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Accelerating circularity systemically: three directions for impactful research

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Over the past two decades, research promoting a sustainable built environment has pioneered new horizons to accelerate the transition to a circular economy. Yet, these efforts are suffering from a significant theory-practice divide. This article offers three interconnected research themes to bridge this gap: 1. Distinguishing circularity practices across spatial and time scales; 2. Redesigning the value of design and its process; and 3. Learning from sister transitions for acceleration.

Urban systems are far from transitioning to a circular economy. They are amongst the most degraded ecosystems, where waste is hard to assimilate and resources challenging to harvest. To ecologically regenerate urban systems, it is crucial to shrink demands in and around the built environment.

Relevant research promoting a circular built environment has been plentiful over the past two decades, yet their practical impacts are still emergent. In fact, while researchers are pioneering new horizons to accelerate the transition to a circular economy, their efforts are still generally siloed and scattered, suffering from a significant theory-practice divide. To bring theory and practice closer, research should be clustered around 'themes that collectively portray the broader picture of transitioning to a circular economy.'[1] To this end, this article offers three interconnected research themes: 1. Distinguishing circularity practices across spatial and time scales; 2. Redesigning the value of design and its process; and 3. Learning from sister transitions for acceleration. As argued in what follows, these directions can effectively guide researchers in channeling their efforts to positively impact practice by addressing key lacunas in urban system regeneration.

Distinguishing circularity practices across spatial and time scales

Research promoting a circular built environment has focussed on enabling the continuous flow of materials within the technical and biological cycles. Respectively, products and materials are reused, repaired, remanufactured, and recycled, and nutrients from biodegradable materials regenerate nature. In theory, such circular flows, as depicted by the circular economy diagram[2], create resilient systems, enabling businesses, people, and the environment to flourish. In practice, such circular flows are missing the spatial and temporal scales, hence lacking practical norms for the built environment[3]. Yet, a circular built environment can neither be researched nor achieved without differentiating practices and their respective impact across scales, recognizing that functional practices at local scales might be dysfunctional at global ones and at different points in time.

For example, focusing on a local scale to close the emission loop might seem attractive for practices such as carbon offsets. Carbon trading is a global multibillion-dollar industry incentivized by the government, NGOs, and businesses. Its value proposition is to keep emitting carbon while performing 'net-zero' by, for instance, planting trees sometime in the present or future in remote areas where it is cheaper and easier. Not only is carbon offset showing marginal impacts and increasing frauds – often avoiding emissions as opposed to capturing them by protecting trees from being cut down rather than planted anew – but it also appears to have damaged Indigenous and traditional communities, harmed biodiversity and fisheries, and is also paradoxically emitting a significant amount of carbon[4]. Such unintended consequences could have been mitigated or avoided by conceiving offsetting as a local practice, with tangible and visible outcomes in the short term[5], and accounting for social justice and equity without discounting the future[6].

As in the case of carbon offsets, a local approach can result in instances of closed loops over time. A territorialized scale such as the urban one is also key to identifying strategies to lower national consumption and shrink cities' demands. In fact, the consumption of Western Countries is significantly above the world biocapacity, with a small percentage of it satisfied domestically – e.g., only 14% for the Netherlands[7]. Without reducing consumption locally and diminishing dependence on global supply, a circular economy remains unachievable. Simultaneously, if only a few countries achieve a circular economy, this will not stop worldwide resource depletion or global warming.

Accounts of global scales for urban circularity practices are also crucial because local approaches can be limited in achieving sustainability targets. Buildings' value chains, for example, mainly rely on outsourcing materials at a global scale. Hence, decarbonizing industries locally is challenging and would only marginally impact the transition from a linear to a circular economy. Besides, one of the most significant threats to the construction and manufacturing industry globally is posed by critical raw material shortage. A promising roadmap for a resilient supply of raw materials is mining these in construction sites, waste processes, and land fields. Such practices occur locally but need to leverage global demands to be valuable. For example, smartphones might contain up to 50 different kinds of metals; they are disposed locally but supplied by multinationals. Raw materials are also closely linked to clean technologies, being irreplaceable in solar panels, wind turbines, electric vehicles, and energy-efficient lighting. Hence, the global need for critical materials and the urgency of the transition to clean energy are determinants of the increase in the value of local construction waste.

Such value creation calls for urban circularity efforts to interconnect with different scales, even smaller than the building level, such as the component and material levels. Mono-scale studies remain problematic. Engineering research with a prominent focus on the material scale has, on the one hand, uncovered new engineering practices crucial to achieving a circular built environment. On the other hand, it has promoted the use of biobased building materials to reduce embodied energy[8]. Yet, biobased materials are also mainly outsourced globally– just like water-intensive avocados cultivated in water-depleted communities feed western plant-based diets. Social and environmental impacts are out of sight, leading to decreased attention and, thus, more consumption[9].

A key research focus for addressing scale and space evolves around mapping and identifying circular practices that demand a specific temporal or spatial scale and differentiating these practices depending on their socio-ecological impacts. How can different scales be integrated to regenerate urban and global systems meaningfully? Which circular practices require specific scales? How can actors, organizations, and institutions enable such practices while navigating the paradox of local versus global impacts without discounting the future? Design – a future-making practice by definition – is critical in navigating this paradox, as discussed below.

Redesigning the value of design and its process

Once upon a time, architects, real-estate developers, and urban planners could focus on optimizing services and creating new architectural values. Material considerations would serve architectural purposes and could be chosen to enhance local identity and architectural beauty while simultaneously satisfying engineering criteria such as safety, durability, and comfort. New demands and technologies, such as parametric design tools, building automation, digitalization, industrialization, an increased focus on life cycles (costs), and new and upcoming directives on adopting circular measures have been to this day fundamentally altering design processes.

Designing for circularity requires in many ways to remodel design processes that have remained stable for centuries despite historical evolutions in and around design practices. Taking the design phases of a building as an example, material choices notoriously pertain to the phase of design detailing, one of the latest stages of design. In this phase, materials used to be chosen to serve specific structural requirements, a pre-assigned function, local mining considerations, or aesthetic demands. Designing for circularity requires architects to revive certain materials through uncharted waters. Which quality assurance on structural properties can architects consider if they are to re-use a 30-year-old reinforced concrete beam when commissioned a circular building for a 50-year lifespan, perhaps in a seismic area? How can old windows be recycled or remanufactured to ensure the high standards of insulation demanded to achieve an emission-neutral building? Several international research projects are grappling with these questions. Their answer might fundamentally shift the phases of design processes. Not the function, but materials might become the new initial boundary condition of the design process. Research should elucidate which types of design, function, and architectural standards architects can strive for, given certain pre-determined materials, rather than the other way around.

Throughout this fast-paced design revolution, the value of design has been slowly moved backstage. Architects have been pushed to become tools experts and process orchestrators. They had to learn to deal with complex multi-stakeholder decision-making processes, juggling various paradoxical demands – rather than pursuing the profession of creative designers many signed up for when choosing to become architects[10]. Such revolution is needed and unavoidable, but as many past transitions teach, chaos and errors characterize this early circular design era, demanding education and practices to adjust and adapt to high degrees of uncertainty quickly.

Initial examples of circularity efforts show that decisions on services, tools, and architectural artifacts have often traded off design values to satisfy many new sustainability demands. Local governments have been commissioning new design tools to relate building costs and circularity, generating new guidelines. These guidelines seldom take design processes and their values into account. As a response, it is not surprising that construction firms – currently struggling with several constraints such as reducing nitrogen pollution in cities, meeting energy-neutral demands, and material shortage resulting in high prices, just to mention a few – tend to cut costs, trading off other design aspects. Designers and architecture schools can – and arguably should – take the role of design advocates and not compromise on value creation in favour of business considerations.

But designers cannot do this alone. In the Netherlands, for example, the government set the target of building 1 million new dwellings to address the housing shortage. At the same time, 5.9 million square meters of office and retail space lay empty. Even though designers are increasingly skilled in the adaptive reuse of existing buildings and could reshape their function[11], these types of interventions often need new urban plans for territorial zoning (e.g., to enable the transition from commercial to residential areas) or might find resistance from real-estate developers who might seek to increase returns by transforming certain areas and complexes to host commercial activities that are more lucrative than habiting. Such a shift is crucial since avoiding demolition at all costs remains one of the most circular choices decision-makers could make.

Designers need a support system across all levels of the urban ecosystem to collectively shift from predominant business-case logic to value-case ones. A collective ecosystem of real estate developers, municipalities, and governments can systemically reshape the existing building stock to serve today's civil society needs while leveraging the value of circularity. Investigating the social value of circularity[12] beyond technical and financial considerations, embedding co-creation[13], and implementing fair participation for transition[14] in widespread design practices constitute a crucial research direction for research with the potential for joint academic and business efforts to shape the urban environment for circularity. As argued in what follows, such principles and research directions are strengthened when seeking to learn from past transitions.

Learning from sister transitions for acceleration

Learning from other transitions through forward-looking research is key. Taking the energy transition of the Dutch built environment as an illustration, a decade ago, researchers were wrestling to prove that energy efficiency would increase the commercial value of buildings[15]. With low energy prices, the investments to achieve high energy standards seemed to make low economic sense due to lengthy return periods in comparison to other types of investments property owners could make[16]. Research advocated for energy measures, arguing that real-estate values would undoubtedly increase. While this was credible for office buildings since tenants and investors started pursuing green certification as a luxury proposition[16], trust in achieving similar values in housing was low, despite researchers arguing otherwise[17]. Fast-forward to today, energy labels and sustainability certifications are determinants in real estate evaluations, even in the residential sector where homeowners are obliged since 2015 to state the energy label when delivering, selling and renting properties.

The value of circularity could also increase through similar measures, e.g., by introducing circular certification. Certification could, over time, impact the real estate value of properties. Architectural endeavors to retain cultural heritage to reduce emissions and avoid demolition[18] could be more appreciated rather than regarded as barriers[19]. Leveraging cultural and identity values[20] and refocusing evaluations from the building as an object towards a community perspective has been revealed to be crucial for the energy transition[21,22], and the same could drive the transition to a circular economy.

In fact, collectively redefining the meaning of objects might be an essential innovation leap for a circular economy. Before the advent of electricity, candles allowed to shed light in the darkness of the evening, enabling daily activities to continue after the sunset. Today, candles serve a completely different purpose[23], creating atmosphere while decorating dinner tables. The meaning humans attach to materials has already been proven to be a critical factor in positively and negatively driving transitions. In fact, unethical mining practices for gold and diamonds are a result of socially constructed meaning. The opposite can also be true, and positive change could be created by socially constructing new meanings around materials. The meaning we attached to materials, such as antique furniture or vintage clothing, could foster this positive change. After all, as stated by Thomas Rau, "waste is material without an identity"[24]. How can urban actants enable such positive change by collectively redefining the meaning of the existing? Though crucial, this remains an under-researched area that could create reciprocal value and temporal impact to foster a circular built environment[25].

Discussion

The theory-practice divide and fragmentation in circular economy research must be addressed to accelerate effective urban measures and enhance their long-term impact. To this end, three key research directions have been outlined. First, mapping and differentiating circular practices across different geographical and time scales–while monitoring their interconnectivity–is vital. This helps reduce unintended consequences, thus enabling more robust and timely circularity. Second, redesigning design values integrates circular principles holistically across disciplines, streamlining the incorporation of sustainability in practical design. Lastly, extracting lessons from sister transitions provides a consolidated set of actionable strategies that enable both retrospective analysis and prospective experimentation. Collectively, these research directions aim to foster a more cohesive field, aligning disparate efforts and promoting a sustainable transition to a circular economy that is relevant and effective in both theory and practice.

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Author contributions

All authors contributed to the manuscript. A.G. was the paper's lead author, crafting the primary draft and ideas. B.L., H.R., and V.G. contributed to the discussions on the paper to refine these ideas. B.L., H.R., and V.G. also added to and edited the manuscript. All authors read and approved the final manuscript.

Competing interests

The authors declare no competing interests.

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