Mapping sustainability indicators for circular built environment in the Global South

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Abstract. The UN Sustainable Development Goals (SDGs) offer a framework for a better future by focusing on people, planet, prosperity, peace and partnerships. SDGs directly relating to the built environment are SDG 11, SDG 9 and SDG 12. The SDGs do not explicitly mention circular thinking or practices. Yet, the principles underpinning sustainability and circularity are the same, especially those focusing on resource efficiency and conservation. The aim of this paper is to map the SDGs against circular built environment indicators in the Global South. In doing so, not only is the alignment between the National Determined Contributions (NDCs) and the built environment established, but the significant position that the built environment plays in the rapidly growing cities of the Global South is also strongly supported. Using secondary research, this paper first investigates the primary and secondary SDG indicators for achieving circular built environments by the One Planet Network's Sustainable Buildings and Construction programme. This is then validated by undertaking workshops with experts in the Global South to determine an interim set of SDG indicators relate to circular economy such as local jobs, design considering climate mitigation, resilience and adaptation and such other indicators. The paper recommends priority indicators for achieving circular built environments in the Global South and suggests further research needs to be undertaken to finalise these indicators.

1. Introduction

The building sector has a very large footprint from a carbon emissions perspective. Approximately, 37% of global energy and process related CO2 emissions are directly or indirectly attributable to buildings across their life cycles. About 9% of global energy and process-related CO2 emissions result from the use of fossil fuels in buildings. A further 10% is related to the manufacture of building materials and another 18% is attributed to heating and cooling buildings [1]. Unlike many objects that are used on a day-day basis, buildings have a comparatively long lifespan of anywhere between 50-100 years. In Europe, residential buildings usually last over 60 years [2]. To prevent lock-in of continued emissions arising from operations of buildings, they need to be well designed not only during the build or construction phase, but also ongoing operation [3] [4].

As demonstrated by the recent report from Intergovernmental Panel on Climate Change (IPCC) (2021), the situation is dire. Implementing decarbonisation measures in buildings is urgent if the buildings sector is to reach Net Zero Emissions by 2050. The Paris Agreement [5] clearly articulated the importance of economic and social transformations needed to limit global warming caused by anthropogenic emissions. The Agreement entered into force in November 2016 and commitment was reaffirmed in COP 26 [6] held in Glasgow in 2021. The goal is to limit global warming to below 2 deg C, preferably to 1.5 deg C compared to pre-industrial levels. The Sustainable Development Goals (SDGs) came into effect in Jan 2016 [7]. The SDGs comprise of 17 Goals, 169 targets and 248 indicators, that balance the economic, social and environmental dimensions of sustainability. They are at the heart of the 2030 Agenda for Sustainable Development [8], focusing on people, planet and prosperity working in collaborative partnership across developing and developed nations to secure a future for the planet.

The Ellen Mac Arthur Foundation have worked with the building and construction industry, such as Arup to actively support the application of the principles of circular economy to the built environment sector. Especially, considering the Global South, adopting circular economy approaches in a high-growth region offers many opportunities. Combined with the typically high-waste sector of the built environment, a tremendous opportunity exists for all stakeholders to collaborate to minimize structural waste and seek greater value from built environment assets [9]. In a circular economy, renewable materials are used where possible, energy is provided from renewable sources, natural systems are preserved and enhanced, and waste and negative impacts are designed out of the system so that operations are also sensitive to environmental and social considerations. Materials, products, and components are instead managed in loops, maintaining them at their highest possible intrinsic value [9].

The Sustainable Buildings and Construction Programme (SBC) is one of six programmes under the One Planet Network (OPN). The OPN is a global community of practitioners, policy-makers and experts from governments, businesses, civil society, academia and international organisations, that implements the10-Year Framework of Programmes on Sustainable Consumption and Production and works towards achieving SDG 12 to ensure sustainable patterns of consumption and production [10]. The SBC programme aims to improve the knowledge of sustainable construction and to support and mainstream sustainable building solutions. Through the programme, all major sustainable construction activities are being brought together under the same umbrella. The work involves sharing good practices, launching implementation projects, creating cooperation networks and committing actors around the world to sustainable construction [11].

Since 2019, the SBC programme has focused on responsibly sourced materials for a circular economy (CE). The programme has had an active presence in international meets such as the Conference of Parties (COP) meetings since 2015 (COP 21, Paris), CIB World Congress (Tampere, 2016), the World Circular Economy Forum (WCEF) events since 2017 and the World Urban Forums (Kuala Lumpur 2018, Dubai 2020). As part of its key performance indicators, the work plan focused on understanding the state of play for circular built environments in various regions across the world, a first for any global programme. These reports were launched at a special session at the World Sustainable Built Environment Conference, WSBE 2020: Beyond 2020. The state of play reports focused mainly on secondary literature reviews undertaken by regional experts in the Global South: Africa, Latin America and Asia. The primary and secondary indicators for circular built environments were mapped against the SDGs and associated indicators by the authors based on the findings of the literature review. The aim of this paper is to extend the work already undertaken by presenting the mapping of these indicators and the process undertaken to validate these indicators.

Following a brief literature review, this paper discusses the research method before providing the findings and analysis. The paper then presents the discussion followed by conclusions and recommendations for further research.

2. Indicators for circularity in the built environment

The built environment sector is the cause for most material flows, with over 90% stock stored in durable goods with non-metallic minerals being the main contributor [12]. There is still great potential to improve urban mining. According to the authors, while recovery rates may be generally high, a little over half of the mineral construction and demolition waste is generally recycled. The authors call for the main actors dealing with building stock to be documented for transparency and promoting circularity. Material inventories are critical for this process. Tools that stimulate and support the management of information on material compositions of the building and regional material flows are needed; so also, clear and transparent criteria for developing material inventories.

Ogunmakinde et al.'s [13] research highlights the role of circular economy in the building and construction industry by supporting waste minimization, keeping materials and resources in a closed loop. The authors argue that such an approach assists with contextualising circular economy as part of the SDGs and they propose a framework that establishes a detailed relationship between the SDGs, construction waste management and CE to direct future research, policies and innovations supporting low carbon outcomes in the building and construction industry. Using a systematic literature review, their work concluded that understanding the connections between CE and the SDGs from a construction waste management perspective is critical for waste prevention, eco-design and re-use of materials, where an enabling environment for stimulating innovation, boosting economic growth and increasing competitiveness are created. Their study concludes that applying new innovative technologies in the construction industry, methods and strategies lead to transdisciplinary and transformative change.

Sustainability underpinnings are essential to reduce GHG emissions and address the priorities outlined in the UN SDGs [14]. The authors argue that addressing the SDGs while reducing our GHG emissions are critical to support a built environment for future generations on the planet. The Graz declaration (arising from the SBE19 Conference) calls for decisive action to reduce GHG emissions by supporting funding programs to achieve this aim. Ensuring adequate capacity building supported by appropriate physical infrastructure to achieve this is critical. This is also supported by authors such as Lanau et al. [15], who examined the built environment stock consisting of buildings and infrastructure. Their analysis showed that a higher percentage of stocks per capita and per area in developed countries and cities is prevalent, demonstrating the state of urbanization in the built environment stock growth in these countries. More detailed work and analysis is required to understand the state of play in the developing countries, where data is often a problem, especially with regard to material intensity, especially considering the life-time of buildings and infrastructure.

Angrisano et al.'s [2] work focused on using life cycle assessment to evaluate building circularity. They use existing certification tools to understand the sustainability and circularity of buildings focusing on using LCA as a method of evaluation. They consider the embodied energy and operational energy, focusing on the energy efficiency aspects of buildings, including evaluation of new innovative and technological materials. This focus on the individual building scale is different from Fusco Girard's approach [16] and [17] focusing on the whole city scale to promote nature-based solutions and urban productivity to promote regenerative and sustainability outcomes. Makenbach et al. [18] propose using modular construction due to its inherent properties of disassembly and reuse. A roadmap for circular business model proposes the use of applicability, usability and adaptability as the main considerations for built environment resulting in business models focusing on maintenance and repair, reuse and refurbishment, upcycling, and using product-as-a-service. Guidelines were developed post consultation with industry, leading to a roadmap to enhance innovative and sustainable industrialisation within the built environment to contribute to a circular economy. Their work primarily targeted SDG 12 on responsible consumption and production. Frequently cited opportunities arising out of this research are business resilience, precisely identifying the value-add, resource conservation, climate protection and the promotion of inclusive and sustainable industrialisation. Barriers identified in their research are dealing with the current building patterns of linear processes, the individuality and composite nature of

building units, complex supply chains, the long life-cycle of buildings, legal and regulatory barriers and uncertainties, risks and profits, and lack of demand by building owners. Broo et al.'s [19] research studied the role of the digital technology in understanding and developing model solutions to address complex issues related to climate change, now more than ever before given the associated uncertainties. Their work focused on the future to better understand the resources needed, technological breakthroughs, economic scenarios, governance arrangements, infrastructure support and social underpinnings in Britain.

It is clear from the analysis of the literature review, that there are no distinct approaches favoured with respect to built environment circularity. While some approaches are linked to the SDGs, others rely on existing ISO standards of life-cycle transparency. Systemic thinking needs to be applied as buildings are part of cities and therefore, the links need to be connected across the environmental, social and economic dimensions of sustainability and across scales at buildings, precincts and cities.

3. Research method

As indicated, this paper focuses on presenting the process of validating the primary and secondary circular built environment indicators. Grey and white literature were used as part of the review process. Grey literature refers to government and reports by international agencies whereas white literature refers to peer reviewed scholarly documents. Each of the reports: Africa, Asia and Latin America were also peer reviewed by local experts prior to the launch of the reports at the WSBE 2020 conference. In addition to this work, a global survey was also deployed to seek expert views on the core or primary indicators and secondary indictors reflecting circularity in the built environment and how circularity relates with UN 2030 Agenda SDGs and Indicators [7]. This was done at two levels: at the level of the overall goal and then a more detailed set of indicators across the various targets and indicators.

Based on the literature, from the 248 indicators, 58 indicators were identified for respondents to choose from. The survey respondents were from various regions but were skewed to developed countries. While this gave an overall signal of which are the indicators particular to the built environment, it did not provide an understanding of the regional variations in climate, building and construction materials used, skills, use of technology, digitalisation and so on. To counteract this and to ensure capture of regional nuances, online workshops across the Global South was undertaken. Ethics approval was sought to ensure that ethical guidelines were followed. The workshops were undertaken at convenient time zones for each of the participants. Each of the workshops lasted at least an hour with some going up to 75 minutes. Workshops followed a consistent format where the authors of this paper presented the background and the context, followed by regional author presentations. Then, themed discussions took place with online questions and real time responses that supported rich discussions in the regions and where appropriate, across regions.

4. Global survey on SDGs and indicators

Based on first 100 expert responses from the survey, four core indicators were selected across the 240 plus indicators available as shown in Table 1.

Table 1. Four core indicators and 10 secondary indicators arising from the Global Survey [a] (N = 100)

Core indicator	Secondary indicator
8.4.1 Material footprint, material footprint per capita, and material footprint per GDP	6.3.1 Proportion of domestic and industrial wastewater flows safely treated
11.c.1 Proportion of financial support to the least developed countries that is	6.4.1 Change in water-use efficiency over time

allocated to the construction and retrofitting of sustainable, resilient and resource-efficient buildings utilizing local materials; a suitable replacement indicator is under development to be proposed for the 2025 comprehensive review	
12.2.1 Material footprint, material footprint per capita, and material footprint per GDP	7.1.2 Proportion of population with primary reliance on clean fuels and technology
12.5.1 National recycling rate, tons of material recycled	7.2.1 Renewable energy share in the total final energy consumption
	9.4.1 CO2 emission per unit of value added
	11.1.1 Proportion of urban population living in slums, informal settlements or inadequate housing
	11.6.1 Proportion of municipal solid waste collected and managed in controlled facilities out of total municipal waste generated, by cities
	12.7.1 Degree of sustainable public procurement policies and action plan implementation
	12.a.1 Installed renewable energy-generating capacity in developing countries (in watts per capita); updated from Amount of support to developing countries on research and development for sustainable consumption and production and environmentally sound technologies in the earlier version
	13.2.1 Number of countries with nationally determined contributions, long-term strategies, national adaptation plans and adaptation communications, as reported to the secretariat of the United Nations Framework.

[a] The indicators are derived verbatim from the UN SDGs (https://unstats.un.org/sdgs/indicators/indicators-list/)

The objective then was to find out how relevant these indicator sets are in the Global South and in different regions within to assess their applicability, set objectives and monitor trends in the built environment. While the overall number of workshop participants in each region were not high due to issues associated with the pandemic; nevertheless, productive discussions resulted.

5. Regional workshops

Three virtual circular built environment workshops were organized in 2020: 15th October in Africa, 19th October in Latin America and 28th October in Asia. The participants were first introduced to the main findings from the State of Play of Circular Built Environment reports in Africa [20], Latin America [21] and Asia [22].

The SDGs and indicator survey results were shared, discussed and prioritized in each regional workshop. Thirty of the 100 survey responses at the time came from the Global South and did not differ much from the overall results. Inadequate housing (11.1.1) was given a higher priority in that sample. Since the number of responses from each region remained rather low, no direct conclusions could be drawn from the survey results. However, it formed the basis for facilitated discussions in each of the regional workshops and provided regional insights.

5.1 Findings from Africa

Based on 13 African survey responses, other indicators highlighted in the survey scored high amongst the 4+10 global indicators as shown in Table 1. These were: 7.3.1 'Energy intensity measured in terms of primary energy and GDP' and 13.3.1 'Extent to which (i) global citizenship education and (ii) education for sustainable development are mainstreamed in (a) national education policies; (b) curricula; (c) teacher education; and (d) student assessment'.

The workshop participants prioritized first five potential indicators finding recycling (12.5.1) as the most important one followed by wastewater treatment (6.3.1) and municipal solid waste (11.6.1). Material footprint (8.4.1 and 12.2.1) followed next. Then, a second set of high scoring indicators were prioritized where energy intensity (7.3.1) and CO2 emission (9.4.1) topped with inadequate housing (11.1.1) and local materials (11.c.1) following closely behind. Renewable energy (7.2.1) and environmentally sound technologies or renewable energy (12.a.1) were not found to be important.

A similar exercise was then made on the third set of indicators where public procurement (12.7.1) was found most important. The following quote from a workshop participant captures the importance of procurement:

> *For procurement, just relying on government is not enough, there is a need to bring in private actors.*

Other indicators the audience engaged with were Nationally Determined Contributions (NDCs) (13.2.1); 1.4.1 'Proportion of population living in households with access to basic services' and 7.a.1 'International financial flows to developing countries in support of clean energy research and development and renewable energy production, including in hybrid systems'.

5.2 Findings from Latin America

Based on the 7 survey responses from Latin America, the findings that scored high amongst the 4+10 global indicators (Table 1) were: 4.7.1/12.8.1 'Extent to which (i) global citizenship education and (ii) education for sustainable development are mainstreamed in (a) national education policies; (b) curricula; (c) teacher education; and (d) student assessment' and 11.b.1 'Number of countries that adopt and implement national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015–2030'. The workshop participants prioritized five potential indicators finding inadequate housing (11.1.1) and local materials (11.c.1) most important, followed by material footprint (8.4.1 and 12.2.1) and renewable energy (7.2.1).

The points raised in the workshop were that in rural environments, reusing and recycling materials is common. Some information about energy consumption exists, but at present, collecting construction related information were at very early stages. The knowledge of recycling building materials is very new in Latin America. Instead, there is a tradition of recycling bottles, paper and metals. One challenge is that the existing buildings constructed in Latin America have not been designed for recycling. The informal sector exploits only what gives them immediate benefit, such as iron scrap or glass. The de-construction of buildings is not taking place piece by piece, buildings are just demolished rather than de-constructed to enable second (or more) life of materials. Recycled materials are not used because they considered to be just for poor people. There is a perception that in a new house, you only use new materials. As a workshop participant indicated:

> *In your new house you don't want to use old windows or old tiles, you want everything new.*

A second set of high scoring indicators were prioritized where education (4.7.1 and 12.8.1) was seen most important, followed by recycling (12.5.1) and public procurement (12.7.1). CO2 emission (9.4.1) and municipal solid waste (11.6.1) were not seen as important in this group. The discussion on these indicators emphasized the importance of education to raise consciousness about consumption patterns.

During the past 10 to 15 years a lot had changed but it is taking place slowly, not moving expeditiously with respect to construction materials. A challenge lies in how to blend traditional knowledge with modern times and how to inculcate understanding of natural cycles to people who live in a concrete environment remote from nature.

A similar exercise was then undertaken on a third set of indicators where in addition to wastewater treatment (6.3.1), water-use efficiency (6.4.1), clean fuels (7.1.2) and education (13.3.1, same as 4.7.1 and 12.8.1), 11.5.2 'Direct economic loss in relation to global GDP, damage to critical infrastructure and number of disruptions to basic services, attributed to disasters' were also seen to be important.

5.2 Findings from Asia

Based on 11 survey responses from Asia, the following indicators as shown in Table 1 scored high amongst the 4+10: 11.7.1 'Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities' and 12.1.1 'Number of countries developing, adopting or implementing policy instruments aimed at supporting the shift to sustainable consumption and production'.

The workshop participants prioritized first potential indicators finding material footprint (8.4.1) and local materials (11.c.1) most important, followed by inadequate housing (11.1.1) and open space for public use (11.7.1). Prioritization of a second set of indicators ranked policy instruments supporting the shift to sustainable consumption and production (12.1.1), recycling (12.5.1), public procurement (12.7.1) and nationally determined contributions (13.2.1) before wastewater treatment (6.3.1).

A similar exercise was then undertaken on the third set of indicators where 11.b.1 'Number of countries that adopt and implement national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015–2030' topped before environmentally sound technologies or renewable energy (12.a.1) and CO2 emission (9.4.1) followed by 11.3.2 'Proportion of cities with a direct participation structure of civil society in urban planning and management' that operate regularly and democratically. Water-use efficiency (6.4.2) and clean fuels (7.1.2) were not seen that important by local experts. The discussion focused on lack of engagement with materials, as one participant highlighted:

> *In a market economy it is very difficult to single out building materials. When you go into practice, it is all about what clients are demanding…. the scale of engagement is important.*

6. Discussion

The global indicator framework includes 248 indicators out of which 231 are unique. Twelve indicators are repeated under two or three targets. Some of the indicators remain generic and could be specified as focusing on circularity. As an example, sustainable public procurement policies (12.5.1) could be defined as circular procurement practices. The workshops emphasised the need for education. The indicator for global citizenship education, education for sustainable development etc. (4.7.1/12.8.1/13.3.1) could be applied for measuring circularity.

Some indicators like material footprint (8.4.1/12.2.1), recycling rate (12.5.1), CO2 emission (9.4.1) or municipal solid waste (11.6.1) should serve as circularity measurements whereas a suitable indicator for local materials (11.c.1) is still being sought. There may be regional or local priorities for water (6.3.1, 6.4.1) and energy (7.1.2, 7.2.1, 12.a.1) and while these indicators are seen as important, they may not always be the most relevant ones in the building sector. In some indicators, such as 'Proportion of urban population living in slums, informal settlements or inadequate housing' (11.1.1) it may not be clear if slum upgrading increases or decreases circularity as it may also increase emissions while improving the quality of the environment and quality of life.

In the case of Africa, more focused discussions are needed to discuss how training (indicators 8.6.1 and 13.3.1) could be included or complemented by exploiting circularity. In the case of Latin America, discussions raised the point that without legislation to bring everyone to a level playing field, it is hard to drive industry acceptance. Top-down approaches with political interventions are needed. It was also recognised that business models which are also profit driven need to be espoused, or there will be no support/uptake. In Asia, the role of water was seen to be supressed because of a focus on materials.

7. Conclusions and further research

Linking nationally determined contributions and national adaptation plans (13.2.1) with circularity makes logical sense as they demonstrate government support and links well with industry practices. However, some key questions remain. *Where could these indicators work best? Can they serve for creating circular policies, can they be used to assess the circularity of the building sector or building products, or even be brought into a project level to assess the current state as baselines, to set targets and to monitor trends? Can specific areas be prioritised such as procurement, education and so on*. OPN SBC at present operates in Bangladesh, India, Sri Lanka, Burkina Faso, Ghana and Senegal to support creating circular policies and circular building products that are sustainable and to support local job creation in a manner that these pilots can be replicated and scaled up.

Based on the global survey analysis and validation in different regions, a number of 2030 Agenda based circular built environment indicators can already be applied. They serve well for assessing the current state, setting objectives and monitoring the trends. The indicator framework can serve for defining building policies, setting procurement guidelines, prioritise whole of life cycle approaches, and such other considerations and may even be applied at project levels. Further research and validation are needed to ensure local adaptation and acceptance of the core and secondary indicators in the region and at a country level. A number of potential indicators, even at a generic level, could be developed further to measure circularity to meet sustainability objectives.

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