Perspective

Transdisciplinary resource monitoring is essential to prioritize circular economy strategies in cities

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1. Introduction

Among the many concepts involved in current urban transformations, the circular economy has become particularly prominent. Many cities have taken up the resource management discourse to design circular economy action plans, which aim to reduce urban environmental impacts while generating new jobs, social wellbeing and room for innovation. At the same time, there is a sense that ‘circular economy concepts are more often celebrated than critiqued’ (Geng et al 2019). Indeed, cities worldwide are committed to becoming more circular in their resource use, but whether or not their actions help them to reduce their environmental impacts is unclear. Without adequate monitoring tools and a basis for prioritizing, cities could be investing their limited organizational, financial and human capital on circular strategies that might not minimize the pressure on natural resources. In fact, academics have repeatedly pointed out the lack of a homogeneous monitoring framework for the circular economy (e.g. Helander et al 2019, Moraga et al 2019). Prioritizing strategies based on their environmental savings is thus no easy task for academics, let alone for decision-makers. It seems then reasonable that cities use the tools at hand to monitor progress of their strategies. Some of these tools stem from policy, such as the UN Sustainable Development Goals (SDGs), which are internationally endorsed and come with their own indicator framework, with several goals targeting resource management (UN 2015). What can we learn from existing monitoring needs and suggested indicators to build robust prioritization frameworks? In this perspective, we posit that a more focused effort can be made by aligning circular economy monitoring with the SDGs. By connecting the urban circular economy and the SDGs, one can identify the challenges and opportunities of these two political frameworks and define an action plan to monitor and prioritize circular strategies.

We acknowledge that scientific and political monitoring frameworks do not often follow the same rationale given methodological and/or practical constraints. For this reason, we discuss how to take stock of existing concepts, methods and indicators stemming from sustainability research fields, such as industrial ecology, that can help monitor resource use while connecting urban circular economy and SDG agendas. We examine what policy suggests to be suitable indicators as opposed to what needs to be measured according to established academic concepts. Figure 1 illustrates this process. We identify resource-related SDGs, suggested indicators and their coverage of the urban circular economy. In parallel, we determine what needs to be measured following a quantitative approach to urban metabolism to study resource use in a given city (steps 1–4) and the environmental benefits and impacts arising from circular strategies (steps 5 and 6). By doing so, we can critically assess both the lessons learned from the SDG framework and the potential struggles in meeting the monitoring needs stemming from sustainability frameworks. We envision the ultimate goal of this critical assessment as a learning process for both science and policy that materializes in the need for actual dialog and interaction between both parties.
2. Lessons from the SDGs

In order for cities to identify the direction of their efforts, those SDGs targeting resource management can define a starting point of action. Of the 17 SDGs, nine (SDGs 2, 6–9, 11, 12, 14 and 15) directly refer to water, energy, food, materials and/or land and its ecosystems, which are to be monitored through 34 different indicators (UN 2017). One of the struggles of SDG localization in cities is, however, the general and overarching formulation of the goals and targets. Common goal formulations include such terms as ‘improve’, ‘substantially increase/reduce’ or ‘achieve sustainable management’. The SDGs are meant to leave room for adapting the goals to particular contexts based on ‘governance through goals’ (Biermann et al 2017). Although this provides flexibility to design action plans, we maintain that it can hinder systematic monitoring and prioritization. While academics might ‘seek data for the sake of having them’ (Shepherd et al 2015), urban decision-makers might stick to measurable indicators based on political prioritization to give an impression of progress (Zinkernagel et al 2018, Hansson et al 2019). For instance, Shepherd et al’s (2015) survey on African agriculture highlighted that climate data are needed but barely collected to conduct assessments, whereas great efforts are invested in areas perceived as less needed, such as biodiversity and poverty data.

Similarly, the circular economy is subject to varying interpretations and a lack of academic consensus (Leipold et al 2021). The main narratives revolve around closed material cycles, extended material value through time, regenerative systems and cleaner production, among others. We argue that some SDGs mirror the traditional views on the circular economy as a recycling strategy. Target 12.5 is a clear example, calling for reduced ‘waste generation through prevention, reduction, recycling and reuse’, which is to be measured using recycling rates. However, many cities have envisioned a wide array of strategies labeled as ‘circular’ involving industries, consumers,
infrastructure and urban planning (Petit-Boix and Leipold 2018), meaning that recycling is only one of many actions. Resource monitoring must not be limited to recycling rates and thus a more holistic approach is needed to cover the various urban agendas for the circular economy and SDGs.

3. Revisiting urban monitoring needs

Given the limitations and opportunities offered by both policy concepts, we need to identify what needs to be measured to capture the environmental effects of circular strategies and their contribution to the SDGs. Here, the established approach of urban metabolism helps to understand the urban structure and its relationship to natural resources and to select suitable indicators. The literature already provides a robust framework for conducting such assessment. In figure 1, we include the three layers of information suggested by Kennedy et al. (2014) to monitor resource use in cities: land use and cover (1), resource stocks and flows (2), and the status of urban utilities and existing circular initiatives (3), which ultimately lead to a hotspot identification (4). Using this information, one can proceed with scenario planning (5) using a circular approach to evaluate the impacts and benefits of these strategies on resource use (6) and finally prioritize desirable actions. Urban metabolism studies can be, however, a burdensome process. Tracing resource stocks and flows, identifying critical sectors and mapping existing circular actions to estimate their potential effects on resource use is essential. Nevertheless, transparent and accurate data are scarce and constitute a barrier to the monitoring of the circular economy (Geng et al. 2019) for science and practice alike.

This focus on the urban metabolism also highlights existing limitations in the SDG indicator framework. Researchers and practitioners are confronted with two types of indicators. We call ‘territorial indicators’ the measurements included in layers 1–3 of the urban metabolism scheme (figure 1), as they give an overview of the resource consumption and production within the city boundaries, as well as the main socioeconomic and physical structures of the territory. Territorial indicators can already provide local decision-makers with initial hints on the main resource hotspots and actions needed. For example, the energy and material flows of 27 megacities (e.g. New York, Tokyo and Moscow) have already been quantified along with their relationship to urban form and built area, among other parameters (Kennedy et al. 2015). Most of the indicators available in the SDG framework could be labeled as territorial. For instance, Indicator 11.7.1 measures the ‘average share of the built-up area of cities that is open space for public use for all’.

However, reporting territorial indicators alone does not cover the environmental rucksack of cities. Given the global impacts of resource trade, a life-cycle and global perspective is required to unveil potential trade-offs, which can be accomplished through footprint accounting (Wiedmann and Allen 2021). Only through a footprint lens can the SDG indicator framework become a comprehensive tool for monitoring not only the environmental hotspots of urban circularity but also any strategy developed in nations and regions to approach sustainable development. Of the available footprint family indicators, such as the water footprint or ecological footprint (Vanham et al. 2019), only the material footprint is suggested to account for national material consumption and trade in SDGs 8 and 12. It is problematic that the urban carbon footprint (Chen et al. 2019), a widely known metric, is not included in the indicator framework. Only Indicator 9.4.1 ‘CO2 emission per unit of value added’ refers to territorial greenhouse gas emissions when addressing industrialization and cleaner production (UN 2017).

We argue that the SDGs provide useful goals but lack accurate indicators for cities. Territorial indicators, however limited, can serve as a step for calculating urban footprints and planning scenarios for a circular economy, as they provide information about resource demand (e.g. ‘7.3.1 Energy intensity’). Analyzing the metabolism of cities can provide a structured understanding of resource and service demands and be coupled with existing consumption-based approaches. Footprint analysis, however, requires a higher level of expertise and more comprehensive data collection than territorial indicators (Wiedmann and Allen 2021). In fact, integrating a broader set of footprint indicators into the SDG framework demands additional knowledge on the interactions between natural resources, such as water, energy, food, materials and land. To understand the implications of the so-called ‘resource nexus’, one must be aware of the trade-offs resulting from certain goals (Bleischwitz et al. 2018). For example, a decreased carbon footprint might come at the cost of an increased water footprint. To enable this holistic evaluation, we call for a more transdisciplinary approach to SDG and circular planning in cities.

4. A pathway towards transdisciplinary monitoring and prioritization

Monitoring and prioritizing circular strategies will remain utopic if academic and practical struggles are not resolved. Footprint accounting requires a time investment and level of expertise that local administrations alone are unable to manage. At the same time, academics with the required knowledge struggle with data collection and implementation. While local decision-makers have the tools to plan and implement circular strategies, scientists can inform about their effects on resource use. Research has shown that transdisciplinarity and ‘real-life experiments’ in cities are central in monitoring and prioritization efforts as
they enable mutual learning and data collection, and generate ‘socially robust knowledge’ (Schneidewind and Scheck 2013, Scholz and Steiner 2015).

We propose a pathway that we view as necessary for monitoring and prioritizing circular strategies in cities. Our stance is that adjusting the SDG framework is not the solution if we want transformation to happen in the short term. Instead, we should take what we have ready at hand—existing transdisciplinary and monitoring tools—to define suitable indicators, collect data and test new strategies. As transdisciplinarity, urban metabolism and footprint accounting are mature methods from the social and environmental sciences, they can help us generate robust action plans for the relatively young SDGs and the circular economy. Experiences of co-created monitoring frameworks using footprint indicators, however, still seem to be rare, but there are calls for monitoring the SDGs through territorial and footprint indicators within a social learning environment involving science and policy (Bringezu et al 2016).

Our proposal is to integrate resource monitoring, SDGs and urban circular economy into real-life experimentation through the so-called ‘transition cycle’ (Schneidewind and Scheck 2013) (figure 2). This process, which can be applied in any urban context, involves four steps, i.e. problem analysis, vision development, real-life experiments, and diffusion and learning (Schneidewind and Scheck 2013). The problem analysis aims to assess the current relationship between the city and natural resources in order to identify environmental hotspots. It will serve as the basis for developing a vision, i.e. identifying goals and targets of local interest within the SDG framework. Real-life experiments can then be conducted to test circular strategies and collect data on changes in resource use. At the end, circular strategies can be prioritized by matching the pre-defined SDGs with data on the urban metabolism.

Through this policy-science dialog, we seek to encourage the integration of existing sustainability research and transdisciplinary frameworks. We strongly argue against creating a new framework. Instead, we propose concrete steps to reimagine proven and tested methods that can make knowledge accessible to urban decision-makers and scientists alike. For an optimal use, more demonstrative research and collaboration is needed to help monitor resource use through footprint and territorial indicators and thus prioritize strategies that are relevant at a practical level. We therefore encourage the funding and development of more transdisciplinary projects dealing with not only the urban circular economy but also strategies dedicated to improving resource and material efficiency more generally.

As the main struggle is data collection, we also call for action from existing initiatives to facilitate experimentation and prioritization processes. For instance, several cities belonging to CE100 or the ICLEI - Local Governments for Sustainability network could coordinate to generate agreed data collection standards. This and other existing networks are a fundamental source of information and experiences in terms of monitoring. They might then hint at additional practical struggles of integrating territorial and footprint indicators into the work schemes of the city’s administrative bodies. We need more examples of transdisciplinarity in cities around the world that follow monitoring and prioritization approaches such as the one discussed in this article.
Data availability statement

No new data were created or analyzed in this study.

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Author contributions

A Petit-Boix conceived the research idea, conducted conceptual research and took the lead in writing the manuscript. A Petit-Boix, S Leipold and D Apul contributed to the conceptualization of the article and the discussion of the framework. S Leipold, D Apul and T Wiedmann reviewed the manuscript and wrote/contributed to specific passages with literature. All authors gave their final approval to the manuscript.

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