Practical guideline for cities and municipalities on an SDG-based assessment in the context of urban surfaces using life cycle thinking

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Abstract. The consideration of sustainability aspects is becoming increasingly important at municipal level in order to implement the SDGs. Some municipalities already have their own concepts for individual SDGs, such as climate protection (SDG 13). There are many fields of action in which municipalities can initiate changes to contribute to the SDGs. An important field of action is the municipal task of planning, building and maintaining urban areas and surfaces sustainably. However, as this topic is quite complex, there is a need for a guide for municipalities on how to conduct such a sustainability assessment. The authors provide a practical guideline for communities to evaluate the sustainability impacts of urban surfaces and their management processes. The guideline has been developed with special focus on its applicability and the reduction of the complexity of the topic for local actors. The authors present the guideline, describe the underlying methods and the five subsequent steps that can be followed by a community in order to conduct a sustainability assessment. First, the scope of the sustainability assessment is defined by classifying the municipal urban surfaces and their management processes and analysing their relevance. Then, the sustainability of the prioritized surface and process is analysed by selecting relevant indicators, identifying the life cycle phases and researching sustainability impacts in the phases for the thematic priorities. For each phase and indicator, relevant municipal areas of action are determined, selected ones further refined and possibilities for their implementation investigated. The guideline operationalizes the sustainability assessment methodology for the management of urban surfaces proposed by Henzler et al. [1], which uses SDG-based indicators and life cycle thinking of LCA, considering the interaction between the life cycle of urban surfaces and their products.

1 Introduction

Existing structures, urban areas and the built environment are increasingly struggling with the fact that they are no longer sufficiently equipped to meet the diverse challenges of the

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future. The impacts of climate change have not only already cost lives and damaged infrastructure and economies, but have also demonstrated the urgent need to change toward more resilient and sustainable environments, as described in Henzler et al. [1]. To ensure that technical solutions make a targeted and sustainable optimal contribution to future-proof cities, this must be in line with the SDGs. This paper presents the methodological assessment approach as well as guidance for implementation at municipal level.

2 State-of-the-art of sustainability assessment methods

In recent years, fundamental research has been done in the field of urban surfaces resulting, e. g., in the project BUOLUS, in the definition of the term and the categorization of urban surfaces based on Leistner et al. [2] as well as a general life cycle of urban surfaces based on DIN EN 15978 [3] in Henzler et al. [4] and an SDG-based impact assessment methodology tailored to urban surfaces in Henzler et al. [1]. However, when it comes to carrying out the steps and applying the indicators proposed in [1, 4] for a holistic sustainability assessment in the context of urban surfaces in municipalities, it becomes evident that there is a need for a simple guideline that helps local actors to navigate through the assessment process. In the case study done in [1], the authors state, e. g., that the object under investigation was "… selected in a participatory process by the municipal stakeholders" [1] but do not disclose details of the selection process. However, in general, cities have a huge number of urban surfaces and management processes that can be innovated in different ways targeting various sustainability issues. Therefore, there is a need for a structured and transparent approach for identifying relevant urban surfaces to be investigated. Besides, in [1], the environmental impacts were assessed with the LCA software GaBi and the authors do not elucidate how an environmental impact assessment can be carried out without the application of LCA software which is not commonly used by municipal stakeholders. Similarly, the authors in [1] do not elaborate on how to assess socio-economic impacts. With Level(S) [5] there is a framework for the evaluation and reporting on the sustainability of buildings looking at areas such as resource use, health and costs which is complemented with information on its usage. However, there is no such information for the assessment of urban surfaces in [1]. Besides, the sustainability assessment approach proposed by [4] needs to be disaggregated into several steps that are easily applicable for municipal actors and allow them to identify relevant fields of action and implement future-proof measures. Based on the findings of the project BUOLUS, the authors have proposed a practical guideline on an SDG-based assessment in the field of urban surfaces in [6] which is herein further refined and described.

3 Practical guideline

Based on [6], the authors propose a five-step approach for conducting a sustainability assessment in the field of urban surfaces and to initiate targeted measures based on the assessment results (see Fig. 1). To begin with, it is advisable to focus on a small number of relevant indicators or a single urban surface and one of its management processes in order to reduce the complexity of the assessment. Therefore, the approach is structured as follows:

Steps 1 and 2: In order to decide on the surface and management process to be assessed, the municipal surfaces and processes are classified and analysed with regard to their relevance.

Steps 3 to 5: The sustainability impacts of the most relevant surface and its most significant management process are assessed; moreover, measures for the optimization of the impacts developed and implemented.

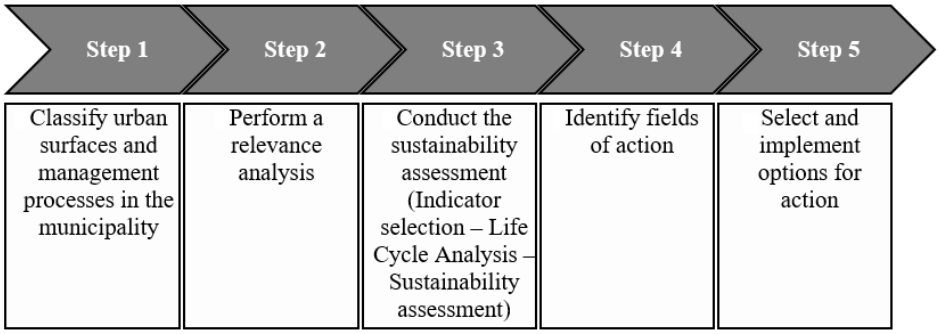

Fig. 1. SDG-based sustainability assessment in the context of urban surfaces, adapted from [6].

3.1 Systematic classification

The urban surfaces in the municipality should be classified systematically in order to limit the multitude of different surfaces and management processes to a manageable number of investigation objects. Table 1, which was compiled from the categorization of urban surfaces in Henzler et al. [4], can be used in the classification process.

Table 1. Classification of urban surfaces, exemplary management processes and material flows, compiled from [4].

Surface category	Surfaces	Management processes	Material usage	Emerging materials
Green spaces	Public parks, playgrounds, cemeteries	Watering, lawn mowing, collecting foliage, fertilizing	Fuel, water, fertilizer	Green waste
Barriers	Walls, fences, hedges	Repairing walls and fences, pruning hedges	Bricks, fence pickets	Rubble, green waste
Vacant lots and brownfields	Typical vacant lots, brownfields	Possibly lawn mowing	Fuel	Green waste
Traffic surfaces	Town squares, pedestrian precincts, cycle paths, roads	Clearing snow, maintaining infrastructure, cleaning, marking work	Water, paving stones, asphalt	Sweepings, rubble
Building surfaces	Roofs, façades	Repairing, modernizing, wet cleaning	Insulation material, façade paint, water	Rubble, waste water
Miscellaneous	Benches	Repairing, maintaining	Wooden batten	Rubble

3.2 Relevance analysis

In order to further limit the number of investigation options, a relevance analysis should be done on the surfaces, the management processes or focused sustainability issues with various municipal stakeholders. Doing so, the urban surface and the process with the greatest need for action and relevance for the municipality for a sustainable material flow management is to be identified. The analysis can be carried out under different aspects, which can also be combined, assessed with a scoring system and weighted. Hereafter, a selection of such aspects is given.

1. By surface areas and shares: A screening of the surface categories and surfaces can help to identify the surfaces and linked management processes with the greatest surface share in the city and to prioritize them according to their size, e.g., traffic areas and cleaning.

2. Regarding costs/environmental impacts of individual management processes: Herein, hot spots can be focused, i.e., for example processes that are linked to very high costs or environmental impacts, provided that such information is already available.

3. Prioritization of surfaces/processes by various municipal stakeholders: Challenges in the municipality and the satisfaction of individual stakeholders can be inquired by conducting surveys in the municipality, e.g., citizen surveys. This can help to collect, e.g., complaints on the uncleanliness of individual surfaces.

4. According to practical relevance for the local administration: Herein, urban surfaces are prioritized whose measures have a high chance of implementation. For example, a city administration might already plan on modernizing a particular surface and look for information to aid with the selection of future-proof materials.

3.3 Sustainability Assessment

In this step, the sustainability of the surface and management processes that were identified as most relevant and consequently prioritized in step 2 should be assessed. The analysis is structured into the steps indicator selection, life cycle analysis and sustainability assessment.

3.3.1 Indicator selection

When selecting indicators, it is expedient to check their thematic relevance. For example, in case the municipality has already developed a sustainability strategy, it is possible to embed the analysis into the existing strategy. The focus can be on individual indicators or sustainability dimensions, e.g., on the Global Warming Potential of management practices in order to integrate them into the existing municipal climate protection concept. A selection of indicators for a holistic assessment is given in Fig. 2. It can serve as inspiration for the selection of relevant indicators or municipal fields of actions. The proposed approach builds on the methods by Maier et al. [7], Wang et al. [8], and Henzler et al. [1] whose publications elaborate in detail on the connection of various sustainability topics to the SDGs.

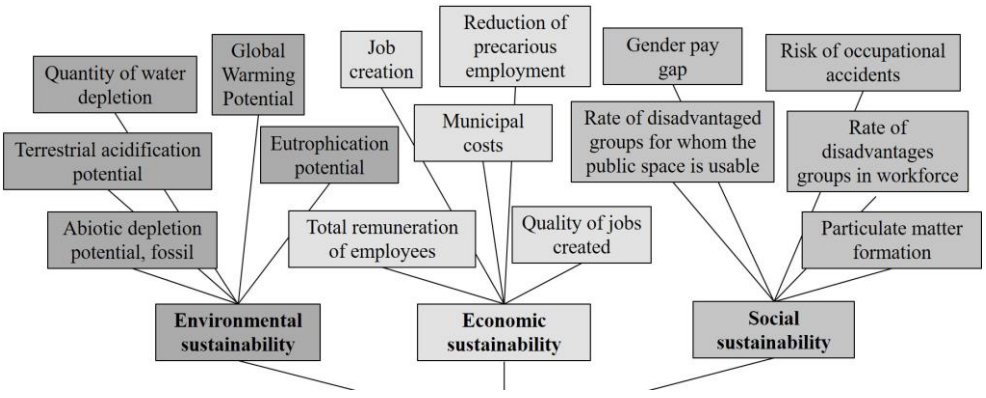

Fig. 2. Exemplary SDG-based indicators illustrated in the form of a Tree of Sustainability. Indicators selected and concept adapted from [1].

3.3.2 Life Cycle Analysis

In order to analyse the selected indicators along the whole life cycle of the urban surface and the relevant management process, the life cycle with its individual life cycle phases should be drafted schematically. The interacting life cycle scheme of urban surfaces and the products used in their management has been shown in [4] and linked to municipal processes in [6].

3.3.3 Sustainability Assessment

The identified life cycle phases should be investigated individually. For this purpose, potential impacts can be researched or products, labels or materials considered that would mitigate negative impacts.

3.4 Fields of action

Based on the assessment results, relevant fields of action for the municipality should be identified for each life cycle phase and indicator. Best practice examples from municipalities can serve as inspiration in this process. Besides, targets set in, e.g., municipal sustainability strategies, can be used as a guide in this step as has been done in Wang et. al. [8].

3.5 Options for action

In the fifth and last step, the previously identified fields of action should be specified and the roadmap for implementing the most promising options for action drafted. For this purpose, first, the fields of action can be selected that are easiest for the municipality to implement. Then, the long-term options for implementing the selected measures can be investigated. Through consultation with the offices concerned, the procedure that needs to be followed in the municipality when implementing measures for optimization can be clarified and stakeholders that need to be involved identified. Checking the budget and potential locations for the change planned, e.g., for a green façade for optimizing the impacts on biodiversity, are equally as important as drafting a schedule and an implementation plan. Besides, a strategy can be drafted for communicating the measures in the municipality internally, i.e., with the offices and executing employees, and externally, i.e., with the public.

4 Application

In this section, the approach is applied to an example. First, the classification and relevance analysis are carried out. The city administration has registered complaints about the lack of accessibility of the town square for handicapped persons which is characterized by concrete pavers with large joints. Therefore, the municipality prioritizes this surface. In the next step, the city considers the latest resolutions of the local council and decides to include indicators that measure the accessibility of the surface, the impact on the climate, the overall municipal costs and the working conditions. Then, the life cycle of the urban surface with the input and output materials and the machines applied in its management is sketched. Using the resulting life cycle scheme as a guideline for the sustainability analysis, the indicators are measured in each life cycle phase. The city conducts a survey among citizens to quantify the degree of accessibility of the town square for different groups of society. The city inquires verified environmental information on the concrete pavers's life cycle, which is provided in the form of an EPD. Based on the assessment results, two fields of action are identified: Replacement of the town square's material to increase its universal accessibility and implementation of

measures to optimize the impact of the surface and its management on the climate. In order to specify the fields of action, the city researches materials that are characterized by a smoother surface and allow for narrower joints than the currently installed paving stones. The municipality researches the Global Warming Potential of various products and considers how the replacement of the material might impact on the surface management to avoid a shift of burden. Based on this information, it selects a material and drafts an implementation plan for the modernization of the town square with local offices.

5 Discussion and conclusions

The herein presented guideline for an SDG-based assessment in the context of urban surfaces refines the approach in [6] and thus provides a starting point for municipalities to conduct holistic sustainability analyses for a sustainable transformation of urban surfaces. However, while the guideline was developed based on the findings of the project BUOLUS [6] in which sustainability assessments of innovations for urban surfaces in two German cities were conducted, there is still a need for municipalities to use the guideline to show its applicability and to give feedback on its ease of use to further develop it. One of the challenges that local stakeholders might face when conducting a sustainability assessment is the lack of publicly available environmental and socio-economic data for products and processes. While ÖKOBAUDAT [9] and EPDs provide environmental information on a variety of building materials, there is still a lack of publicly available and verified socio-economic data along the value chain for products and processes. Besides, there are significant data gaps at municipal level which need to be closed, e.g., regarding material flows and working time.

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References

1. K. Henzler, S.D. Maier, M. Jäger, R. Horn. Sustainability. **12**, 4466 (2020).
2. P. Leistner, A. Kaufmann, M. Koehler, M. Würth, W.K. Hofbauer, S. Dittrich, S. Maier, A. Gordt, M. Jäger. Bauphysik. **40**, 358-68 (2018).
3. EN 2012 DIN EN 15978:2012-10 Nachhaltigkeit von Bauwerken - Bewertung der umweltbezogenen Qualität von Gebäuden – Berechnungsmethode (Berlin: Beuth Verlag).
4. K. Henzler, R. Horn, M. Jäger, S.D. Maier. Earth Environ. Sci. **323**, 12068 (2019).
5. European Commission. Level(s): European framework for sustainable buildings. Available online: https://ec.europa.eu/environment/document/download/b20a88be-910e-437d-a77c-18df49be67fc_en (accessed 09.09.2021).
6. K. Henzler, S.D. Maier, M. Jäger, Practical guideline for cities and municipalities on an SDG-based assessment of innovations for urban surfaces using life cycle thinking, as Poster at the 10th International Conference on Life Cycle Management, LCM 2021, online, 5-8 September 2021, Stuttgart, Germany (2021).
7. S.D. Maier, T. Beck, J. Francisco Vallejo, R. Horn, J.-H. Söhlemann, T.T. Nguyen. Sustainability. **8**, 1006 (2016).
8. J. Wang, S. Maier, R. Horn, R. Holländer, R. Aschemann. Sustainability. **10**, 3208 (2018).
9. ÖKOBAUDAT. Available online: https://www.oekobaudat.de/ (accessed 09.09.2021).