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Research article

Sustainable Development Goals (SDG) indicators for municipalities: a comprehensive monitoring approach from Germany

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Abstract

While the 2030 agenda addresses the United Nation member states primarily at their national levels, municipalities play a crucial role in implementing all of the 17 SDGs and many of the 169 targets. These processes must be monitored and evaluated. However, the UN indicators are not sufficiently applicable to the local context. Therefore, a multi-stakeholder working group was formed in Germany to develop a comprehensive set of Sustainable Development Goal (SDG) indicators for municipalities, together with additional instruments to support local SDG monitoring such as an SDG data portal. The first catalogue which included 47 core SDG indicators was published in 2018. According to consecutive evaluations and practical tests, the indicator set was substantially expanded and revised to a final number of 120 SDG indicators. About half of the 120 indicators are provided with local-level data and the other half must be assessed individually for comprehensive local SDG monitoring. Likewise, accompanying tools were relaunched with additional functionalities. Although this new and unique set of indicators now covers a majority of the municipally relevant targets, there are still some decisive monitoring gaps for various reasons. The strengths and weaknesses of our methodological approach, as well as implications for future research and practical developments, are discussed.

Key words: SDGs, sustainability monitoring, sustainability indicators, sustainable urban development, sustainability management

Introduction

Municipalities have played a vital role in the sustainability initiatives of the United Nations (UN) at least since the adoption of Agenda 21 at the United Nations Conference on Environment and Development 1992 in Rio de Janeiro (United Nations Sustainable Development 1992). In 2015, the UN General Assembly combined the Agenda 21 process and the Millennium Development Goals (MDGs) into the 2030 agenda as a comprehensive and integrated roadmap for sustainable development (United Nations General Assembly 2015). The 2030 agenda includes 17 global goals for sustainable development called the Sustainable Development Goals (SDGs) and 169 associated more operationalizable thematic targets. Through the inclusion of an own goal for the local level—SDG 11 on sustainable cities and municipalities—local authorities were for the first time explicitly assigned a decisive role (UN Habitat Technical Support 2016; Vaidya and Chatterji 2019). To monitor and report progress towards achieving the goals and to facilitate cooperation, the UN encourage its member states to submit voluntary national reviews (VNRs) on a regular basis. For this

purpose, the UN developed an extensive catalogue of SDG indicators (United Nations 2016)—that is, measures to assess the state or level of any topic addressed in a target, mainly using quantitative data.

According to the 2030 agenda, any development policy can only be sustainable when different dimensions are tackled equally and in a balanced way—with reference to the five principles people, planet, prosperity, peace and partnership. Thus, the SDGs are highly interrelated, with various potential synergies ('goal congruences') between different goals or targets, as well as challenging trade-offs ('goal conflicts') (Pradhan et al. 2017; Nilsson et al. 2018; Bennich, Weitz and Carlsen 2020). This complexity requires holistic monitoring approaches to 'break down the silos' for a cross-sectional and integrated perspective (Niestroy and Meuleman 2016; Valencia et al. 2019).

As the SDGs must be addressed not only on the national level but also at subnational levels, multilevel monitorings of signs of progress toward achieving the SDGs are necessary (Valencia et al. 2019). Initiated by the United Cities and Local Governments (UCLG) network, more and more SDG monitoring reports focusing on subnational levels (voluntary subnational review, VSR) or individual municipalities (voluntary local review, VLR) are being published. However, the SDGs with their 169 targets and the associated indicators provided by the UN refer predominantly to the national level and can only be applied locally to a limited extent. Thus, systematic processes of localization of the SDGs as well as their implementations are needed (see, e.g. Hák, Janoušková and Moldan 2016; Valencia et al. 2019). With the localization of the SDGs and their targets, we refer to local adaptations that include the 'translation' of the goals and targets to the municipal level, their local choices and prioritizations, context-relevant framing and the assignment of locally valid target values. With the implementation of the SDGs, we refer to the entire management cycle when implementing sustainability measures. In a simplified way, it starts with goal-setting processes and the derivation of goal-related projects and other measures, followed by the implementation of measures. Implementation is accompanied by comprehensive monitoring, which results in the evaluation of the sustainability management process (Hansson, Arfvidsson and Simon 2019). For monitoring and evaluation, a valid set of—quantitative and other—indicators related to the targets is needed (cf. Mair et al. 2018; Valencia et al. 2019). As stated above, the United Nations SDG indicators refer to the national level and must therefore be adapted to the local level before progress towards achieving the SDGs can be evaluated. At the same time, on a global or regional level, there is no 'one fits all' set of municipal SDG indicators for many reasons, inter alia the high diversity of the way official statistics are organized, as well as the different availabilities of data from commercial providers and open sources such as scientific databases and certifications by NGOs. Thus, comprehensive indicator sets are urgently needed to ease municipalities' initiation of tackling and monitoring their contributions to the SDGs.

In cooperation with multiple stakeholders, we developed a comprehensive set of German quantitative 'SDG Indicators for Municipalities'. Our first catalogue (Assmann et al. 2018) included 47 key indicators for a quantitative representation of those targets or parts of SDG targets ('sub-targets') of the 2030 agenda that have been identified as particularly relevant to German municipalities (see Section 2). A data portal for municipalities was developed and launched with the catalogue. The indicator set was subsequently tested in several cooperating municipalities and additionally evaluated through interviews with operators and stakeholder workshops. These practice tests and evaluations helped to identify specific gaps. Accordingly, several topics on the level of SDG targets were chosen for selective elaborations to enhance the number of indicators in these gaps. At the same time, the entire catalogue was revised into a set of 120 indicators and was published in December 2020 (Bertelsmann Stiftung et al., 2020).

In this article, we present the entire methodological approach that was chosen to develop the German SDG Indicators for Municipalities, including unpublished analyses and process experiences, as well as the latest catalogue of 120 indicators and accompanying tools. In addition, we critically discuss potential shortcomings in the latest catalogue as well as the limitations of the chosen methodological approach in general.

Methodological approach of the German SDG indicators for municipalities

Formation of a multi-stakeholder process to develop SDG indicators

In order to develop a comprehensive, municipal-level SDG indicator catalogue, a multi-stakeholder working group in Germany was formed from representatives of the Bertelsmann Foundation, the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR) which is a departmental research institution under the portfolio of the Federal Ministry of the Interior, Building and Community, the three German municipal umbrella organizations German County Association (DLT), German Association of German Cities (DST) and German Association of Towns and Municipalities (DSTGB), the German Institute of Urban Affairs (DIFU) as the largest urban research institute in Germany, and Engagement Global with its Agency Communities in One World (SKEW). Later, the German section of the Council of European Municipalities and Regions (RGRE) also joined the working group. These member institutions cover different roles: The German Association of Cities initiated the project in 2017, moderates the working group and, together with DLT, DSTGB, RGRE, reviews milestone results and supports the acceptance and application of the catalogue in their member municipalities. DIFU as the affiliated institute of the authors has been commissioned by the Bertelsmann Foundation to develop the indicators in the lead. The Foundation is responsible for the overall organization of the project, for publication of project results and the provision of data. BBSR cooperates in developing and refining the indicators and also provides them in their data portal. SKEW has supported the work with funding from the German Federal Ministry for Economic Cooperation and Development. The members of the working group regularly reviewed research outputs by DIFU and discussed them with thematic experts in their institutions before working group meetings, where decisions were (in most cases) taken per consensus following extended discussions. Milestone outputs from this working group were in turn reviewed in two other advisory committees: First, a project council with around 20 invited members from scientific institutes, NGOs and decision-makers from municipalities that are considered advanced with respect to sustainable development policy. Second, a panel of several dozen practitioners is responsible for relevant monitoring processes in local authorities. The inclusion of all these perspectives thus formed a highly participatory process. Such an approach requires substantial resources and brings about challenges, for example potentially conflicting demands of manageability, parsimony and

comprehensibility in practice versus the need for scientific precision and comprehensiveness from the scientific perspective. However, evaluations carried out after the first catalogue was published prove the merits of this participatory approach, especially with regard to a considerable level of acceptance and application of the catalogue amongst the target group.

One of the milestone results that underwent reviews and adaptations in all these committees was the relevance check of the SDG targets which is described in the following section.

Assessing the relevance of the SDG targets

Looking at the wide thematic range in many of the 169 targets, it can be estimated that at least several hundred indicators would be required if all 169 targets were to be monitored. In addition, some of the targets would need to be translated to the municipal level. To come up with a catalogue that is sufficiently manageable in local monitoring processes as an entity and adequate for German municipalities, we initially conducted a so-called 'relevance check' to focus on priority targets in all of the 17 SDGs, which will be described in more detail below.

In the first relevance check conducted in 2017, we focused on targets that could be addressed by measures 'in the municipality and for the municipality'. With the aim of better representing municipalities' efforts in municipal development politics and their commitment to global responsibility, we revised the initial relevance check to include more measures 'in the municipality for the world' and measures 'in other countries and by other countries' (Knipperts 2020). Despite these additions, it should be noted that the chosen indicators do not include telecoupling strategies. These would comprehensively analyse any ecological, socioeconomic and cultural impacts of relevant acts and measures within German municipalities that are outsourced to other countries due to the complex global interrelations. One example is the lack of an estimate of the greenhouse gas emissions caused by the production of imported products relevant to the sectors that are covered in the CO_2 emission indicators in SDG 13. The following description refers to the latest recommended procedure.

To assess the relevance of the 169 targets for German municipalities, they were first examined to check whether they encompassed different sub-goals whose relevance may be assessed differently. In this case, they would be subdivided into two or—in eight cases—even in three partial statements ('sub-targets'). This first check was initially performed by two independent raters at DIFU and disagreements were resolved by discussion before it was discussed in the above-mentioned committees.

Some difficulties in the way the SDGs are formulated became relevant in this step and they were redressed with the following rules of thumb: First, some targets are quite abstract or could be interpreted in different ways. In these cases, we decided to interpret the target according to the main principles of the 2030 Agenda (i.e. people, planet, prosperity, peace and partnership). For example, SDG 7.1 refers to modern energy services, which could also include nuclear power plants or even coal power plants from the perspective of developing countries. However, with the principle of protecting the planet from environmental problems and protecting people from environmental health risks, we interpreted modern as clean and renewable. Another rule of thumb was to avoid changing the content of a target to assimilate it into the German context. For example, in SDG 11.1 we did not exchange the term slum with 'informal voluntary settlement' or 'troubled neighborhood' even if the latter concepts may apply to Germany. On the contrary, actual slums—as they are predominantly found in developing countries with very weak built structures and a lack of basic services such as access to clean water, sanitation and electricity—were not assumed to be 'sufficiently relevant' (see below) on the German federal territory. This way, we subdivided 43 of the 169 targets into 94 sub-targets, resulting in 220 targets or sub-targets that were subsequently checked for relevance in two further steps, a 'problem check' and a 'task check'.

The problem check assessed whether the challenges addressed in the sub-targets were directed at a particular problem for German cities, municipalities or districts—or a problem for municipalities in the global south that could be tackled by municipal development politics in Germany (see Knipperts 2020). The benchmark was defined as a substantial effect on more than 10% of German municipalities or more than 10% of relevant population groups, whereby for example development goals for marine protection were mostly excluded, as the number of German coastal municipalities is less than 10% of all municipalities. The same applies to targets specifically related to alpine regions. Notwithstanding the above rule, some rather 'rare' challenges were also appraised as 'problem-relevant' nonetheless when we assumed a political consensus that actions towards specific problems would be required (e.g. relevant with targets related to malnutrition, illiteracy or human trafficking, which may affect less than 10% of the German population). Moreover, some targets were considered relevant despite their reference to unrealistic or locally inadequate terminations or target values. One example is the bisection of traffic accidents by 2020 (target 3.6) which was unlikely in the light of comparatively low-status scores and high safety standards. Another example is afforestation (target 15.2), which would not be equally eligible in all German municipalities. Altogether, 145 of the 220 sub-targets (65.9%) were appraised as relevant for German municipalities (see Supplementary Material). For these sub-targets, we finally checked whether these problems were located within the sphere of action of a local authority—in accordance with the German federal constitution—and could therefore be solved through municipal tasks. This was unproblematic for those objectives that could be addressed directly by municipal tasks or products—in other words, by the competencies and scope of action of the local government, political actors or municipal companies ('high options for action'). One example is ensuring access for all to adequate, safe and affordable housing (target 11.1) which clearly is a statutory duty for municipalities in Germany. Sub-targets were also considered relevant if municipalities could specifically design framework conditions for other actors to achieve them ('medium options for action'), such as target 8.1 to sustain per capita economic growth. In contrast, targets for which the municipality could at most motivate other actors for a certain target behaviour ('limited options for action') were dropped in the task check and thus, did not pass the relevance check. One example here is target 14.a that refers to scientific action for marine conservation. Overall, many additional rules of thumb were necessary for this third step (see Assmann et al. 2018). However, we believe that they are rather specific to German administrative laws and would therefore be of limited interest to cities in other countries.

The problem and the task check were initially carried out by three independent raters. For all targets that did not yield rater agreement in either of the two checks, the three raters assigned a rating by discussion to complete a first proposal of the relevance check. This proposal was reviewed by the working group

and accordingly, by other committees, where critical cases were solved by group discussions.

Ultimately, 163 of the 220 sub-targets (74.1%) were defined as relevant problems and challenges for German municipalities. For these 163 targets, appropriate indicators had to be identified.

Finally, the relevance check proved useful as a first step and was usually well-accepted due to the high transparency of the decision process and the wide possibilities for participation of different stakeholders. However, it should also be highlighted that each local authority is responsible for critically reviewing the relevance of further targets for its individual needs and circumstances and adding respective indicators to our set accordingly.

Identifying and Choosing SDG Indicators

To identify suitable indicators, different sources that provided sets of sustainability indicators (whether SDG-specific or not) were studied. These sources were the SDG indicators of the UN itself (United Nations 2016; UN Habitat Technical Support 2016; United Nations 2019) and other international references (Bertelsmann Stiftung and Sustainable Development Solutions Network 2019), as well as sources at the European level (Eurostat 2019, 2020) and the national level (Die Bundesregierung 2018; Statistisches Bundesamt 2018). Moreover, we assessed selected sustainability strategies of the German federal states (Ministerium für Umwelt, Klima und Energiewirtschaft Baden-Württemberg 2019; Die Landesregierung Nordrhein-Westfalen 2020) and municipal-level references (Ministerium für Umwelt, Klima und Energiewirtschaft Baden-Württemberg 2015; Riedel et al. 2016; Landesarbeitsgemeinschaft Agenda 21 NRW 2018; KOSIS-Gemeinschaft Urban Audit 2019; Landeshauptstadt Stuttgart 2019; Knipperts 2020). All indicators from these sources were first assigned to the sub-targets assessed as relevant. Subsequently, for targets or sub-targets that were not covered with indicators, additional databases containing official data sources at the municipal level were searched for suitable indicators (that is, the German regional database of the Federal Statistical Office, the INKAR database of the Federal Institute for Research on Building, Urban Affairs and Spatial Development or the data portal 'Wegweiser Kommune' by the Bertelsmann foundation). After adjusting indicators that were assigned multiple times or had identical contents, the initial compilation comprised 468 different indicators. In the next step, these indicators were evaluated according to the quality criteria defined in the project: validity, data quality, data availability at the municipal level and function (i.e. input, output, outcome or impact-related). While minimum requirements were defined for validity, data quality and function, the assessment of data availability merely determined if an indicator would be of 'Type I' or 'Type II'. Type I indicators are indicators that can be provided with individual data because municipal-level or county-level data to these indicators are available from official statistics or other, centrally accessible data sources. Type II indicators are only available locally or they have to be assessed individually as part of local sustainability monitoring processes. As a result of the assessment of quality criteria, 195 out of a list of 468 indicators were considered potential SDG indicators, amongst them 96 of Type I and 99 of Type II. From those, 47 core indicators (30 Type I and 17 Type II) were selected for the first catalogue according to further aspects and questions, including equal distribution of indicators across the 17 SDGs, potential multiple classifications, and the vertical integration into sustainability reports at state and federal levels.

As stated above, practical tests, applications (e.g. Klein and Zender 2019; Landeshauptstadt Stuttgart 2019) and evaluations revealed several weaknesses, gaps and additional needs of practical operators. This is especially important in regard to topics of municipal development policy and education for sustainable development, climate change mitigation and adaptation, mobility, housing, land use management, digitalization, and care, amongst others. Thus, these limitations were addressed in the first revision of the original catalogue. Another aim of that revision was to improve vertical integration—that is, to better align the municipal SDG indicators to higher-level sustainability monitorings such as those from selected federal states and especially the national German Sustainability Strategy, which also relates to the SDGs. Finally, the possibility of adding additional Type II indicators using data from open and/or alternative data sources was examined, however, with limited success. Thus, the first catalogue was revised from 2019 to 2020 and finally amended by 73 additional indicators to a final set of 120 SDG indicators for municipalities, with almost half of them (56 or 47% Type I indicators, 64 or 53% Type II) being provided in related data portals (see below). Detailed fact sheets were prepared for all 120 indicators. As a novelty, the revised catalogue contains a few new and individually developed indicators for the first time: Indicators that summarize nonquantifying but very relevant information into indices; that is, indices for climate change mitigation, climate change adaptation, sustainable procurement, digitalization and prevention of corruption. The new catalogue was published in German language in December 2020 (Bertelsmann Stiftung et al. 2020).

The 2020 German set of 'SDG indicators for municipalities'

Overview of the 120 indicators

Although all SDGs and most of the targets could be addressed with indicators, the distribution of the 120 indicators over the 17 SDGs varies considerably (see Fig. 1).

Sustainable Cities and Communities (SDG Goal 11) is quite overrepresented as opposed to goals such as SDG 2 'Zero Hunger', SDG 6 'Clean Water and Sanitation' or SDG 14 'Life Under Water'. The low coverage of such goals, however, has different reasons. For example, some aspects of the food supply and agriculture addressed in SDG 2 (targets 2.a, 2.b, 2.c) do not fall within the scope of responsibilities of German municipalities and therefore did not pass the task check as the final part of the relevance check (see chapter on the methodological approach and Supplementary Material). The same applies to SDG 14 since less than 10% of German municipalities can be geographically assigned to the coast. Thus, such targets (target 14.2—target 14.7 and target 14.b) did not pass the problem check as the second step in the relevance check. Furthermore, there is a lack of measurement methods when considering, e.g. river plastic emissions into the oceans or the contribution of consumer behaviour to overfishing. This lack of adequate methods in combination with sparse comprehensive data sets as a result of diverse administrative responsibilities for different types of waters is the reason for the low coverage of indicators at SDG 6. SDG 13 and SDG 17 can be regarded as critical examples for data availability, as not one (sub-)target could be served with Type I indicators. As mentioned above, these were amongst the few topics that were specifically targeted in the enhancements of the catalogue from 2019 to 2020. Therefore, our inability of providing Type I indicators point to a clear gap in open data and

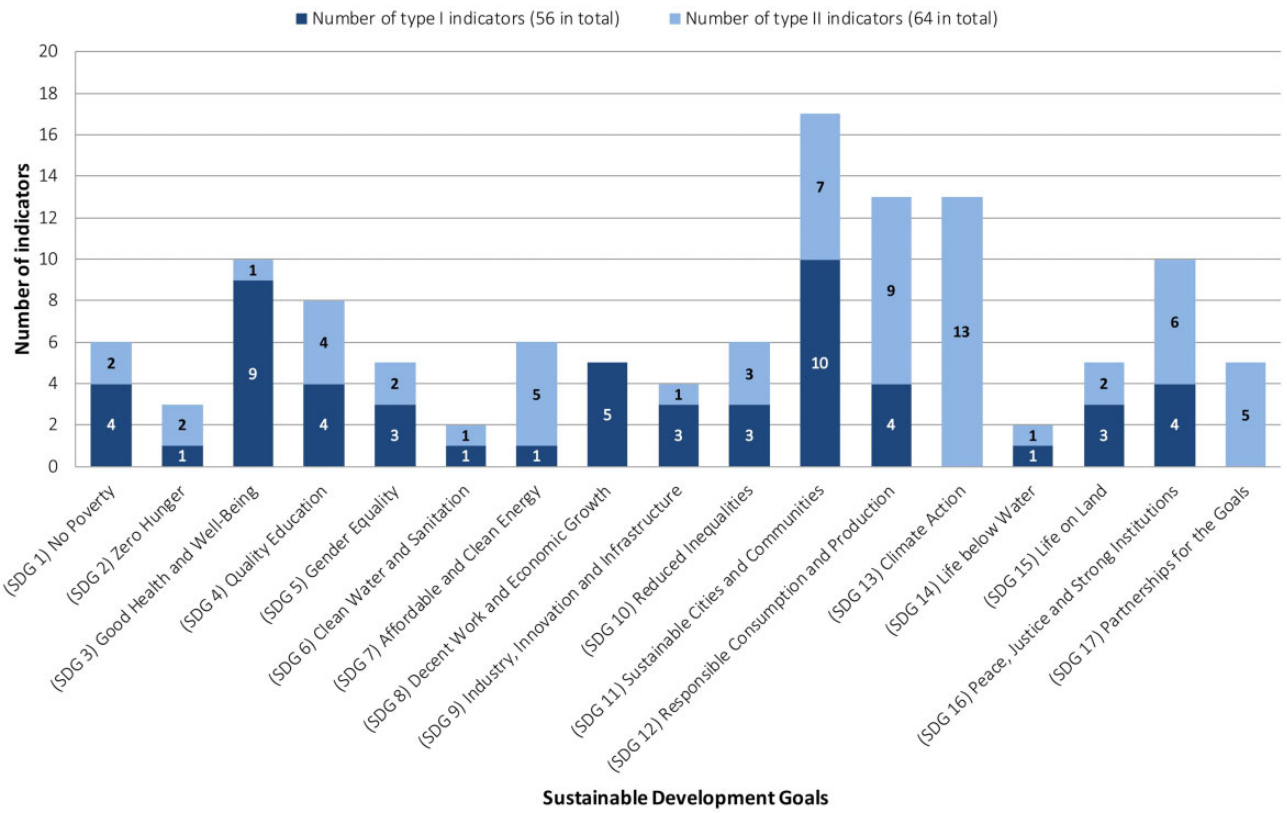

Figure 1: Distribution of the 120 German 'SDG indicators for municipalities' for monitoring SDG achievement on a local level in Germany over the 17 SDGs (X-axis). Of the 120 indicators (Y-axis), 56 are provided with centrally accessible data ('Type I indicators'; lower and dark column) and 64 indicators must be collected or assessed individually on a local level ('Type II indicators', upper and light column).

official statistics which leads to a gap in municipal monitoring practices with initiations or support from higher-level authorities. Plans are in place to compensate for these deficits in the following years by employing technical assistance to the provision of data from the municipalities. As an example, the tangible indicators for SDG 11 and SDG 15 are presented in Table 1; an overview of the entire indicator catalogue is available in the Supplementary Material.

Analysis of the coverage of all relevant targets

The expansion of the indicator set from 47 in 2018 to 120 in 2020 indicators was implemented in order to cover more relevant (sub-)targets of the SDGs. Considering that we could increase the share of (sub-)targets assessed as relevant for municipalities and served with indicators from 39.7% in 2018 to 64.4% in 2020 we can regard this aim as achieved. Figure 2 shows the results of the relevance check and the indicator development per individual SDG.

Our analysis indicates that health (SDG 3) and ecological indicators (SDG 15) serving different (sub-)targets are missing most, whereas any type of indicators regarding education (SDG 4) and affordable and clean energy (SDG 7) as well as climate action (SDG 13) are more abundant. In SDG 8, 10, 14 and 17, indicators are also more abundant but they include many nonrelevant (sub)targets for German municipalities. Thus, each city should critically review the relevance of its individual needs and circumstances and add respective indicators as required to address local issues.

It should also be noted that all indicators were included in this graph, regardless of their data availability. Therefore, for example, SDGs 13 and 17 appear as 'served with indicators', however, this statement is limited to Type II indicators that are not provided with data and must be collected or assessed individually.

The different natures of SDG targets and their relevancies to municipal SDG indicators

In general, the SDG targets consist of two different types of objectives: First, there are 107 outcome targets which relate to desirable outputs, outcomes, or even impacts of any measures that may be implemented for sustainable development. These targets are numbered consecutively by decimal places. Second, the SDGs contain 62 means of implementation (MoI) targets which corresponds to 36.7% of all targets. They were introduced because one of the major limitations of the MDGs was considered the lack of appointing the resources required for achieving the goals (Bhattacharya and Ali 2014). The MoI either point to financial or nonfinancial measures for achieving the goals, and they differ in the level addressed, from the global like the United Nations to national or sub-national politics. Moreover, some of them are unspecific in the level they address and can thus be applied to regional or municipal levels, especially in regard to municipal development policy and international cooperation. The MoI targets are numbered by alphabetical letters from SDG 1 to SDG 16. However, SDG 17 is fully devoted to MoI. Therefore, it is somewhat inconsistent that all targets in SDG 17 are numbered by decimal places instead of letters. In our

Table 1: Exemplary excerpt from the German 'SDG indicators for municipalities' catalogue: indicators for SDG 11 and SDG 15 in the first (2018) and second (2020) versions of the catalogue

SDG 11	Type I indicators (provided with centrally accessible data)	Type II indicators (must be collected or assessed individually on a local level)
First catalogue (2018)	• Rent prices • Road traffic casualties • Land use • Local recreation areas	• Modal split
Second catalogue (2020)	• Living space • Basic supply close to home—supermarket • Car density • Public transport—local supply with stops • Land use change • Land use intensity • Completed residential buildings with renewable heating energy	• Housing cost overburden rate • Cars with electric drive • Cycle path network • Public transport—local supply with stops • Rate of energetic renovation of buildings • Public transport—accessibility of (main) regional centres
SDG 15 First catalogue (2018)	Type I indicators • Nature conservation areas	Type II indicators • Sustainable forest management • Common bird index
Second catalogue (2020)	• Landscape quality • Unfragmented habitats	

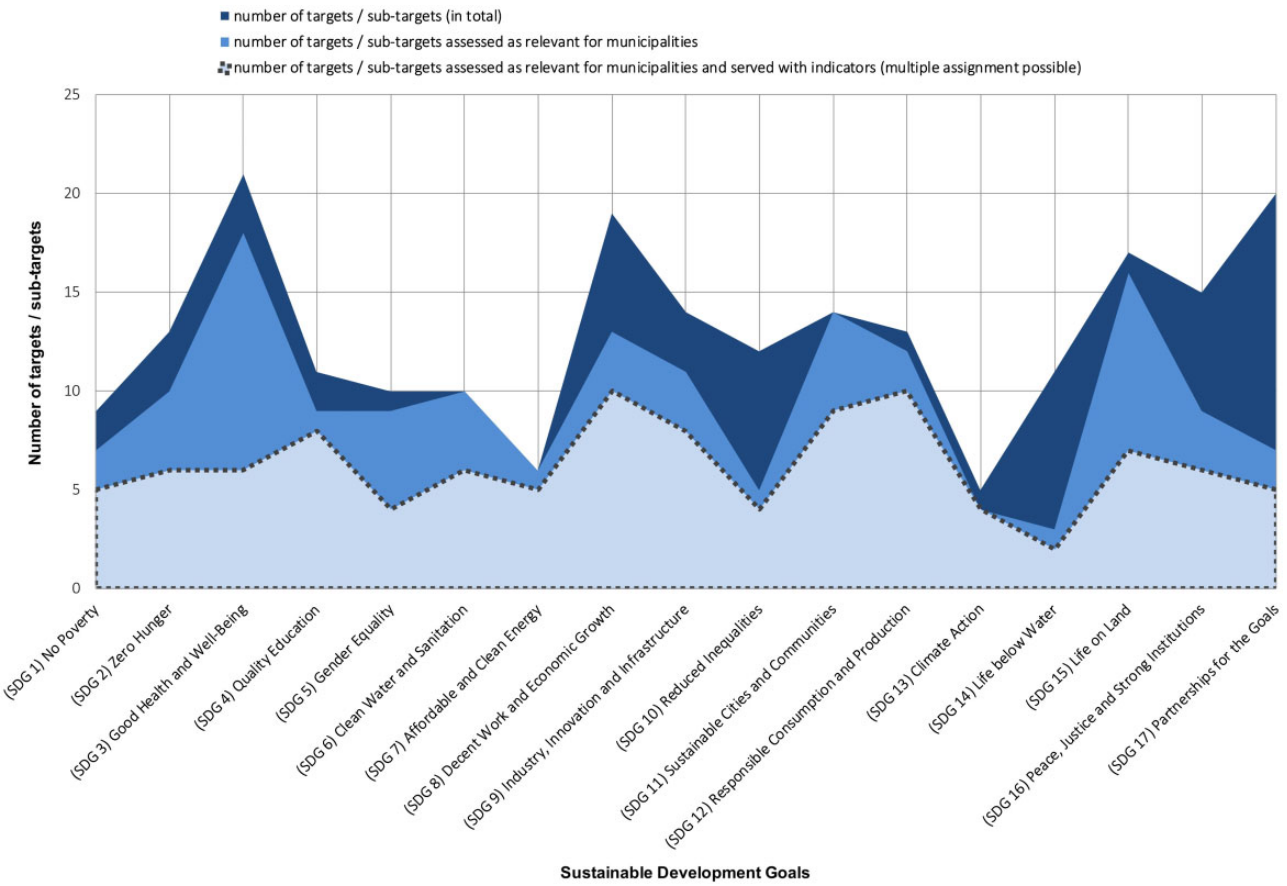

Figure 2: Coverage of the SDGs (X-axis) with the indicators from the 2020 German 'SDG indicators for municipalities' catalogue (dotted line/light area) against the background of (sub-)targets that were assessed as relevant for German municipalities (medium area) and all 220 (sub-)targets of the SDGs that were generated in the reported project (dark area).

relevance check, we divided 10 of 62 MoI into 21 MoI sub-targets, which is a share of 16.1% that were assumed to contain statements that are only partially relevant to municipalities. Thus, the total number of MoI targets or sub-targets that were checked for relevance was 73. Of those 73, more than half (41 or 56.2%) were rated as relevant to the municipal level, which

shows that municipalities are an important operational level in implementing the SDGs. Amongst the outcome targets, 33 of 107 were subdivided into 74 outcome sub-targets, which corresponds to 30.8%, and results in a total of 147 outcome targets or sub-targets. Of those 147, 122 (83.0%) were assessed as relevant. To conclude, the large majority of all outcome targets passed the relevance check for German municipalities. This supports the often-mentioned claim that although the 2030 Agenda was developed as a framework mainly for the national levels, local-level activities will largely determine whether or not global goals can be reached. The process of identifying suitable MoI indicators has once again proven the need for 'translation' of the targets to the municipal level with less room for interpretation, whereas the indicator gaps underline the need for better data transfer from the local to the global level and vice versa.

Accompanying tools: data portals for municipal reporting on the 2030 Agenda

For the more than 3000 German cities, towns and districts with over 5000 inhabitants, data for SDG Type I indicators are available in different data portals. Bertelsmann foundation's portal 'Wegweiser Kommune' (https://www.wegweiser-kommune.de/) enables municipalities to compare themselves with several other municipalities. The INKAR database of the Federal Institute for Research on Building, Urban Affairs and Spatial Development (https://www.inkar.de/) contains more than 700 indicators on living conditions in Germany and Europe. In addition, an own tool specifically targeted at SDG monitoring at the German municipal level was developed within the above-mentioned working group 'SDG indicators for municipalities': The 'SDG portal' that is also available in English language (https://sdg-portal.de/en/). It provides a quick assessment of the state and dynamics in specific indicators in a municipality, enables comparative analyses with other municipalities and average scores from similar municipal types, and offers individual text-based reports. In addition, good practice examples of tackling specific SDGs from German municipalities and general policy recommendations are provided. The portal was awarded the UN SDG Action Award (Top 3) at the SDG Global Festival of Action of the United Nations in 2018 and is subject to ongoing enhancements.

The SDG portal was transferred to Italy in 2020 (https://sdg-portal.it/it) as a result of a wider partnership between Fondazione Eni Enrico Mattei, the Bertelsmann Foundation, and the Italian Association for the Council of European Municipalities and Regions (AICCRE). In its Italian version, the portal contains data for indicators for the Italian Sustainable Development Goals at the city level (SDSN Italia SDGs City Index) (Cavalli and Farnia 2018; Cavalli et al. 2020). While there are numerous SDG data portals on regional, sub-regional and national levels (see Sustainable Development Goals Helpdesk 2020), we have—with the exception of SDG dashboards of individual municipalities—not found comparative local-level SDG portals in other countries. Thus, the responsible working group is planning on further scaling the portal to other European or non-European countries, with the long-term aim of enabling direct cross-national comparisons between different municipalities. Beyond the data portals, additional reports were published to support the municipal implementation of SDG monitoring (Jossin and Peters 2021; Peters et al. 2021).

DISCUSSION

Summary

The German SDG indicators for municipalities were developed in a multi-stakeholder working group to publish a comprehensive, realistically manageable set of indicators to monitor and evaluate the degree of achievement of the global goals on a municipal level. Beyond the core working group, many other stakeholders from German cities, towns and counties as well as stakeholders from governmental and scientific institutions and associations were included in the process to establish transparency and enable participation in decisions. In its latest version from 2020, the indicator catalogue contains 120 indicators. Almost half of these indicators are so-called 'Type I indicators' that can be provided with municipal-level (i.e. county or town level) data in portals for central and easy access. The indicator set is communicated as a toolkit that can be adapted according to individual needs and goals. In other words, it may be used as an entire set when the aim is to survey the current state-of-the-art in sustainable development and/or in achieving the SDGs in a municipality. At the same time, municipalities may choose a limited set of indicators when they want to focus on specific SDGs or evaluate measures and projects in specific areas of action—the latter potentially combined with further indicators from other sources to differentiate the monitoring in specific topics. The entire new set of indicators covers a majority of the municipally relevant targets—this applies to outcome targets as well as MoI targets. However, several translation and data challenges still exist.

Strengths of the German SDG indicators for municipalities

To our knowledge, our indicator catalogue is the first and most comprehensive set of SDG indicators specifically developed for the municipal level in an individual national context, which significantly increases the adequacy and ease of use in comparison to more general indicator sources (e.g. Bertelsmann Stiftung and Sustainable Development Solutions Network 2019; Eurostat 2020). Another approach from another country is the Italian SDG indicators (Cavalli and Farnia 2018; Cavalli et al. 2020) mentioned above that adapted a European cities index (Bertelsmann Stiftung and Sustainable Development Solutions Network 2019) to national needs. In the latest version, the Italian set comprises 46 indicators (provided with data) which are combined in a city index. The index informs 103 Italian municipalities about their level of achievement of all SDGs except SDG 14 with a traffic light logic. While indices such as the Italian example provide a simple overview, it is an evaluative 'top-down approach' that may suffer from a neglect of various relevant targets (cf. Diaz-Sarachaga, Jato-Espino and Casto-Fresno 2018) and that differs fundamentally from our approach of an individually adaptable toolbox.

Due to the highly participatory process initiated by the German SDG working group, the acceptance of the indicators amongst relevant stakeholders is quite high. For example, the executive committee of the German association of cities (Deutscher Städtetag) officially recommended the catalogue to its member municipalities in 2021. This could only be obtained by presenting it as an adaptable toolkit. However, a toolkit implies that the responsibility for tackling the SDGs holistically

with an integrated perspective and obtaining from 'cherry picking' (i.e. choosing and treating specific goals in an isolated way and thereby neglecting potential conflicts of interest with other goals and targets) is with the municipalities who apply the catalogue. It is nonetheless clearly recommended that municipalities use the catalogue comprehensively for local SDG monitoring. Besides the actual indicators, detailed profiles are provided for each indicator that indicate its sources, statistical properties, relevance to the SDGs and sustainable development in general, and potential interactions and interlinkages with other indicators. The indication of interactions and interlinkages supports integrated perspectives and the detection and handling of goal conflicts and congruences, which may be the key factors for successfully localizing the SDGs. In addition, the catalogue was developed with the SDG portal as a tool for easy access to relevant data on more than 50 SDG indicators. It was developed to be used by different target groups and also supports SDG-related communication of municipal authorities to the public.

The limitations of the German SDG indicators for municipalities

Despite its comprehensiveness and broad acceptance, our indicator set has some limitations that need to be discussed. One of the limitations is inherent in any set of quantitative indicators: Not all aspects of municipal sustainable development can be indicated by numbers, but qualitative information must be amended (Mair et al. 2018). This not only applies to some highly complex SDG targets (e.g. SDG 1/target 1.5 which refers to building the resilience of the poor and vulnerable in the light of various potential crises; United Nations General Assembly 2015). It also relates to the quality of the processes in sustainability management that should be monitored and evaluated just as the outputs and outcomes not least to understand why their sustainability management is successful or not (see, e.g. Hák, Janoušková and Moldan 2016). For example, it is important to describe the degree to which municipal authorities proceed in an integrated way, with different departments of the municipal administration working highly interdependently yet cooperatively. By doing so, they may avoid conflicts of goals and related trade-offs, and optimize congruencies of goals within different departments and areas of action (see, e.g. Giles-Corti, Lowe and Arundel 2020; Valencia et al. 2019). A second limitation is a lack of so-called interlinkage indicators (Spangenberg and Odile 1998), which can be defined as higher-level indicators that combine monothematic indicators from at least two different areas of action for a more integrated perspective, e.g. the indicator eco-efficiency (Spangenberg 2002). Although our set of indicators contains some indicators that integrate different information such as the 'Landscape Quality' or 'Digital Municipality' indices, our approach was criticized for not focusing on interlinkage indicators. We did not develop our own indicators but rather focused on collecting the best available indicators from various sources. Thus, the underrepresentation of interlinkage indicators points to the lack of existence of such excellent sustainability indicators overall. Moreover, the development of new interlinkage indicators is everything but trivial and would thus require individual research projects with a focus on specific topics and basic research on how to mathematically combine information from different areas of action in one indicator. Third, the fact that the number of Type I SDG indicators (i.e. indicators that are provided with data in the adherent data portals) does not clearly outweigh Type II SDG indicators (i.e. indicators that must be collected or assessed individually on the local level) is somewhat unsatisfactory. The more indicators can be provided with data, the less difficult it is for municipalities with limited resources to set up local SDG monitoring processes. However, many of our Type II indicators require individual assessments and some of them can only be operationalized with a considerable amount of financial and personal resources, for example, the estimation of greenhouse gas emissions in different sectors to adequately monitor some of the targets in SDG 13. In addition, we were not able to provide detailed measurement concepts for Type II indicators. The assessment of many of those indicators (e.g. mappings for ecological indicators such as common bird index or nutrient pollution in running waters) requires advanced technical knowledge and experience, which may additionally lift the inhibition threshold in some municipalities where specific expert knowledge is lacking. Fourth, while the 2030 Agenda and the SDGs may be the best blueprint we currently have for sustainable development, they currently fail to address various thematic gaps such as aspects of community resilience and social cohesion, culture and art as well as digitalization as a means of sustainable development, sustainable finance, and the unquestioned belief in economic growth. Thus, they fail to promote strong sustainability and sufficiency (e.g. Linz et al. 2002; Ott and Döring 2008) including deglobalization and de-centralization of the production of building materials, consumer goods and services. Therefore, our catalogue reproduces these limitations against a better and more holistic perspective of municipal sustainable development.

Implications for further research and practice

Our SDG indicator catalogue can serve as an extensive source for the developments of local-level SDG monitoring in other countries, especially those with similar levels of development (cf. Lior, Radovanović and Filipović 2018; Jabbari et al. 2020). To improve sustainability monitoring approaches, new research projects need to better represent the conflicts and potential congruencies between different goals with more complex, but fewer indicators overall. For example, the—national or local—gross domestic product may be replaced by an individual 'sustainability indicator' for a more robust ecological and social measure of prosperity (Coscieme et al. 2020). Second, there are several rather monothematic, but highly relevant issues that are difficult to monitor sufficiently. With respect to (urban) ecology, one example is the plastic emission into inland waters and oceans; another example is species protection, in particular Red List monitoring on the municipal level. Third, regarding future enhancements of official statistics and openly available data, there is a clear potential for improving access to big data also from private-sector providers such as mobile communications or housing portals and to remote sensing data for public interests (Estoque 2020) and better access to alternative data sources, amongst them citizen science and subjective data from citizen surveys (for a discussion of the potentials and challenges related to alternative data sources, see Mair et al. 2018; KOSIS-Gemeinschaft Urban Audit 2019; MacFeely 2019). In recent years, such enhancements of data availability as well as the growing list of best practice examples can be experienced every day. The improvements in our SDG indicator catalogue that were possible within only 2 years lead to a growing number of German municipalities applying the catalogue and show that indicator development is a very dynamic field. Thus, we assume that monitoring approaches will soon be even easier to apply and thus distribute. Against this background, bridging the gap

between monitoring and local action (Mair et al. 2018) is becoming increasingly important.

Supplementary data

Supplementary data are available at *JUECOL* online.

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