs as well as the effort of reaching the goals has had a great impact on the way that the SDGs have been developed, in particular by acknowledging the need to cover all aspects of sustainability, including possible synergies and contradictions between the different goals [33,83]. As Figure 3 shows, both SDGs and MDGs have a strong focus on health and wellbeing (SDG goal 3) and partnership and cooperation (SDG goal 17). What also becomes apparent, however, is the increased focus on gender equality (SDG goal 5), economic development (SDG goal 8), sustainable cities and communities (SDG goal 11) and sustainable production and consumption (SDG goal 12). This clearly indicates that the aspects of sustainable development are evolving towards a more holistic approach.

Furthermore, *Figure 3* indicates that there are a number of 'hot-spots', i.e. goals, that have received more attention than others. Theses hot-spots are goal 3 (good health and wellbeing), goal 6 (clean water and sanitation), goal 8 (decent work and economic growth), goal 11 (sustainable cities and communities) and goal 16 (peace, justice and strong institutions). These five topics receive higher

indicator counts throughout the indicator sets, even when disregarding the SDG indicators. The accumulation of indicators under some aspects, and the consequentially arising gaps under other aspects in the six pre-2015 indicator sets, indicates that sustainability is covered only to a varying degree during that period. This is confirmed by the work of Luederitz et al. (2013) using a cluster analysis of scientific literature on the sustainability performance of urban neighbourhood development, concluding that none of the 21 papers covered all three of the sustainability aspects (economic, environmental and social), or at least not to a significant degree.

There might be several reasons why certain sustainability aspects are prioritised. One reason is the historic development of indicator use in cities, where the monitoring of environmental degradation (in this case indicators under goal 6 and 15) have received a lot of attention since the 1960s when industrialisation started to have a major impact on people and environmental awareness in society started to grow [66,74]. This history and tradition of monitoring environmental performance also means that the collection of this type of information is relatively easy.

A similar explanation can be used for economic development. GDP as an indicator for economic growth has been established since the 1940s [22]. Despite the fact that there have been numerous attempts at finding other indicators, GDP is so established as an indicator that it is 'the easy way' for use as a main indicator to cover the economic aspects of sustainability. The high indicator count for goal 11, on the contrary, can be attributed to the more recent trend of increasing focus on cities as actors to push for sustainable development also on the global level.

Building on past experiences when developing new indicator sets can be seen as way to continuously improve and adapt the indicator set but this approach entails the danger of reinforcing a path dependency. As the example of GDP above illustrates, analysing past indicator sets and choosing the ones that 'have been working well previously' can easily lead to the use of established indicators without necessarily reflecting whether these indicators really monitor what is in fact most relevant in current times. It could be argued that it is easier to introduce new aspects to the monitoring of sustainable development than to change well-established indicators. To give an example, introducing indicators to monitor accessibility to green areas in cities is anticipated to be more easily added to sustainability indicator sets, rather than exchanging the existing indicator of GDP with a measure of non-economic prosperity. Familiarity with quantitative indicators can lead to a misconception that everything can be quantified. Thus, soft aspects of sustainability are most likely measured through quantitative indicators, as this is what we are used to, thereby risking the overlooking of important elements.

### *3.4 Anything new with the SDGs?*

Compared to previous indicator sets, the SDG indicators cover aspects that have not been covered before. Sustainable cities (Goal 11) and Strong institutions (Goal 16) are areas that have only recently received attention when assessing sustainable development. As for the ISO 37 120 standard, the focus lies predominantly on sustainable cities. This indicator set has cities as its specific target group and hence trying to align the required information to a maximum within this field, resulting in that 30% of all ISO 37 120 indicators fall under Goal 11.

Two areas – gender equality (goal 5) and reduced inequalities within and amongst countries (goal 10) – attract attention for another reason: these aspects have so far not been covered by indicator sets at all or only to a very small degree. These 'soft issues' have presumably been avoided as they are based on underlying, societal values that are difficult to question from an outsider's perspective. Furthermore, they are very difficult to isolate and quantify. The SDG indicators do cover these aspects. No poverty (goal 1) and zero hunger (goal 2) are also aspects that have not featured as distinctly in previous indicator sets. It can be assumed that they are a legacy from the MDGs and reflect a desire to make the SDGs globally applicable.

There are a number of areas that the SDG indicators do not cover. In general, it can be said that the SDG indicators remain on a more general level. Examples for this are indicators on access to health services. The SDG indicators cover health aspects on a general level but other indicator sets are more specific, such as the number of hospital beds/100 000 people, or indicators on key diseases.

The same is the case for indicators on waste and waste water management or air pollution, where in the SDGs only Particulate Matter concentrations are required and other air pollutants are summarised in an indicator on mortality rate due to air pollution. Two aspects that seem particularly relevant from an urban perspective are missing, which are the availability and/or accessibility of green, recreational areas and the modal split of individual mobility. Voter participation in elections is one aspect that other indicator sets have commonly included but which is missing in the SDG indicators.

The majority of indicators that have previously been used are included in the SDG indicators. However, the SDGs remain on a more general and overarching level and lack some degree of detail. It can be argued that this is due to the fact that the SDGs themselves are meant to follow the logic of 'governance through goal setting' where it is beneficial to stay on a more general level leaving room for specifying goals based on the local context [90]. The purpose of following governance through goal setting is to be able to be more inclusive, thereby stimulating action, rather than being able to hold parties to account or benchmark. The generic characteristics of the goals have been translated into indicators, but this still raises the need to localise goals, targets and indicators. Of the SDG indicators, it is assumed that the absolute majority are relevant on the city level. Some of the indicators under the goal 'Reducing inequalities within and amongst countries' (goal 10) can be considered less relevant for cities as they mainly deal with countries' role in international organisations or money flows between countries.

The challenge of capturing the complexity of urban systems [12,46] and acknowledging system interactions and interrelationships also remains. Assuming that the majority of SDG indicators are relevant on the urban level, a process of localising them, including some form of political prioritisation amongst them, is necessary in order to end up with a policy relevant indicator set for which reliable data can be collected. It does not necessarily follow that the resulting indicator set will take into account the possible contradictions in the urban system or how factors might influence each other. This challenge has not been addressed in the SDG indicator framework, as it has not been addressed in any robust process for prioritising certain goals or defining baseline goals that need to be met before others [34,91].

The Sustainable Development Solutions Network has developed a guide for stakeholders, "Getting started with the SDGs in cities" [48], outlining steps local governments can take to localise the SDGs. The report highlights some of the challenges identified in this paper, i.e. to "develop an affordable yet comprehensive monitoring and evaluation system […] effective in reliably capturing progress on local goals and targets". The indicators that the SDGs suggest are all quantitative and the majority of them are proportional indicators indicating a relation between two variables, such as renewable energy share in the total final energy consumption. There are no indicators that are based on qualitative aspects or that ask for subject valuation, both of which are key to reflecting local needs and desires. Examples for qualitative and/or subjective indicators can be found in the Better Life Index developed by the OECD in 2011 such as "How do you judge your health situation?" or "Do you feel safe walking alone at night in the city or area where you live?" More research is needed if qualitative indicators are to complement the SDG indicators by capturing the local needs and desires more efficiently than a larger number of quantitative ones.

## 4. Conclusion and directions for further research

The aim of this paper was to analyse how the SDGs can advance the assessment and monitoring of urban sustainability by comparing the SDG indicators with previously developed indicator sets. One of the main differences of the SDG indicators compared to previously used indicator sets is the total number of indicators in the SDG system. This fact affects a number of the above-mentioned challenges positively or negatively, as outlined in Table 3.

Table 3 Positive and negative effects of each identified challenge regarding the implementation of SDGs at local level

| Identified challenges | Negative | Positive |
|---|---|---|
| **Access to reliable data** | Difficult to gather data of sufficient quality for all indicators | More chance of being able to collect data for some indicators and opportunity to engage wider range of stakeholders |
| **Policy relevance and political prioritisation** | Risk that groups of indicators are ignored if defined as non-applicable for political reasons | Possibility to choose indicators that are policy-relevant at local level |
| **Capturing the complexity of the urban system** | Despite the large number of indicators, interrelationships, interdependencies and synergies are not highlighted or considered | The higher the number of indicators the higher the likelihood of being able to capture complexity |
| **Covering out of boundary challenges and externalities** | Difficult for cities to generate data covering these elements. | The higher the number of indicators the greater the likelihood of covering out of boundary challenges and externalities. |
| **Acting in a multilevel and multi-actor governance system** | A number of indicators are targeting levels other than the urban level | Possibility of capturing issues that influence the urban level but are dealt with at other levels |
| **Availability of capacity and skills** | The higher number of indicators, the higher the need for skills in more areas of expertise and the higher the need for capacity | Involving other competences and other actors will result in better cooperation across sectors |

The SDGs themselves cover sustainability aspects that have not been covered previously, namely aspects of gender equality and reduced inequalities, thereby balancing aspects that have been overly covered in previous indicator sets, such as environmental aspects, aspects of health and aspects of economic growth. Overall, the SDGs as a whole are more integrated and may therefore make policy integration across sectors easier [83]. The high number of SDG indicators can facilitate a stronger cooperation across sectors where universities, NGOs, the private and the public sector need to contribute with data to be able to monitor development and thus report in line with the SDG requirements. However, in order to capture the complexity of urban systems, monitoring needs also to include qualitative aspects of development. A number of the SDGs and targets are formulated qualitatively rather than quantitatively. Yet, it is unclear as to how far the SDGs and other indicator sets cover the qualitative sides of sustainable development. In the process of localising the SDGs, it becomes increasingly important to monitor city-specific conditions, thereby increasing the need to identify relevant, qualitative indicators that enable the monitoring of soft aspects of sustainable development.

The analysis also indicates that the idea of an underlying model for human-ecosystem relationship on which to develop the indicators, which was popular in early work on indicator development [22,59], has been given up. Instead there seems to be acceptance that a number of important aspects are worth following. The goals and associated indicators are not ranked or weighted and some are even contradictory. This suggests that decision makers need to evaluate on a case-by-case basis what is deemed more important, as has been suggested by some research [84,92], especially in the context of implementing the SDGs at local level [28,43,46,48,49].

*Recommendations for future research*

The study found that the SDG indicators have the potential to monitor urban sustainable development, but that future research needs to analyse and support their practical application in cities. In detail, research needs to be carried out with regard to:

- How the localisation process of the SDG indicators can be carried out, taking into account the potential for local policy making and political prioritisation
- Potential for quadruple helix cooperation and participation for implementation (reflecting the complexity of urban systems) and monitoring and evaluation
- How to identify relevant and achievable targets by long-term, goal-based planning for SDG implementation and counteracting short-termism
- Effective and efficient capacity building for practitioners and within academia with regard to local monitoring of SDG implementation
- At what levels of governance the SDG indicators should be applied to deal with externalities and how monitoring might be tested
- Whether the suggested indicators, as they are currently formulated, can be optimised in a specific urban context taking into account different local conditions
- Investigate whether alternative or complementary qualitative indicators are needed that are more relevant at urban level and able to capture missing aspects.

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