sustainability

Editorial

Is Circular Economy for the Built Environment a Myth or a Real Opportunity?

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Citation: Charef, R. Is Circular Economy for the Built Environment a Myth or a Real Opportunity? *Sustainability* **2022**, *14*, 16690. https://doi.org/10.3390/su142416690

Received: 2 December 2022
Accepted: 7 December 2022
Published: 13 December 2022

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1. Introduction

Our world is facing a dilemma: we have a linear economy based on perpetual growth which, due to finite resources, now needs to reduce that growth to avoid endangering the planet [1]. Meanwhile, the demand for housing continues to increase with the population. Global housing is experiencing a deficit of 1.6 billion dwellings, which is expected to increase to 3 billion by 2050 [2]. Therefore, the current and future severe extraction of resources will drastically increase to meet humankind's physiological need for shelter, the bottom level in Maslow's Hierarchy. At the same time, the waste generation and emissions resulting from production are increasing exponentially, with serious repercussions for the planet. Therefore, to tackle all these parameters simultaneously, we need to radically change the way we produce, consume and live.

Some authors believe that the current linear economy should be replaced by the circular economy (CE) [3,4]. As the construction sector has already begun the journey of digitalization worldwide, many authors think that the CE should be considered in that context. Indeed, researchers are exploring how the digitalization of the construction industry, seen as the 4th Industrial Revolution (4IR) could be a powerful catalyst to drive the shift from linear to CE of the built environment (BE) as stated by [5–7], and solve the global dilemma. Several authors have hopes for the transformation faced by the construction sector, including the CE approach, industrialization, automation or robotization, among others. Other schools of thought believe that the CE is impossible and will not solve all the issues, and that the popularity of the CE is due to "the promises it makes rather than to the results it can reasonably produce" [8]. Some arguments against and in favor of the CE and the digitalization of the construction sector are presented below.

2. Some Arguments against

Although the digitalization of the BE began decades ago in some countries [9] and is recognized for its benefits [7], it is also meeting hostile acceptance [10]. Some believe that working in silos has always been the path of the highly fragmented construction industry and although it may break down, digitalization could lead to a doubled wall silo for facility managers in the form of a language and knowledge gap [11]. Additionally, the cost of digitalizing their activities is, for small practices, a colossal challenge. In addition to the cost, the sector suffers from a shortage and aging of workers. This last aspect makes it more difficult to learn and adopt new technologies [12]. The resistance to change is also a critical challenge that the construction sector has to tackle [13], which is commonly considered very conservative [14]. One important argument against digitalization is the huge amount of data and information which raises problems and risks for exchange, storage, management and security. Moreover, technology is not infallible and cyber-attack are a high risk, as reported by [15].

Although off-site construction is perceived by many construction actors as having the potential to improve construction efficiency [16], some authors believe that prefabrication and layering can lead to job disappearance and uniformity of buildings [17,18]. Other design approaches have also been criticized, such as modular integrated construction

(MiC), for which some authors pointed out several barriers, including aesthetics, such as blandness and uniformity of outlook of buildings or even cities losing their identity, the flip side of standardization [19].

After the digital shake and the consequent radical change, the sector is fragilized and reluctant to implement CE and Circular engineering, another shift which will require a change of mindset by additionally using system thinking, system engineering and Artificial Intelligence (AI), either via machine learning or robotics. Many people are against this, perceiving it as expensive, destroying creativity and replacing human labor with machines [20]. In opposition to digitalization and CE, the "rebound effect" flag (material and economic) highlights that manufacturing smaller technologies could be more resource intensive or, in the case of energy efficiency improvements, could lead to increased GHG emissions [21,22].

Questioning also exists at a bigger level, with some authors wondering if the idea of green growth launched by some economists and politicians is realistic [23]. Others researchers argue that the CE (where material loops are closed, recycling is indefinite and waste is eliminated) is practically impossible due to the inevitable consumption of resources, generation of waste and emissions [24,25].

3. Some Arguments in Favour

"With respect to digitalization, construction is currently second-to-last out of 23 industries reviewed by McKinsey Global Institute, illustrating that vast improvements can be made". BIM is a powerful tool that could be considered the first step towards digitalization enabling the "Digital twins", the key to the establishment of anthropogenic stocks or material banks [26,27] that can solve the problem of depletion of construction materials. Buildings are considered material banks, and it became crucial to understand the imports/exports and how much the system is resilient. To tackle the multiple life cycles and owners throughout the whole life cycle of an asset, cloud-based collaboration tools are crucial for seamlessly performing a construction project [28].

Designing products with the end in mind and long-term thinking are important aspects of a CE aiming to extend the material lifespan and maintain materials into a closed loop. Unlike the current linear approaches, a holistic approach and the design for X approaches (e.g., design for disassembly) enable the creation of value and prolong the lifespan of materials/products, responding to environmental issues and fulfilling the evolving users' needs [29,30]. The idea is to keep the materials in the loop by considering reuse, repair and remanufacture [31]. Digitally and holistically managing projects and buildings throughout their lifecycles by using BIM appears as a key and a facilitator for the adoption of a circular economy [6,32]. Moving from ownership to service would also help with this implementation [33].

Circular engineering is an emerging approach aiming to keep products in use longer to address issues faced by the BE, such as the lack of upgradability, flexibility, circularity, sustainability, uncertainty and resilience of our building stocks (Course in Maastricht University and TU Delft). Applying circular engineering in the construction industry will enable us to design a cleaner, healthier and more sustainable world [34,35] by addressing five critical Sustainable Development Goals (SDGs 9-11-12-13 and 17) over the 17 mentioned in the 2030 Agenda [36].

Although, as claimed by the opponents, jobs are lost, the need to create new roles will compensate for these losses, and as a minimum, the logistic challenges (storage and transport) and material recovery processes have the potential to create new positions [37]. Similarly, deconstruction and renovation activities are labor intensive and will require the creation of new jobs [38]. There are also opportunities for emerging markets and the organization of second-hand markets to coordinate and align the demand/supply [39].

The industrialization of construction activities is also well supported as an enabler for efficiency and waste reduction. Offsite manufacturing has also many benefits reported by several authors, such as the improvement of quality, working conditions and productivity but also the reduction of waste generated and the overall level of sustainability [40,41]. The

Design for Manufacture and Assembly (DfMA), a mature principle in the manufacturing industry, has some well-recognized advantages, such as resource/cost-effective production and faster production speed without compromising safety [42,43]. Some authors explored the association of BIM and DfMA to develop the concept and process of DFMA-oriented parametric design [44]. The MiC, DfMA or industrialized construction are usually associated with digitalization, as a facilitator for their implementation [45]. In addition, it is usually claimed that they have the potential to tackle some of the environmental impacts of the construction sector, such as waste generation [43] and material consumption through prefabrication. Moreover, digitalization and AI-based solutions offer a large range of applications for controlling, monitoring, risk forecasting and automating repetitive tasks, construction errors, productivity issues and shrinking the pressure on human workers [46]. A range of new technologies has the potential to support the BE, whether for data collection and transfer (IoT, digital platforms), distribution and storage (Blockchain and cloud computing) and applied engineering (robotics, 3D printing) [47,48].

Many authors have argued that the transition to the CE could be accelerated through digitalization. Promising automation applications could result in robot-assisted disassembly tasks, helping with the reuse of building materials. Anthropogenic and recovered materials stocks could be monitored by AI to find the best option for the material and align demand/supply. To go beyond the three main principles of CE, which are to narrow, slow and close the material flows, there is a need to explore the regenerative design that mimics natural processes to reconnect and realign humans with nature.

4. Conclusions and Contents

To conclude, a circular economy, as opposed to our current linear economy is a realistic solution to the planetary issues caused mainly by human activities. Despite the good acceptance of the promises claimed by the EMA (Ellen McArthur) foundation for a circular economy as "restorative or regenerative by intention and design" some authors refuted the possibilities of closing the loop [8].

This Special Issue "A Circular Economy for a Cleaner Built Environment" is devoted to the Circular Economy as a means for a cleaner built environment. Topics include the implementation of the circular economy and applications of principles of circularity (case studies/best practice examples), assessment tools (indicators, methodologies), practitioners' feedback, the barriers and drivers for the adoption of a circular economy, policies, business models and new forms of shared services, etc.

Conflicts of Interest: The author declares no conflict of interest.

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