Chapter 16
CapSEM Applied to the Construction Sector

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Abstract The construction sector and built environment have the potential to impact on a variety of systemic dimensions, ranging from specific processes in the production of construction materials to pan-national regulations affecting regional areas and cities. This case study uses the CapSEM Model in order to identify the potential enabling and constraining impact of different methods, schemes and regulations for reducing environmental impact in the construction sector. The use of a systemic perspective highlights that all methodologies are working recursively in actor-networks, thereby affecting society and the market differently, depending on the systemic level.

16.1 Introduction

The construction industry and built environment represent significant pressure on the environment by being the largest consumer of natural resources in the world: it alone uses over a third of the energy produced annually worldwide (Munaro et al. 2020). In addition, the rate of urbanisation has an increasingly negative impact on biodiversity around the globe (McDonald et al. 2008). The need to reduce this impact by moving away from a linear consumption pattern into more circular solutions, thus reducing the footprint of the built environment is therefore evident (Arora et al. 2020).

There are several ways the construction sector may reduce the impacts from the activity involving material considerations, design and resource use, see Fig. 16.1.

To effectively reduce environmental impact during the construction, use and end-of life phase of a building, there is a need for environmental assessment tools with the ability to analyse environmental aspects and impacts during the lifetime of the

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Fig. 16.1 Focus areas to reduce environmental impacts in the construction sector. (Sparrevik et al. (2021)

building solution, thus capturing that 'contribution' across different impact categories simultaneously. In addition, life cycle-based management schemes, and regulations support environmental performance across the building life cycle better, consequently affecting the variety of actors in the construction industry. The individual effects of these methods, schemes and regulations are widely investigated in literature (Gallego-Schmid et al. 2020; Górecki et al. 2019; Munaro et al. 2020). However, it is also important to consider the role and impact of these methods in different systemic dimensions, a topic often overlooked. Applying the CapSEM Model to the construction industry and built environment gives a better understanding of impacts horizontally (across topics and involved sectors), and vertically (from individual projects to international bodies).

16.2 Implementation

According to the CapSEM Model, methodologies for systematic implementation of sustainable solutions can be organised in a stepwise progression through four levels: (1) process, (2) product, (3) organisation, and (4) system. The methods may be separated across two dimensions: (i) in terms of the increasing complexity of the scope (increasing systemic scope in the original model) and (ii) by the increasing comprehensiveness of performance (increasing performance scope in the original model). How one defines the content of each level depends on the point of entry, i.e., from which perspective one views the systemic levels. Figure 16.2 shows how the model can be adapted to the construction sector with the most important assessment methods indicated at each level, (Sparrevik et al. 2021). The point of entry here is the building, seen itself as a product and placed in an organisational context.

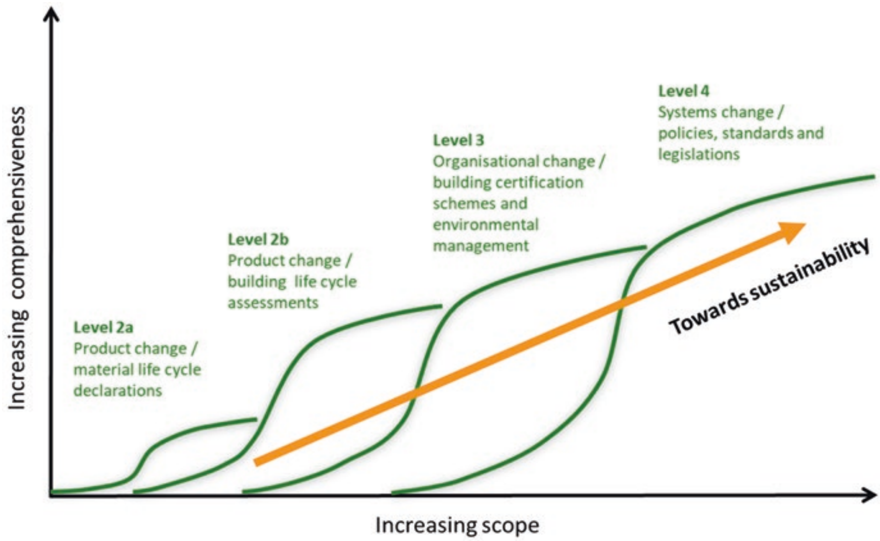

Fig. 16.2 Adapting the CAPSEM Model to the construction sector. (Sparrevik et al. 2021)

Each subsequent level is then defined according to this approach. We can disregard the process level and assume that process improvements and related impact assessment methods are an integral part of the work by suppliers to improve their products.

The initial product level connects to resource performance of the components of the building and the performance of the building itself. We may therefore divide this level into two sub-levels: (i) building components and (ii) the building itself.

For building components (i), using materials with a high degree of recycled content, and produced without polluting materials, ensures environmental benefits. High technical capacity and long lifetime expectancy are also important to keep the products and materials in use for as long as possible, thus reducing the environmental footprint in the life cycle. In this case, it is not only the embodied emissions from products and materials that count, but also the operational emissions and end-of-life treatment. For the building (ii), the location of the building affects travel patterns for residents and users of the building, causing emissions from transporting people, goods and services to the building. Since the lifetime of a building is long, minimising the environmental footprint from the building perspective may require further optimisation between construction (including maintenance and renovation) and operational emissions.

According to the model in Fig. 16.2, the organisation level relates to standardisation across construction projects in a geographical or organisational context. Examples are strategic decisions taken to follow certain standards or certification arrangements that ensure buildings are constructed according to organisational objectives. This may create new internal markets based on standardised construction activities, or result in new solutions, thus affecting the whole supply chain. However, this level also refers to the strategic decisions made by entrepreneurs in the early design phase of new buildings, new construction projects and to the development of new environmentally friendly concepts.

Finally, the system level relates to larger initiatives, either cascading from pan-national regulations, such as EU regulations, national regulations, standards or from various voluntary initiatives at the national or regional level, such as the development of the European framework for sustainable systems (EU 2020). Environmental friendliness in the systemic dimension has a broader impact than at other levels. It allows for long time predictability, thus creating a new market that may compete financially with established traditional solutions.

Sparrevik et al. (2021) highlights several findings with management implications for advancing environmental performance in the construction industry, thus relating the complexity and scope of the decision to the CAPSEM Model of systemic thinking. As summarised in Table 16.1, the methodologies, which are all based on life cycle thinking and aimed to reduce environmental impact, will have different functions depending on their placement in the CAPSEM Model. In practice, effects are thus tailored to the appropriate systemic level where they can act as both enablers and constraints for improvement, depending on the context.

For standardised product (building component) impact assessments, use of environmental product declarations (EPD) to provide transparent information on the environmental impact have gained popularity worldwide and EPDs are now widely available for most products and materials in the construction sector (Andersen et al. 2019; Burke et al. 2018; Passer et al. 2015). The use of EPDs is transparent and allows the procurer access to information about the environmental impact of a material, a product or service, in order to be able to make well-informed decisions. By using EPDs, decisions can be made by the builder to choose to select materials and products with the lowest environmental impacts. Suppliers will thus be encouraged to use more recycled materials to reduce environmental impact, but also to improve production processes through cleaner production technologies, lower energy use and selection of more sustainable transportation services. However, not all life cycle

Table 16.1 Overview of the potential enabling and constraining impact of different methods, schemes and regulations for reducing environmental impact in the construction sector

Level	Methodology	Potential enabling implication	Potential constraining implication
2a	Material life cycle declarations (EPD)	Better performance at supplier level, product improvements	The ability to compare impacts across areas and life cycle stages
2b	Building life cycle assessments (LCA)	Optimal building design and circular solutions	Standardisation due to case-to-case based solutions
3	Building certification schemes, environmental management	Higher built environment standard and better organisational performance	Unidirectional effect due to voluntariness and user-driven ambition levels
4	Policies, standards and legislations	Broad scale systemic effects	Voluntary initiatives for innovative solutions

Modified from Sparrevik et al. (2021)

stages are treated equally (Durão et al. 2020) and this may bias the results towards materials and products with low emissions in the production stage without giving enough focus on impacts created in the use or end of life stages of the products.

Use of life cycle assessments (LCA) for buildings is far more comprehensive than of each material. On the other hand, using an LCA is more likely to result in an optimal building design and circular solutions adapted to the wider context. For example re-use of building materials will according to Arora et al. (2020) and Eberhardt et al. (2019) reduce environmental life cycle impacts from the building perspective, but extensive refurbishment to enhance energy performance may be counterproductive due to the technical lifetime of building materials, especially if renewable energy is used in the building. The optimum balance here is difficult to evaluate on the material level, but may more easily be optimized at the building level. However, since circular solutions on the building level are mainly developed on a case by case basis, standardised solutions might be more costly and difficult to reproduce since improvements should ideally be tailored to each individual building.

On an organisational level, building certification schemes and environmental management systems (EMS) are widely used both to achieve higher built environment standard as well as better organisational performance. In building certification schemes (LEED,[1] BREEAM[2] or similar), the proposed project is scored against specific predefined targets covering a variety of topics valid for the construction and use phases of the building. Introduction of EMS will also require the organisation to identify significant environmental aspects such as energy, material use and water efficiency and set objectives and targets accordingly. Even though building certification and certified EMS affords the possibility of benchmarking environmental status at the organisational level (Cole and Valdebenito 2013), these systems are still voluntary and allow for the user to set appropriate ambitions in terms of performance. In addition, the various schemes emphasise sustainability aspects differently, and the content and weighing are neither unified, nor coordinated in their development (Mattoni et al. 2018).

Finally, at the system level, a wide variety of policy, standards, and regulations with expected broad scale systemic effects exist. Various EU policies on resource policy direct the construction sector towards circularity and are enforced by national regulations, standards and priorities to be effective (Domenech and Bahn-Walkowiak 2019). Requirements related to energy management, nature conservation and technical design to avoid pollution are examples of requirements often found in regulatory frameworks. More innovative activities depending on cooperation between market and builders, such as the introduction of emission free construction sites, are difficult to regulate unless demonstrated as successful at a lower building level (Fufa et al. 2018). On the contrary, detailed non-functional requirements for performance may, in fact, be counterproductive for innovation (Sparrevik et al. 2018).

[1] LEED (Leadership in Energy and Environmental Design).

[2] BREEAM (Building Research Establishment Environmental Assessment Method).

16.3 Concluding Remarks

This example of applying the CapSEM model to the construction sector and built environment shows the benefit of reviewing the methodology using a systemic perspective, especially for policy implications. Two findings illustrate this.

The first finding emphasises the importance of addressing environmental performance with the correct complexity context to be able to make well balanced and sustainable decisions (Labonnote et al. 2017). For example, embodied material related emissions often dominate GHG emissions in a building life cycle (Wiik et al. 2018), thus, suggesting a strong focus on process improvements at the supplier level. This is inherently robust and positive since it pushes the market to be innovative and develop more environmentally friendly solutions. However, from a broader perspective and higher systemic perspective, decarbonisation of the energy supply may be a more effective enabler for reduced environmental impact than material focus depending on the energy situation in each country and expected life cycle cost savings (Ibn-Mohammed 2017). A recursive structure will then encompass both materials and energy but allows for different prioritisations depending on the context of the decision.

The second finding stresses the importance of finding the appropriate scope for environmental improvements. As Pomponi and Moncaster (2017) point to, circular building design encompasses not only environmental and technical aspects but also governmental and behavioural dimensions. These are best developed through organisational tools such as building certification schemes or even by regulatory work at the system level. However, high score levels in schemes and more stringent regulations are not possible without proper technical solutions at the product level or at a functioning market with the ability to supply solutions.

With a systemic perspective, it becomes clearer that all methods, schemes and regulation are working recursively in the actor-networks and therefore affects society and the market differently depending on the systemic level. Methods at lower systemic levels, such as the use of EPDs and LCA of buildings, may stimulate the market to create environmentally friendly solutions. However, methods in higher systemic levels, such as building certification, environmental management systems and regulations, are used by real estate builders, trade organisations and governments to create incentives for development and innovation.

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