

Chapter 9

Ecosystems and Reuse of Building Materials: An Exploratory Study



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Abstract The implementation of circular economy strategies, such as the reuse of building materials, represents a valid opportunity for the building and construction sector to diminish the consumption of raw materials and generate revenues and, thus, to contribute to the Sustainable Development Goals 11 and 12. However, the reuse of building materials is still limited. Previous studies suggest that one reason is the lack of communication and collaboration among the actors involved. By using an ecosystem perspective, this study focuses on the characteristics of the ecosystem of actors involved with reuse of building materials. An exploratory research approach was used, which consisted of scientific literature and six semi-structured interviews with actors in the Öresund region. The interviews were conducted to elaborate on the characteristics that best represent this ecosystem. The results suggest that these characteristics are (a) complementariness and collaboration, (b) capability to evolve, (c) willingness to align to circularity, and (d) platformization. In particular, these characteristics highlight the needs of (1) collaboration among the actors already in the early stages of a project, (2) more actors and new roles in the ecosystem, (3) awareness of the objectives and values which guides the ecosystem, and (4) better knowledge and use of the ecosystem platforms.

Keywords Circular economy · Building and construction sector · Reuse of building materials · Ecosystem · Actors

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9.1 Introduction

The building and construction sector is currently responsible for the consumption of 35% of total energy use and 35–45% of raw materials and generates up to 38% of global carbon dioxide and circa 36–40% of landfill waste (UNEP, 2020). Previous studies show how the circular economy (CE) represents a valid opportunity for both diminishing the use of raw materials and creating economic revenue (Gerhardsson et al., 2020; Munaro et al., 2021; Nußholz et al., 2020; Pomponi & Moncaster, 2017; Sezer & Bosch-Sijtsema, 2020; Whicher et al., 2018). However, the implementation of CE strategies, such as the reuse of building materials, is still limited. The reuse of building materials is a key part of the circular economy in the building and construction sector since reuse is necessary for reducing the use of virgin materials in new developments. The slow progress of the reuse of building materials, as a strategy to achieve circularity in construction, can be attributable to several reasons such as the following:

- The lack of commitment from the authorities that leads to a lack of policies, regulations, and institutional procurement that favor the diffusion of CE (Hart et al., 2019; Knoth et al., 2022)
- The practical barriers inherent in the implementation of circular practices such as the lack of knowledge, technologies, and appropriate business models that would support the transition of organizations (Gerhardsson et al., 2020; Hart et al., 2019; Kanters, 2020; Knoth et al., 2022)
- The inclination of the actors in the building and construction sector to follow the dynamics and processes of the traditional linear method of production (Knoth et al., 2022; Kooter et al., 2021)

The last reason is the focus of this study. The reuse of building materials redefines relationships and establishes new ways of working; thus, it challenges the existing knowledge and roles of the actors. Furthermore, the involvement of new actors is often required to fill the missing knowledge and skills. This is an additional element that challenges the relationships and dynamics established within the traditional linear process. The literature suggests that for the successful implementation of reuse of building materials, a further development of interactions and collaborations is required (Hart et al., 2019; Kooter et al., 2021). With the help of an ecosystem perspective, this study investigates the collaborations and interactions that arise with the reuse of building materials in the building and construction sector.

In the literature, the concept of ecosystem is usually used as a lens to examine the relationship between different, mutually dependent actors who coevolve to respond to a shared purpose to obtain a competitive advantage (Aksenova et al., 2019; Bosch-Sijtsema & Bosch, 2015; Moore, 1993; Vargo & Lusch, 2014). The concept of ecosystem has also been applied to the building and construction sector (Pulkka et al., 2016); however, there are still few studies that connect this concept to circular strategies, and none of them is focusing on the reuse of building materials. Moreover, the characteristics with which ecosystems are usually described do not seem to be

sufficient to explain the interactions between the different actors involved with the reuse of building materials.

The aim of this paper is therefore to fill this gap and elaborate on the characteristics of the ecosystem of the reuse of building materials. With the support from both scientific literature and an exploratory interview study, the goal is to argue for the relevance of these characteristics. The interview study consisted of six interviews, with actors in the field of reuse of building materials, all active in the Öresund region (Sweden and Denmark). To promote the transition to the reuse of building materials in the building and construction sector, this study targets, namely, the Sustainable Development Goal (SDG) 11 which seeks to create sustainable cities and communities that are inclusive, safe, and resilient and SDG 12 that promotes sustainable consumption and production.

The rest of this paper is structured as follows. In the next section, the method for the exploratory interviews and the analysis are explained. In the theoretical framework section, the concepts and characteristics of ecosystems and the applicability of ecosystem concepts in construction, as well as literature on circular economy and reuse of building materials, are presented. In the results and discussion section, the data obtained from the interviews are combined with the literature to elaborate on four characteristics of the ecosystem of the reuse of building materials, which were identified. In the conclusion section, the key findings from the study are highlighted, and future research is proposed.

9.2 Method

This study was based on abductive research where the researchers attempted to explore the importance of the ecosystems concept in relation to the reuse of building materials in the building and construction sector. The study relied on scientific literature on the topics of ecosystems and reuse of building materials, as well as data gathering in the form of interviews.

The first step was to search for literature regarding the concepts and characteristics of ecosystems and the applicability of ecosystem concepts in construction, as well as literature on the CE and reuse of building materials. Both the field of reuse of building materials and the literature on the application of ecosystems in the building and construction sector have lately been gaining traction in academia. Nevertheless, the practical application of the reuse in the building and construction sector is still in its infancy and the literature on the use of ecosystem in relation to the implementation of CE strategies is scarce. Therefore, this study examined how the characteristics of ecosystems can be applied to the reuse of building materials.

The second step was to gather data from actors involved with the reuse of building materials. Semi-structured interviews were chosen as the data collecting method since interviews offer a flexible approach where the interviewer gathers experiences and knowledge from the interviewee. As suggested by Alvesson (2011), this was a flexible approach since the interview questions changed and were adapted to the

specific interviewee in order to extract more data. On the other hand, interviews were also flexible in the sense that the researchers had to interpret the data from the interviews, meaning that other researchers might draw other conclusions from the same data.

A relevant aspect to define is the ecosystem boundaries since they depend on the goal of the study (Bröchner, 2016). For this study, the circular ecosystem is assumed to have regional boundaries. In particular, we looked at the Öresund region and the actors involved, who were both Danish and Swedish. In this study, six actors were interviewed: two suppliers of reused materials, two developers, and two consultants; see Table 9.1. The suppliers acquire their reused materials mainly from two sources: unused materials from contractors and materials which need upcycling from demolition firms. Both developers identified significant cultural value in the local building materials and wanted to embrace reuse throughout their projects. In both cases, these projects are their first with a focus on reuse. The consultants have been active in the reuse of building materials for several years and thus have significant experience in the field. All the interviewees were reached by an email which provided information about the study. Since the collection of data was carried out during the COVID-19 pandemic, almost all the interviews were conducted online and, with the consensus of the interviewees, were recorded and transcribed. The language used for the interviews was Swedish, apart from the interview with the Danish actor which was held in English. The interviewees were asked questions about previous experiences with the reuse of material; the type, time, and management of the collaborations and relationship with the actors involved in reuse; the essential knowledge and skills needed in the reuse; the challenges the actors had to overcome individually as an organization or as an ecosystem; and the main value of working with the reuse of building materials.

The structure of the analysis was as follows. First, an initial framework of ecosystem characteristics based on the review of the literature was made. The design of the interviews followed this initial framework. The transcribed interviews were then assessed and categorized. Subsequently, the initial framework was then adapted to suit the data from the interviews and literature on the topics of circular economy and reuse of building materials. Finally, the adapted set of characteristics was used as headings in the results and discussion section; under each heading, the categorized data from the interviews are discussed together with relevant literature.

Table 9.1 The interviewees participating in the study

Interviewee (nr)	Type of organization	Role	Nationality
1	Private supplier of reused materials	CEO	Sweden
2	Municipal supplier of reused materials	Foreman	Sweden
3	Private developer	Project manager	Sweden
4	Municipal developer	Project manager	Sweden
5	Sustainability consultant	Consultant	Denmark
6	Reuse consultant	CEO	Sweden

9.3 Theoretical Framework

9.3.1 *Circular Economy*

Circular economy (CE) is described by Korhonen et al. (2018) as “a sustainable development initiative with the objective of reducing the societal production-consumption system’s linear material and energy throughput flows to the linear system. CE promotes high value material cycles alongside more traditional recycling and develops systems approaches to the cooperation of producers, consumers, and other societal actors in sustainable development work.” In addition to highlighting the role of the CE for the creation of economic value by exploiting cyclical and regenerative materials flows, this definition also emphasizes that CE should be a process that favors sustainability in all its forms and that requires the contribution of all the actors involved. CE is a broad concept that includes sublevels of definition and strategies such as recycling, reuse, remanufacturing, refurbishment, repair, cascade, and upgrade of products, components, and materials (Mhatre et al., 2021). The building and construction sector contributes with 12% of the global GDP (Crosthwaite, 2000) and plays an important role in the transition from the linear to the circular economy. In order to move toward CE strategies and minimize the production of waste while reducing costs, it is however necessary to reconsider current construction practices, change and improve methods and organizational resources, and allow the reuse of building components and materials (Bertino et al., 2021; Konietzko et al., 2020; Pomponi & Moncaster, 2017). Furthermore, to produce buildings that are circular for their entire life cycle, it is necessary to implement circular strategies and practices in all phases of the building process (Gerhardsson et al., 2020; Mhatre et al., 2021; Pomponi & Moncaster, 2017), thus involving all the relevant actors in this transformation (Konietzko et al., 2020; Pomponi & Moncaster, 2017). The ability to accept and embrace these organizational and role changes is necessary for the transition to circular economy in the building and construction sector.

Currently, the implementation of circular practices in the building and construction sector is still limited due to both a conservative mindset and the intrinsic characteristics of the sector (Munaro et al., 2021; Pomponi & Moncaster, 2017; Hart et al., 2019; Knoth et al., 2022) and to the several practical barriers that are interconnected with circularity (Gerhardsson et al., 2020; Kanters, 2020; Hart et al., 2019; Knoth et al., 2022). Furthermore, the implementation of circular processes in construction involves both radical and incremental innovations throughout the entire life cycle of a building, and for the effective success of this transition, it is essential that these innovations are also supported by further innovations in policies, business models, procurement, and the interrelation of actors (Whicher et al., 2018).

9.3.2 *Reuse of Building Materials*

The entire life cycle of a building can be summarized in three stages: the pre-use stage (i.e., initiation and preparation, design, and construction), the use and operation of the building, and the stage following the use, usually called end of life (Ghisellini et al., 2018). Mhatre et al. (2021) argue that the circularity of a project depends on the sourcing of building materials. The selective demolition and deconstruction of a building at its end of life contribute to reintroduce building materials in the loop (Ghisellini et al., 2018), and thus, the reuse of building materials can be considered as the key for a successful transition to a more developed CE in the building and construction sector. The European Commission Waste Framework Directive (EU, 2008) presents a five-step hierarchy where reuse is the second-best option in terms of waste prevention. Reuse is typically defined as the use of products in their original form or subject to minimal recovery activities (Ghisellini et al., 2018). Although the reuse of building materials is of critical importance, there are many barriers hindering its implementation on a significant scale. The first barrier is that less than 1% of the current building stock is fully deconstructable (Ghisellini et al., 2018), and thus, there is a need not only to produce new building with reused materials but also to design with the deconstruction in mind.

A recent study conducted in Sweden (Gerhardsson et al., 2020) shows how the reuse of materials in the Swedish construction sector is mainly prevented by the lack of knowledge of all the processes and practices to be implemented and integrated. Starting from the analysis of projects already carried out, Gerhardsson et al. (2020) propose a series of work practices that favor the reuse of building materials: *a materials inventory, targets for reuse, circular building design, planning for new processes resulting from reuse, incentives for reuse in procurement, and long-term documentation strategies enabling future reuse*. Moreover, Knoth et al. (2022) identified several barriers in their interview study and argued for three ways of addressing these barriers, namely, *establishing reuse infrastructure and knowledge base, getting manufacturers onboard, and enabling reuse through regulations and increased reputation*. Both the barriers identified and the practices proposed by Gerhardsson et al. (2020) and Knoth et al. (2022) focus mainly on the pre-use stage of a building revealing that the actors' main efforts should converge during the initiation and preparation, design, production, and construction phases.

It is worth noting that for the implementation of any kind of innovation to create value, all the actors involved must provide a solution to their innovation-related struggles (Adner & Kapoor, 2010), in this case, to the problems related to the reuse of building materials. Working with new practices and following new processes goes, in fact, beyond the capabilities and knowledge of individual organizations and requires effort from all actors involved (Adner & Kapoor, 2010; Vosman et al., 2021). It is therefore essential to use a theoretical framework that helps to understand both the complex interactions that are established in circular projects and the attitudes that can favor the diffusion of the reuse of materials outside the boundaries of a single project or organization.

9.3.3 *Ecosystem: Concepts and Characteristics*

The concepts of ecosystem and circular economy (CE) were combined before the ecosystem metaphor was introduced into strategic management research to explain the escalation in cooperation and collaboration between interdependent (but also competing) organizations (Aksenova et al., 2019; Bosch-Sijtsema & Bosch, 2015). The interest of researchers in responding adequately to the growing awareness of the environmental, social, and economic consequences that the current economic paradigm was producing dates to the 1970s and 1980s (Pomponi & Moncaster, 2017). As a response to this need, Frosch and Gallopoulos (1989) proposed a new industrial ecosystem that imitated the characteristics and dynamics of biological ecosystems in order to transform the linear model of production and thus limit the consumption of energy and raw materials. The authors hence suggested that the effluents of industrial processes were used as raw materials for other processes, thereby exploiting their intrinsic circularity. It is worth noting that the commitment of both producers and consumers in changing their attitudes and behaviors was highlighted by Frosch and Gallopoulos (1989) as an important aspect to implement a paradigm shift and ensure the success of the new industrial ecosystem.

The involvement of actors, such as producers and consumers or other organizations, is further emphasized in the ecosystem concept developed by Moore in 1993 (Aksenova et al., 2019; Bosch-Sijtsema & Bosch, 2015; Moore, 1993; Pulkka et al., 2016). This ecosystem, however, no longer looks at industrial process as a metaphor for the natural ecosystem, since the focus shifts on to the relationships between the actors involved in the process (Moore, 1993). The characteristics of both ecosystems as presented above envisage (a) a form of symbiosis between the elements of the ecosystem, (b) the coevolution of the actors involved around an innovation, and (c) and the ability to create collective value (Aksenova et al., 2019; Bosch-Sijtsema & Bosch, 2015; Pulkka et al., 2016). Another aspect that is relevant for the success of an ecosystem is the *platform* (Bosch-Sijtsema & Bosch, 2015; Moore, 1993). The latter is considered as the shared tool used to sustain the ecosystem activities and novelties (Bosch-Sijtsema & Bosch, 2015).

9.3.4 *Applicability of Ecosystem Concepts in Construction*

In the application of the ecosystem concept to the building and construction sector, the studies are divided mainly between those who see similarities between the construction and the service sector and therefore use the lens of the *service ecosystem* (Bröchner, 2016; Sezer & Bosch-Sijtsema, 2020) and those who look at the modalities of innovation in construction and therefore shift the emphasis on to the *innovation ecosystem* (Vosman et al., 2021; Yang et al., 2021; Whicher et al., 2018). Moreover, the concept of *business ecosystem* is also used to understand the need for network-based collaboration and shared logic to approach complex and risky projects (Toppinen et al., 2019).

Sezer and Bosch-Sijtsema (2020) used the concept of service ecosystem to study the barriers and tensions between the actors involved in construction and demolition waste refurbishment projects in Sweden. Vosman et al. (2021) employed the concept of innovation ecosystem as an approach to facilitate long-term collaborations that favor the necessary level of innovation and change to meet the needs and challenges of contemporary society. A couple of studies have focused their analysis on the relation between information and communication technologies (ICT) innovation in construction and the ecosystem concept (Aksenova et al., 2019; Yang et al., 2021). Moreover, Whicher et al. (2018) suggested how ecosystems theory could be used to identify all actors affected by a circular economy action plan, such as the one proposed and implemented for Scotland. The aim of identifying the affected actors is to be able to involve and include all of them in the creation and implementation of circular economy action plans. Finally, Toppinen et al. (2019) scrutinized the fitness of the business ecosystem concept in the context of multistory timber buildings, paying particular attention to the creation of value and benefits for the actors involved in the business. In all these studies, the four aforementioned characteristics return, sometimes taking on slightly different aspects and sometimes complementing themselves with further characteristics.

9.4 Results and Discussion

For this study, literature on the subject of ecosystems and the reuse of building materials has been examined. Definitions of ecosystem concepts and their characteristics were sought and categorized; see Table 9.2. Subsequently, an attempt was made to apply each of the characteristics identified for the reuse of building materials based on both the literature and the six interviews. This attempt showed that in the case of actors involved with reuse of building materials, none of the previous ecosystem definitions in the literature fully explain their interactions and struggles. It was therefore decided to adapt the characteristics presented in previous studies and to use four main characteristics in an attempt to cover all the aspects within an ecosystem of actors working with the reuse of building materials. These four characteristics are (a) complementariness and collaboration, (b) capability to evolve, (c) willingness to align to circularity, and (d) platformization.

9.4.1 *Complementariness and Collaboration*

As stated by Pulkka et al. (2016), the construction sector is based on a high level of compliance among organizations as each individual actor becomes less and less capable of providing all the technical and process knowledge necessary to develop and complete a given project. The need for collaboration among different actors is a recurring aspect in the literature about the reuse of building materials (Gerhardsson

Table 9.2 Identifying the characteristics of ecosystems

Type of ecosystems	Definition	Characteristics	Literature
Ecosystem (general description applied in different fields)	From an ecosystem perspective, a company can be viewed “not as a member of a single industry but as part of a business ecosystem that crosses a variety of industries and to coevolve capabilities around a new innovation. Companies work cooperatively and competitively to support new products, satisfy customer needs, and eventually incorporate the next round of innovations” (Moore, 1993)	<ol style="list-style-type: none"> 1. Symbiosis 2. Coevolution 3. Platform 	Bosch-Sijtsema and Bosch (2015), Frosch and Gallopoulos (1989), and Moore (1993)
Business ecosystem	It is a set of core features which includes nonlinear value creation, interdependency of participants, substantial knowledge exchange, and nonmarket governance mechanisms, and coevolution of capabilities (Pulkka et al., 2016). “The ecosystem is focused on collective value creation as the recognized area of institutional life” (Pulkka et al., 2016)	<ol style="list-style-type: none"> 1. Network of participants 2. Governance system 3. Shared logic 	Pulkka et al. (2016) and Toppinen et al. (2019)
Service ecosystem	Service ecosystems are defined as “relatively self-contained self-adjusting systems of resource-integrating actors connected by shared institutional logics and mutual value creation through service exchange” (Vargo & Lusch, 2014)	<ol style="list-style-type: none"> 1. Institutional arrangements and mutual value creation 2. Ability to self-adapt to changes 	Bröchner (2016), Sezer and Bosch-Sijtsema (2020), Trischler et al. (2020), and Vargo and Lusch (2014)
Innovation ecosystem	The innovation ecosystem can be understood as “a multi-stakeholder network around certain innovative value propositions” (Vosman et al., 2021)	<ol style="list-style-type: none"> 1. Heterogeneity of actors 2. Strategic alignment of actors 3. Alignment with respect to the value proposition 4. Nonformal governance 	Vosman et al. (2021) and Whicher et al. (2018)
Circular innovation ecosystem	“A number of products, business model and ecosystem principles that when combined enable firms to take an ecosystem perspective on the circular economy and work towards higher circularity” (Konietzko et al., 2020)	<ul style="list-style-type: none"> Collaboration Experimentation Platformization 	Konietzko et al. (2020)

et al., 2020; Kanters, 2020; Knoth et al., 2022). In fact, the complementarity between actors is often insufficient to reach the right level of knowledge for CE implementation in building projects; additionally, it is necessary that the actors interact and collaborate even in phases of the project in which they were not traditionally involved (Gerhardsson et al., 2020; Knoth et al., 2022). It was stressed by the private developer and the sustainability consultant that actors such as architects, consultants, demolition and deconstruction firms, recycling companies, and contractors need to collaborate and be more involved throughout the project stages, especially in the earlier stages. Moreover, both the sustainability consultant and the municipal developer emphasized the need to include more actors in the early strategic work “to make them (the other actors) co-owners of the ambition and to understand what we want to do” (Interviewee 5).

All the interviewees mentioned at least once that frustration is one of the most recurrent moods among actors. In collaboration, a winning way to achieve circularity is to manage the relationships through increasing communication, involvement, and motivation of all the actors. This will also prevent frustration (Hart et al., 2019; Knoth et al., 2022; Konietzko et al., 2020). The sustainability consultant explained how collaborating with architects has enabled them to generate design ideas for reusing building materials and thus create new knowledge that can be used in various projects. The municipal developer describes its approach to the engagement and motivation of other actors; it is one of recognizing the importance of stimulating collaboration and making room for other actors’ new ideas. The aim is to ensure that the knowledge of the contractors is integrated with that of the architects or with that of the demolition contractor, for example. This type of collaborative attitude is considered as one of the facilitators for the creation of long-term relationships, which in turn represent one of the conditions for the diffusion of innovation (Bosch-Sijtsema & Bosch, 2015). Moreover, as suggested by Sezer and Bosch-Sijtsema (2020), the actions of the actors within a network reflect, directly or indirectly, upon all other actors. For example, according to the sustainability consultant, developing close relationships with clients enables them to influence the sustainability objectives of the project “and push the limits of their boundaries” (Interviewee 5). The same kind of effect was described by the private developer when referring to how the collaboration between the developer and the sustainability strategist helped to achieve a reuse target of 80% for their project.

Moreover, it is worth noting that the interviewees highlighted the need to collaborate not only with complementary actors but also with competing organizations. Collaboration between competing organizations is needed to be able to respond to the market, to grow the market itself, to improve pricing of materials and services, to improve procedures, and to develop certification (Gerhardsson et al., 2020; Knoth et al., 2022). The need to collaborate is in line with previous literature based on competitive engagement approaches (Bosch-Sijtsema & Bosch, 2015).

9.4.2 Capability to Evolve

Previous studies show that one of the major barriers to the implementation of the reuse of building materials in the Swedish building and construction sector is the lack of knowledge and experience in reuse practices (Gerhardsson et al., 2020; Kanters, 2020; Knoth et al., 2022). While Kanters (2020) focuses on the need for architects to acquire both technical skills and greater flexibility, the interviews reveal the necessity of bridging the knowledge gap and encourage the flexibility of all the actors involved in the reuse of building materials. This flexibility is perceived as the ability of the actors to redefine their roles and responsibilities. As explained by some of the interviewees, actors who are new to reuse practices often remain skeptical “just because they are not used to it” (Interviewee 4). The interviewees stressed that, during the design phase, the architect and the client must cooperate with contractors, consultants, demolition contractors, and suppliers for successfully implementing the reuse of building materials. In this process, a new responsibility is added to the role of architects; they are no longer just designers, but they also become the organizers of a logistics process (Kanters, 2020). According to the sustainability consultant, inflexible architects may perceive this new responsibility as a threat not only to their creativity but to their profession.

The transition from a traditional building process to one focusing on the reuse of building materials leads to the creation of new roles and the involvement of actors from other sectors (Gerhardsson et al., 2020; Konietzko et al., 2020; Vosman et al., 2021). The interviewees underline, for example, the lack of actors who can classify and certify the reused materials. Some interviewees believe that public procurement and legislation could push organizations to fill these new roles. Thus, the ability of the actors to respond to the need of the ecosystem by evolving, transforming, and filling new roles is one of the main characteristics of the ecosystem of actors involved with reuse of building materials.

9.4.3 Willingness to Align with Circularity

Whether or not an actor belongs to a certain ecosystem is defined both by the ability of each actor to evolve and coevolve but also by the willingness to align with certain targets (Konietzko et al., 2020; Vosman et al., 2021) and according to certain engagements or interdependencies (Bosch-Sijtsema & Bosch, 2015; Bröchner, 2016; Konietzko et al., 2020; Vargo & Lusch, 2014). As highlighted by Bröchner (2016), ecosystems in construction are often dominated by contractors and by their ability to select procedures that favor the collaboration between all the actors involved in a project. Gerhardsson et al. (2020) add that the clients also play a relevant role for the transition to the reuse of building materials because they can include reuse as a requirement in the procurement process. All interviewees agreed with this last statement; for example, the private developer suggested that the

creation of a sustainability action plan can be used to facilitate the selection of the other actors in a project. In their project, those actors who lacked the skills needed or the willingness to strive for certain goals were removed, thereby reducing the number of potential candidates. In this sense, the sustainability action plan can also be considered as an institutional arrangement as described by Bröchner (2016). In line with what stated by Pulkka et al. (2016), all the interviewees emphasized that mutual awareness and alignment with certain values encouraged relationships between the different actors.

Moreover, framing joint strategies, such as the sustainability action plan presented by the private developer, can help the actors to understand that an efficient reuse of building materials can only be reached if all the actors work together. For this purpose, both the private developer and the sustainability consultants declared that defining the objectives and goals of a project should be its very first step. On a similar note, both consultants highlighted the importance of their roles in promoting sustainability since they are often the initiators for the transition to the reuse of building materials. These consultants do not only advise developers, municipalities, and small companies; they also set sustainability strategies for specific projects. A different situation was presented by the municipal developer. In its project, the reuse of materials was first considered after the actor selection process had finished. In this case, the trust between the actors (built on long-term collaboration), the positive attitude to reuse, and the willingness to align with circular practices proved to be the winning factors for the successful implementation of reused building materials.

An important aspect that hinders the willingness to align to circularity is the lack of legislation and regulations related to the reuse of building materials (Gerhardsson et al., 2020; Hart et al., 2019; Knoth et al., 2022). Sometimes, the current regulations constitute an obstacle for the reuse of building materials (Knoth et al., 2022). This was highlighted by almost all the interviewees, especially referring to risk management and to the management of material transportation and ownership from one project to another one.

9.4.4 Platformization

The creation of an online platform that guarantees collaboration, an efficient level of communication between the actors, and the sharing of knowledge and information is a fundamental aspect within the ecosystem (Bosch-Sijtsema & Bosch, 2015; Gerhardsson et al., 2020; Knoth et al., 2022; Konietzko et al., 2020; Toppinen et al., 2019). Both the literature and the interviewees suggest that the presence of a platform is fundamental for the success of a circular project and for implementation of the reuse of building materials. Even so, four out of six interviewees revealed a form of skepticism or lack of knowledge toward the most common platform in Sweden (CCBuild) in favor of platforms within the project or developed by individual actors. In a couple of interviews, the role of a platform was reduced to that of a materials inventory, which is only one aspect a platform can fulfill. The private developer said

that their material inventory is an open-access platform which is able to share materials among other projects; however, they later revealed that they want to keep all the materials within the project and will not sell anything. One of the suppliers revealed a lack of a digital system for cataloging materials, stating that all information relating to quantities and costs is better kept in the foreman's head and the heads of a few other employees. In the first of the two examples, it was not made explicit if the material inventory also reports the materials' characteristics, potential for reuse, quality, or environmental potential as suggested by Knoth et al. (2022); in the second example, it was clearly stated that none of these data were collected. This confusion regarding platformization can be a hindrance to further implementation of the reuse of building materials (Knoth et al., 2022). An open-access material inventory is one of the first steps to initiate the reuse of building materials, but it is not sufficient to stimulate and diffuse the knowledge about the building materials alone. The two consultant organizations were well aware of this and, therefore, had developed an information sharing platform to facilitate interaction with other actors and increase the knowledge of the members of the ecosystem.

9.5 Conclusions

If the building and construction sector aims to reach a more sustainable development, the increased reuse of building materials will be necessary. The further implementation of the reused of building materials could contribute to the Sustainable Development Goal 11 (sustainable cities and communities) and Sustainable Development Goal 12 (responsible consumption and production). In this paper, four characteristics of the reuse of building materials ecosystems are presented. These are complementariness and collaboration, capability to evolve, ability to align to circularity, and platformization. Each of these four characteristics is elaborated in the results and discussion and is supported by literature and an exploratory study. Six actors involved with the reuse of building materials were interviewed: all are active in the Öresund region.

There are four overarching results from this study about the successful implementation of the reuse of building materials. First, there is a need for collaboration between multiple actors from an early stage. Since there is a lack of knowledge in the sector, all key actors, in a project, have to contribute with their expertise in order for them to identify collectively how much material reuse is realistic to implement for each project. Secondly, since the field is under development, more actors are needed; in addition, some actors have to take on new roles. Third, there is a need for increased awareness of the project objectives and values. It is essential that actors are willing to align themselves to circularity and that they remain flexible in their roles. Finally, there are a few platforms under development which will accelerate the implementation of the reuse of building materials and increase knowledge sharing; however, better platformization of the knowledge and tools than are currently available is needed.

Suggestions for future research on this topic include expanding the interview study presented here and mapping the actors in the ecosystem. Even though the findings are consistent with the literature, six interviews are not enough to explain the full ecosystem. There are likely, therefore, to be more findings in an extended study. Another suggestion is mapping actors in other regions, where implementation of the reuse of building materials is more advanced. It could be fruitful to compare these different regions by examining their strengths and weaknesses. An in-depth case study is also proposed since thorough data gathering concerning the actors and their roles could give insights into how the reuse of building materials is implemented in practice.

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