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CIRCULAR DESIGN IN THE GLOBAL SOUTH

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Abstract. One Planet Sustainable Buildings and Construction Programme (SBC), led by the Ministry of the Environment, Finland and co-led by RMIT University and UN Environment Programme was initiated in 2015. Work on circular built environments commenced in the second iteration of the programme's work plan. SBC was the first global programme that worked on circularity and responsibly sourced materials in the buildings and construction sector. In 2020, the SBC programme published a range of reports focusing on the state of play for circular built environments across specific regions, tied together with a global report. The present focus of the programme is on Africa, Asia and Latin America, where case studies are collected following a common framework.

These case studies together with a global survey provide reliable performance data for responsibly sourced building materials in the Global South. The underpinning premise through this process is to support related SDGs across the social, environmental, and economic considerations and enable countries to achieve their targets under the Paris Agreement. This paper presents key findings from this study, largely derived through case studies in the Global South. The results show that not all stages of the building life cycle are addressed through local examples.

Keywords: Case studies, circular built environment, life cycle, sustainable buildings and construction, sustainable development goals (SDGs).

1. Introduction

The buildings and construction sector has an important impact on the planet. The sector is often a test of how well economies are performing, as this sector contributes to local employment and revenue generation, yet, also influences environmental impacts, being quite resource intensive. Global material use has been increasing and expected to increase in the near future due to the increased urbanisation in the African, Asian and Latin American regions. Material use expected to increase are steel, cement and glass with concrete alone contributing to about 12 % of global emissions in 2060 [1].

This paper builds on work undertaken by the One Planet Sustainable Buildings and Construction programme [2] in 2019-20 on circular built environment and launched at the Beyond 2020 Conference [3]. The global report presents ten recommendations [4]. These are integrating circular principles into planning and design, developing and applying circular built environment indicators, considering building and material lifecycles, developing innovative and new circular building materials and techniques, planning for resilience, drawing on local and indigenous solutions, developing new circular business models, developing a culture of collaboration, supporting skills and capacity building, and creating new financing and procurement models that support sustainability.

Even though the UN 2030 Sustainable Development Goals (SDGs) do not specifically refer to circular economy, the principles underpinning them are aligned with circularity. Circular practices are directly linked to SDG 12 on responsible consumption and production. Circularity can support the move to a less resource intensive building and construction sector. Circularity can be applied to different phases of the building lifecycle. These are:

(1.) design: site planning that influences design of the building (e.g. modular design) as well as of the building products,

(2.) construction: technical know-how of construction,

(3.) building operation: use of the buildings and maintenance,

(4.) renovation: refurbishing, renovating or changing

the building for adaptive reuse,

(5.) post-life or deconstruction: reuse as well as recycling of materials and building elements, and

(6.) manufacturing: both of the products and the construction of buildings that are needed for construction and operational maintenance or for renovation/reconstruction.

These steps are derived from ISO Standards (International Organisation for Standardisation) [5].

The objective of the research was to consider the different life cycle phases of buildings and construction using ISO standards [6] alongside the triple bottom line (TBL) approach [7] capturing environmental, economic, and social considerations in the form of the SDGs [8]. In doing so, the paper focuses on highlights from three regions in the Global South: Africa, Asia and Latin America. The underlying intent of this study is to share knowledge on circular practices in these regions, support place-based knowledge and practices, and support local demonstrations of circular practices. Analysis of the case studies are undertaken for different building life cycle phases, and across the TBL represented through selected SDGs. The analysis is followed by conclusions.

2. Research Approach

Case study research has been used commonly in the built environment and business disciplines to analyse specific issues within a narrow and well-defined scope [9]. The approach taken in this research is an in-depth investigation of circularity approaches and outcomes across particular types of buildings to understand the drivers and challenges in achieving these outcomes across the selected regions. Top-down and bottom-up initiatives were considered.

Data was collected by the regional authors through a process of selection through literature reviews (grey and white) and selective interviews with the stakeholders involved in design, construction, and operation of buildings. A template was developed, so there is consistency in the information collected across the three regions. Researchers across the regions were guided by the template in data collection.

3. Highlights from Africa

Africa, as a region, is one of the least developed in the world. 29 out of the lowest 32 countries ranked low in Human Development Index are from Africa [10]. The region is, however, the fastest growing in the world, with the United Nations estimating the population to reach 2.5 billion by 2050 [11]. The rapid population increase, coupled with increasing wealth and urbanization, drive the demand for new buildings and infrastructure in every country across the continent.

The building and construction sector of Africa is worth USD 5.4 billion, and it is expected to increase at a compound annual growth rate of 6.4 % by 2024 [12]. In 2019, buildings used 57 % of the total energy consumption and accounted for 32 % of the process-related CO_2 emissions in Africa [12]. This may partly be ascribed to the linear operation of the built environment where materials are extracted, used in buildings and discarded as waste.

3.1. Green Building Minimum Compliance System, Rwanda

The Rwanda Green Building Minimum Compliance System [13] has been developed as a holistic system with a set of green building indicators to guide building designers and practitioners to integrate energy and water efficiency, environmental protection, better indoor environmental quality and green innovation in new buildings during the design, construction and operational stages. Compliance with GBMCS is mandatory for new and larger commercial and residential buildings and major refurbishments and serves as. an Annex-3 to the Rwanda Building Code 2019. It has been recognized as an exemplar adopted by African government to promote green buildings.

GBMCS was developed with technical support local and overseas partners. Implementation of the GBMCS is led by the Rwanda Housing Authority (RHA) with support from 30 District One Stop Centers located throughout the country. Since its adoption in 2019, several new developments have applied the GBMCS in the design and construction phases of the projects. Over time, the RHA plans to integrate the GBMCS into an online portal for building permit applications. At present, resource limitations to country-wide sensitization and roll out of the GBMCS result in a more gradual implementation of the new system. The RHA plans to extend the GBMCS to cover all building typologies in Rwanda in the long term. The same approach of developing a customized policy for green buildings can be replicated for different countries.

3.2. Upcycle Africa (Sina Village), Uganda

Upcycle Africa is a social enterprise based in Uganda. They aim to address the plastic pollution problem while creating employment opportunities for disadvantaged women and youth in Uganda. The enterprise conducts initiatives to sensitise high school students to the problems caused by plastic pollution and instil good waste management practices. Over 20 000 students have been trained since the founding of Upcycle Africa in 2015.

The organization also operates a waste picker's program, employing women and youth from marginalized communities. The program focuses on plastic waste collection from beaches, streets and public spaces. The waste collected is sorted, with some sold to recycling companies and suitable plastic bottles being upcycled for construction. Upcycle Africa estimates over 3 million plastic bottles have been removed from the waste stream through their program [14].

Figure 1. House in Sina Village, Uganda constructed by Upcycle. Credit: GGGI.

Figure 2. Before and after images of the Denzo Hall Rahaguzar Street. Credit: Heritage foundation, Pakistan.

Suitable plastic bottles retrieved from the environment are used for construction of affordable housing. The bottles are filled with compacted soil by hand, increasing their compressive strength and thermal insulating properties. These bottles replace bricks as walling material to produce houses which are robust and affordable. The structures are durable, comfortable and earthquake resistant (see Figure 1). Upcycle Africa has constructed houses in different parts of Africa while creating employment opportunities for rural women and youth, bringing economic empowerment for them. This livelihood opportunity has a further benefit of enabling low-income families to pay the school fees for their children to access education.

4. Highlights from Asia

The urban population of South Asia is expected to increase by nearly 250 million people by 2030, leading to a shortage of affordable housing and resulting in unplanned urbanization with 130 million people living in slums [15]. The lack of affordable housing affects not only the poor but also many middle-income households. It is estimated that 203 million housing units will be needed in South Asia from 2010 to 2050 to accommodate the projected growth of the urban population [15]. Asian nations have begun to recognize the benefits of circular models for their economies and are taking steps to implement circular economy principles and closed-loop systems through regulatory measures and national policy frameworks. Two examples from Pakistan and India demonstrate this trend.

4.1. Denso Hall Rahguzar Walking Street for Regeneration of Karachi's Historic Core, Pakistan

Urban disarray in developing countries, such as Pakistan, is a growing problem due to poor governance and lack of funding for urban services. In response to this issue, the Denso Hall Rahguzar Street project represents an effort in low-carbon, climate-smart eco-urban regeneration in Karachi's historic core. This area has suffered from high-density urban issues, including an ineffective waste management system, deterioration of historic buildings and public spaces, and overcrowding.

The project is a collaborative effort between civil society organizations, local administration, and the community. It was conceived and designed by Architect Yasmeen Lari, and was financially supported and implemented by the Heritage Foundation of Pakistan in partnership with the Karachi government departments [16].

The project adopts a sustainable approach that incorporates locally sourced and hand-crafted biodegradable materials, minimized water usage and waste, and a focus on refurbishing historic structures to reduce energy consumption (see Figure 2). The project features a landscaped walking street that promotes commerce, recreation, creative and cultural activities. It also provides a healthier environment through the planting of 600 trees to absorb carbon, restricting vehicle entry to prevent air and visual pollution, and using permeable pavements to mitigate urban flooding and heat.

Other sustainable features include the use of recycled wood for lamp posts and cast-iron elements from discarded materials in entry gates, aquifer pits for rainwater harvesting, and the reuse of grey water for sustaining vegetation. The project has had a positive impact on the local community, with increased safety and job opportunities, and has become a source of pride and ownership for shopkeepers located in the street. This initiative demonstrates the potential for urban regeneration through the application of sustainable and eco-friendly approaches.

4.2. C&D Recycling waste plant, Surat, India

India generates approximately 150 million tons of construction and demolition waste each year, however, only a small portion, around 1 %, is recycled, with a daily rate of 6 500 tons [17]. A state-of-the-art mobile recycling facility was established in Surat, In-

dia through a public-private partnership to process 300 tons of waste daily, in compliance with the C&D Waste Management Rule 2016 of the Ministry of Environment, Forest, and Climate Change.

The waste is collected from 10 collection centers and processed using ReUrban Compact technology, resulting in the recovery of high-quality sand (50 %), aggregates (28 %), and soil (18 %). These recycled materials are then utilized in construction and for producing certified products, such as tiles and blocks, which are sold at a 30 % discount with a buyback option by the local government.

This circular waste recycling model offers significant environmental benefits compared to landfilling and is being replicated in other cities in India. Although the capital and operational costs are high (USD 1 481 730), it will reduce 508 tons of CO_2 emissions, the equivalent of burning 250 000 kg of coal annually, save 9100 Giga Joules of energy, enough to power 3 000 homes in India for a year, free up 30 000 yd^2 of land from landfills, and unlock 100 crore (or ten million) worth of real estate annually [18].

5. Highlights from Latin America and the Caribbean (LAC)

Current population in LAC Region is 659 million inhabitants [18]. Despite declining rates of population in the region generally, by 2050, the population is expected to reach 759 million. Currently, 81 % of its population live in cities being the most urbanized developing region in the world [19]. Although highest rates of urban population growth in LAC Region occurred during the 1950s to 1970s, driven by rural-urban migration, urbanization will continue growing and will reach 90 % in 30 years [20, 21]. Although there has been a decline in overall population, the region has been affected by increased rural-urban migration. Consequently, population has been increasing in the cities. The two case studies chosen from Latin America are focused on a material use and an urban regeneration project.

5.1. CEMEX Circularity Strategy

CEMEX is a global building material manufacturer focusing on concrete and cement products. This case study covers multiple countries in the region: Colombia, Costa Rica, Dominican Republic, El Salvador, Guatemala, Jamaica, Mexico Nicaragua, Panama, Peru, Puerto Rico, and Trinidad and Tobago. The company's mission is to "create sustainable value by providing industry-leading products and solutions" [22] which is expressed through their priority SDGs focusing on SDGs 8 (economic growth), 9 (industry, innovation and infrastructure), 11 (sustainable cities and communities), 13 (climate action) and 15 (life on land). These SDGs are relevant to their overall goal of increasing their economic revenue while creating innovative solutions to reduce impact on local air, water and waste and conserving biodiversity. Thus, their sustainability model covers environmental, economic and social governance.

CEMEX's environmental focus is on a net zero CO_2 emission strategy by creating a circular economy through use of zero carbon concrete and water, implementing biodiversity conservation, and preserving water on site. Their work in zero carbon concrete is achieved through clinker plants using biomass and non-recyclable waste as a source of energy; use of alternative raw materials and industrial waste/by-products to manufacture cement and use of recycled aggregates from construction and demolition waste and ensuring transport emissions are offset via a planned afforestation program. From a water perspective, nearly all their water is recirculated and recycled in the production process.

A concrete plant in Colombia is treating water from the food sector and reusing it for concrete production in a joint initiative with a food company "Meals de Colombia S.A". Rehabilitation of quarry sites post extraction is part of the company's commitment to ensure regeneration where biodiversity is monitored. In addition, health and safety considerations, respect of human rights and diversity, equity and inclusion are all important social considerations that underpin CEMEX's approach to sustainability.

Figure 3. Moravia before intervention. Credit: UNESCO Chair on Sustainability.

5.2. Moravia Urban Renovation Project. Medellin, Colombia

From 1970-80, "Morro (hill) Moravia" was Medellin's municipal dump. The poor used this hill for recovering waste as a source of income. The dump was eventually closed, and the closure attracted informal settlement in the area. By the turn of the 21st century, the population increased leading to large informal settlement in the same area. Urban regeneration and social intervention supported by spatial and physical planning resulted in de-risking the space. In 2007, a project was developed by the Medellín mayor's office, with the cooperation of the Government of Catalonia and the participation of the UNESCO Chair of Sustainability,

Figure 4. Moravia after intervention. Credit: UNESCO Chair on Sustainability.

with the aim of improving life conditions for the local community [1] while reducing environmental risks such as fires, landslides and environmental pollution.

The main achievements of this project resulted in improvement in the life of poor parts of Moravia, due to the focus on environmental and landscape recovery of such a degraded urban area as shown in Figures 3 and 4. The stakeholders involved are Medellin Mayor Office and Community action boards. The main outputs as a result of this project are land remediation and relocation of are over 2 220 families. In total, 4.4 hectares of land was remediated by phyto-remediation, using buffer-strips and constructed wetlands. Hundreds of jobs were created on community gardening and flowering production, where compost from organic waste is used as substrate.

The rate of urbanisation in the Latin American region has shown an increase of 73 % since 1990 [22]. The urban sprawl has been driven by two main factors: informal urban development, and sub-urbanization produced by formal development of new residential areas occurring at the urban peripheries [23–25].

6. Analysis and discussion

Through literature review and stakeholder interviews, the case studies presented in this paper are quite varied. To promote circularity in the built environment, mapping and promotion of best practices are crucial. These practices are context dependent and need to consider a range of localised considerations such as skills and capacities, business practices and culture, manufacturing capacities, local regulations and the like. Focusing on the capital cities of Burkina Faso, Rwanda, Senegal and Uganda, the Africa research team found an encouraging number of initiatives promoting circularity in buildings.

These initiatives span a range, including bottom-up and top-down approaches, with direct benefits of reducing construction and demolition waste, as well as the demand for raw building materials. Many of the projects also produce other social and environmental co-benefits. Due to the high level of informality of the building sector in many African countries, the transfer of building and construction materials between parties is often casual and undocumented. Government policies are gradually catching up to provide an operational framework within which material and water circularity can be promoted.

Building and construction stakeholders in Asia have a long history of incorporating sustainable practices, such as reusing, renovating, sharing, and upgrading products. This results in an advanced form of circular economy. The push towards sustainability in this region is largely driven by government regulations, policies, and technological advancements in the construction industry. However, these policies need to be further advanced. The Latin American case studies focused on building materials manufacture across several countries in this region and on an urban development project. The collaboration and leadership shown across both these projects clearly demonstrates replicability and scalability across not just the Latin American region but also into other parts of the world.

The case studies have been analysed from a life cycle perspective using ISO life cycle approach, and following the approach undertaken by Iyer-Raniga and Huovila [4]. The analysis is across the main goals underpinning the SDGs rather than considering the indicators in each of these goals. Table 1 shows that while most of the life cycle phases have been considered across the case studies, renovations and end of life considerations need more attention.

7. Conclusion

This paper focused on a snapshot study to understand what if any, and how circularity practices in the built environment in Africa, Asia and Latin America existed. The presence of initiatives as shown from the eclectic samples presented from urban design solutions to building code development and material considerations show a willingness and clear opportunities to demonstrate circular practices across many

Environmental Impact Life cycle stage	Africa	Asia	LAC	Africa	Asia	LAC	Africa	Asia	LAC	Africa	Asia	LAC
	SDG6 Water			SDG7 Energy			SDG12 Materials and waste			SDG15 Biodiversity		
Design	X	X		X	X		X	X		X		
Construction	X	X	X	X	X		X	X				
Operation and use	X	X	X	X	X	X	X	X				
Renovation											X	X
Deconstruction/End of life					X	X		X				
Manufacturing		X	X						X	X		

Social Impact Life cycle stage	Africa	Asia	LAC	Africa	Asia	LAC
	SDG3 Health and Well-being			SDG8 Green jobs		
Operation and use	X					X
Renovation						
Deconstruction/End of life						
Manufacturing					X	
Design	X	X		X		X
Construction	X	X		X		X

Economic Impact Life cycle stage	Africa	Asia	LAC	Africa	Asia	LAC	Africa	Asia	LAC
	SDG11 Capital cost			SDG12 Operational costs			SDG9 New businesses		
Deconstruction/End of life									
Manufacturing		X	X			X	X	X	X
Design	X	X		X	X			X	X
Construction	X	X		X	X		X	X	X
Operation and use	X	X		X	X			X	X
Renovation		X						X	

Table 1. Analysis of the case studies.

of the SDGs. While there are some examples available, it is clear that considerable barriers exist to the institutionalization and mainstreaming of such initiatives and substantial investment in institutional and capacity development will be required.

Generally, the transition to circularity in the built environment offers opportunity for countries in the identified regions to improve waste management, reduce cost of buildings, create new value chains and jobs and significantly reduce the dependence on material imports to fulfil the demand for housing and other buildings spaces.

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