BUILDINGS & CITIES

Social life cycle assessment of adaptive reuse

SPECIAL COLLECTION: UNDERSTANDING DEMOLITION

RESEARCH

REBECKA LUNDGREN

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ABSTRACT

Adaptive reuse of existing buildings and shared spaces has been highlighted as a key circular economy concept in the built environment, with the former also having been found to increase social sustainability through the preservation of cultural heritage. However, circular economy research has focused on the economic and environmental dimensions, with the social dimension receiving less attention. The aim of this study is, therefore, to establish the social impact of an adaptive reuse case with shared spaces. A supplementary aim is to test and adapt the general social life cycle assessment (S-LCA) framework to fit the built environment context. A qualitative single case study method is used. The study finds significant positive social impacts from the adaptive reuse case, mainly in the form of economic and cultural impact on the local community. The S-LCA framework was a useful tool in assessing the social impact of the case. Additional indicators of particular relevance to the built environment are identified relating to the end-users and local community, as well as indicators relating to society, value chain actors, and workers.

PRACTICE RELEVANCE

A set of sector-specific indicators is created to capture the social impact. The findings are useful for researchers and industry professionals intending to evaluate and increase the social sustainability of a construction or demolition project. The improved S-LCA framework and set of indicators allows for an improved understanding of built environment implications. Planners, designers, and clients can employ the revised framework to evaluate projects pre- and post-construction or demolition.

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1. INTRODUCTION

The balance between the so-called triple bottom line of sustainability, *i.e.* economic, environmental, and social dimensions (Elkington 1997), has received increased research interest in recent years (Geissdoerfer *et al.* 2017; Henry *et al.* 2021; Padilla-Rivera *et al.* 2020). However, within the circular economy realm, Geissdoerfer *et al.* (2017) found that most research on the circular economy focuses on environmental aspects. Henry *et al.* (2021) reviewed 4422 papers to explore the circular economy in the existing literature and noted a bias towards economic and environmental assessments, with the social dimension receiving less attention. Padilla-Rivera *et al.* (2020) noted in their review of 3647 papers that the social dimension of the circular economy is underdeveloped, often only focusing on employment opportunities, which could be categorized under the economic dimension as well.

Several scholars suggest that the most effective circular strategies reduce demand or optimize use with the least possible intervention to the product (Bocken *et al.* 2014; Ellen MacArthur Foundation 2015; Höjer & Mjörnell 2018; Kyrö 2020; Reike *et al.* 2018). In the built environment context, adaptive reuse has been found to save significant embodied carbon compared with demolition and new construction (Baker *et al.* 2021; Pomponi & Moncaster 2016; Röck *et al.* 2020). Huuhka & Vestergaard (2020) present a relationship between the circular economy and building conservation, where avoiding demolition both conserves the building and delivers circularity. In addition to heritage value, the social impact of adaptive reuse has been linked to the revitalization of neighborhoods and subsequent increased living standards, and even the lessening of crime and unsocial behavior as it typically aims to optimize the use of vacant or underused paces (Langston *et al.* 2008).

Another circular strategy of the built environment that is considered effective due to its potential of reducing demand is sharing (Arup 2016; Bocken *et al.* 2014; Ellen MacArthur Foundation 2015; Kyrö 2020; Reike *et al.* 2018). The environmental benefit of sharing is through reducing space demand, and consequent energy use and carbon impact (Francart *et al.* 2020; Höjer & Mjörnell 2018). Positive social impact from shared spaces has been linked to community (Curtis & Lehner 2019; Kyrö *et al.* 2016; Kyrö & Lundgren 2022; Orel & Alonso Almeida 2019; Waters-Lynch & Potts 2017), as well as knowledge-sharing and collaboration (Kyrö *et al.* 2016; Weijs-Perrée *et al.* 2019).

While life cycle analysis (LCA) is an established method for assessing the life cycle environmental impact of buildings (Crawford 2013), the assessment of social impact is not well established. Social life cycle assessment (S-LCA) follows the structure of environmental LCAs (UNEP 2020), and the guidelines were published already in 2012, yet few circular economy studies using the framework have been conducted to date (Padilla-Rivera *et al.* 2020). Padilla-Rivera *et al.* (2020) suggest that the social impact of the circular economy should be assessed through case studies, and social sustainability indicators need to be defined. The S-LCA method has, several years after its release, been criticized for many different applications of the method where further research is required to identify improvement actions (Arcese *et al.* 2018). Larsen *et al.* (2022) concluded that the S-LCA framework is useful for assessments in the built environment, but needs to be developed further. Benoît *et al.* (2010) suggested case studies can be used to gain practical experience from the application of the framework. Moreover, a need for selecting relevant indicators for specific fields has been highlighted (Arcese *et al.* 2018).

The aim of the present paper is two-fold: first, to establish the social impact of an adaptive reuse project with shared spaces; and second, to give an insight into the usefulness of the S-LCA tool in the built environment context and to propose a set of sector-specific indicators to capture the social impact. To achieve this, the general S-LCA framework is first supplemented with indicators from existing research on social considerations in the built environment. Primary case-specific data are then collected through interviews and analyzed to extract further indicators. Finally, the case is assessed using the adapted S-LCA framework.

The paper is structured as follows. The next section presents the research design, including an overview of the S-LCA framework. The case study findings are then presented. The paper finishes with a discussion and conclusions.

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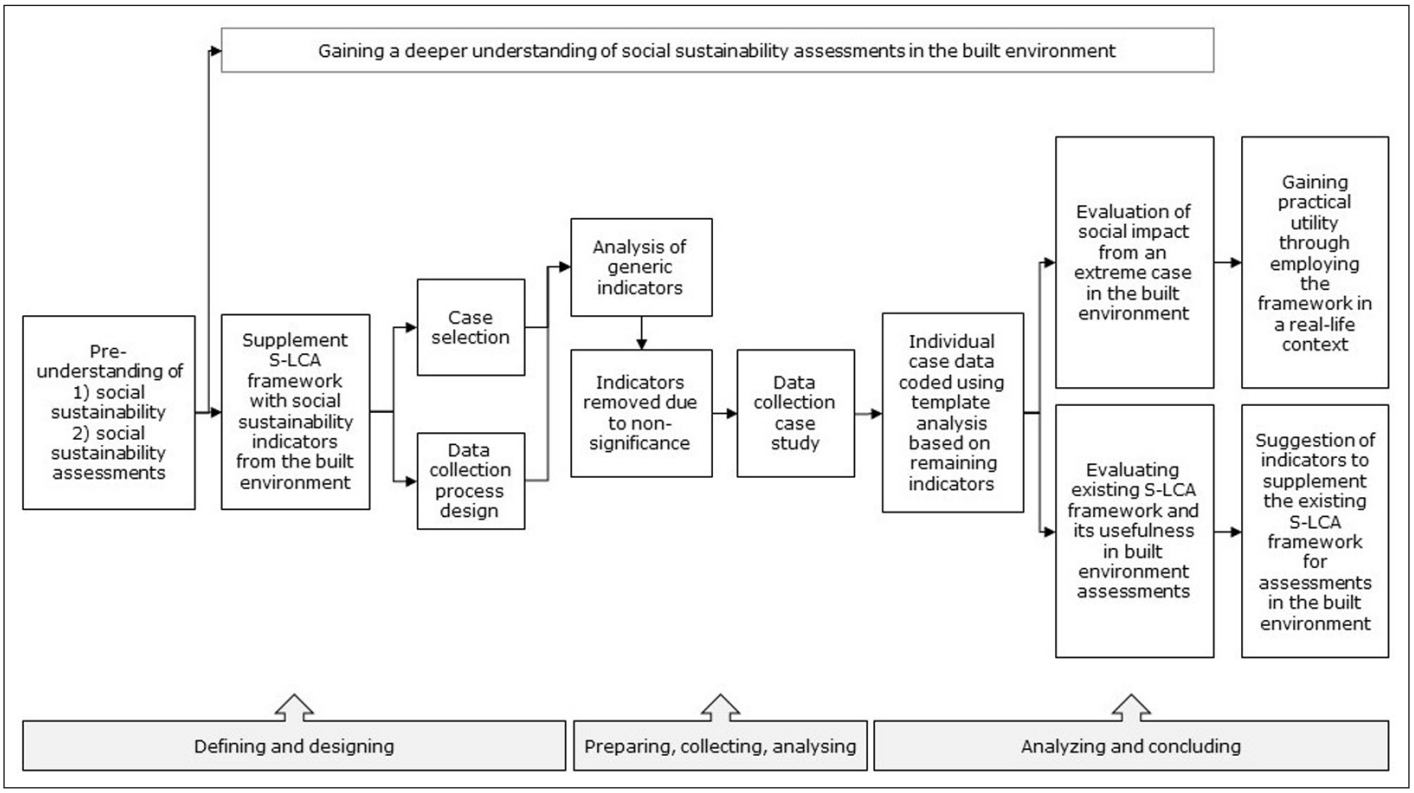
2. RESEARCH DESIGN

The study begins with developing an understanding of social sustainability and social sustainability assessments, which continues throughout the study. The S-LCA framework is then supplemented with social sustainability indicators from the built environment before the case selection and data collection process. The social indicators are then first assessed based on a generic assessment, followed by site-specific data from the case study. The case data are coded using template analysis. An overview of the research design is presented in Figure 1.

Figure 1: The research design.



2.1 S-LCA

The S-LCA guidelines provided by the United Nations Environment Programme (UNEP) are a uniform framework intended to provide flexibility (Benoît *et al.* 2010). However, Arcese *et al.* (2018) found that the assessments performed based on the framework are fragmented, with different approaches, priorities, and inputs employed in studies. Selecting the correct stakeholders, impact categories, and subcategories has been emphasized as a critical step for the application of the S-LCA method (Subramanian *et al.* 2018).

The framework consists of two documents, namely, the guidelines first released in 2009 and last updated in 2020 (UNEP 2020); and methodological sheets last updated in 2021 (UNEP 2021). The latter includes a suggestion of 165 social sustainability indicators grouped within subcategories relating to six stakeholder categories, namely, children, consumer/end-user, local community, value chain actors, society, and workers. The suggested indicators are intended to help the S-LCA data collection process and function as an inspiration rather than a complete set of indicators. It is stated in the methodological sheets that their content should evolve over time and will be expanded as the field advances (UNEP 2021).

Subcategories in the framework are first evaluated using generic country and industry-level data which can assist in effectively identifying hotspots, which is the process of finding high-risk or opportunity areas within stakeholder categories. Effort should be put towards assessing the site-specific indicators (UNEP 2021). An overview of the framework is presented in Figure 2. Both positive and negative impacts are included in the assessment (Arcese *et al.* 2018), however a lack of positive impact inclusions was highlighted before the guidelines were updated (Subramanian

et al. 2018). The current S-LCA guidelines suggest the use of reference scales for each indicator, *e.g.* a generic ascending reference scale where zero is applied for activities complying with rules, regulations, and societal expectations, +1 and +2 applied when the performance is beyond compliance or ideal, and –1 and –2 applied to activities below or starkly below the compliance level. The criteria for assigning ratings are suggested to relate to the performance based on specific norms, practices, and best practice specific to a single indicator and can be either qualitative or quantitative. To compare S-LCA assessment results, the goals and modelling choices, as well as the sector to which it is applied, need to be consistent (UNEP 2020). Liu & Qian (2019) also stress the need for consensus on the weighting of the different categories and indicators.

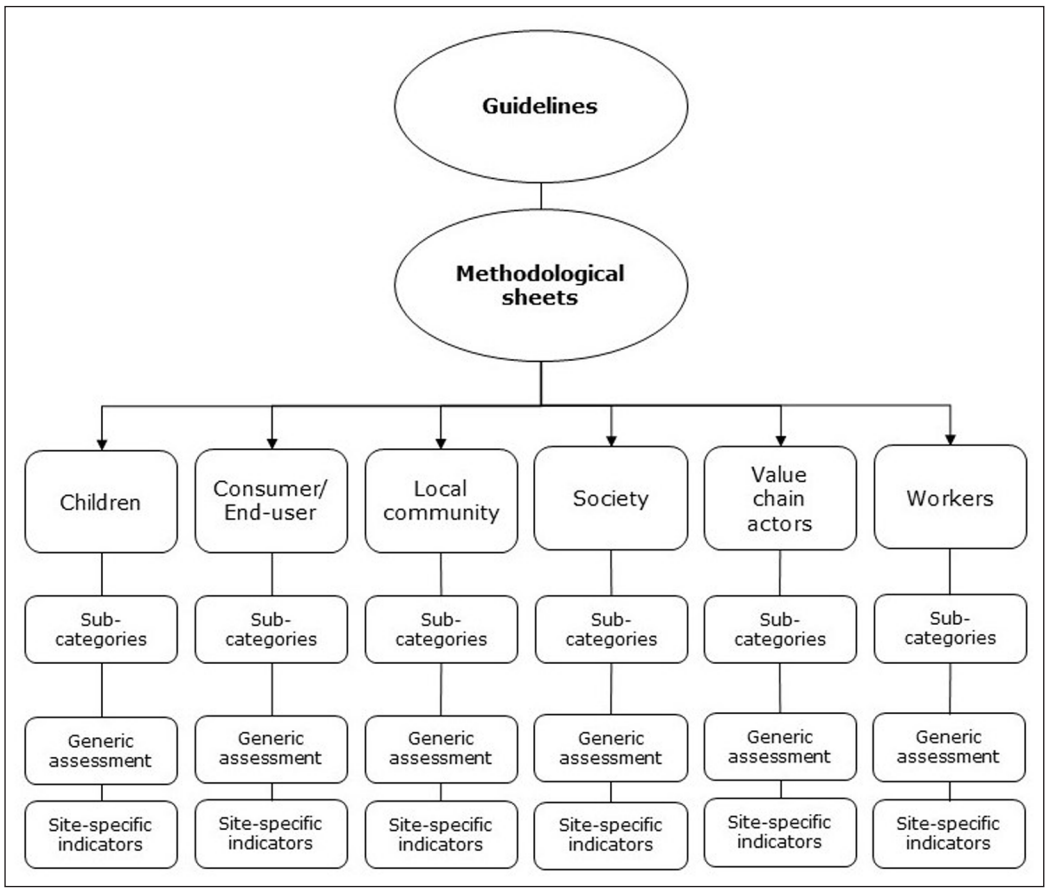


Figure 2: Overview of the social life cycle assessment (S-LCA) framework.

2.2 INDICATORS AND ASSESSMENT

In line with the case study design, the step following the pre-understanding of social sustainability assessment was to supplement the S-LCA framework with indicators from existing built environment social sustainability studies. This led to 53 indicators from built environment social sustainability assessment research added to the 165 site-specific indicators from the S-LCA framework, adding up to a total of 218 site-specific indicators. The indicators were chosen based on the study's relevance in terms of assessment object and provision of indicators. The assessment object was considered relevant if it related to a physical building or a construction project, whether in a real-life context or in a simulated or generalized setting. This excluded any studies on a construction material level as the product phase is out of scope for the case study assessment. Further, the studies needed to explicitly list the included indicators in the main body of text to be practical in the extraction of indicators. The list of selected social sustainability assessments is not exhaustive and is limited to those deemed most relevant and which provided a more diverse set of indicators, from the perspective of different assessed objects, to complement one another and the existing S-LCA methodological sheets. The studies and their indicators were selected based on their ability to complement the S-LCA methodological sheets, which meant they needed to include indicators which were not part of the most recent published framework.

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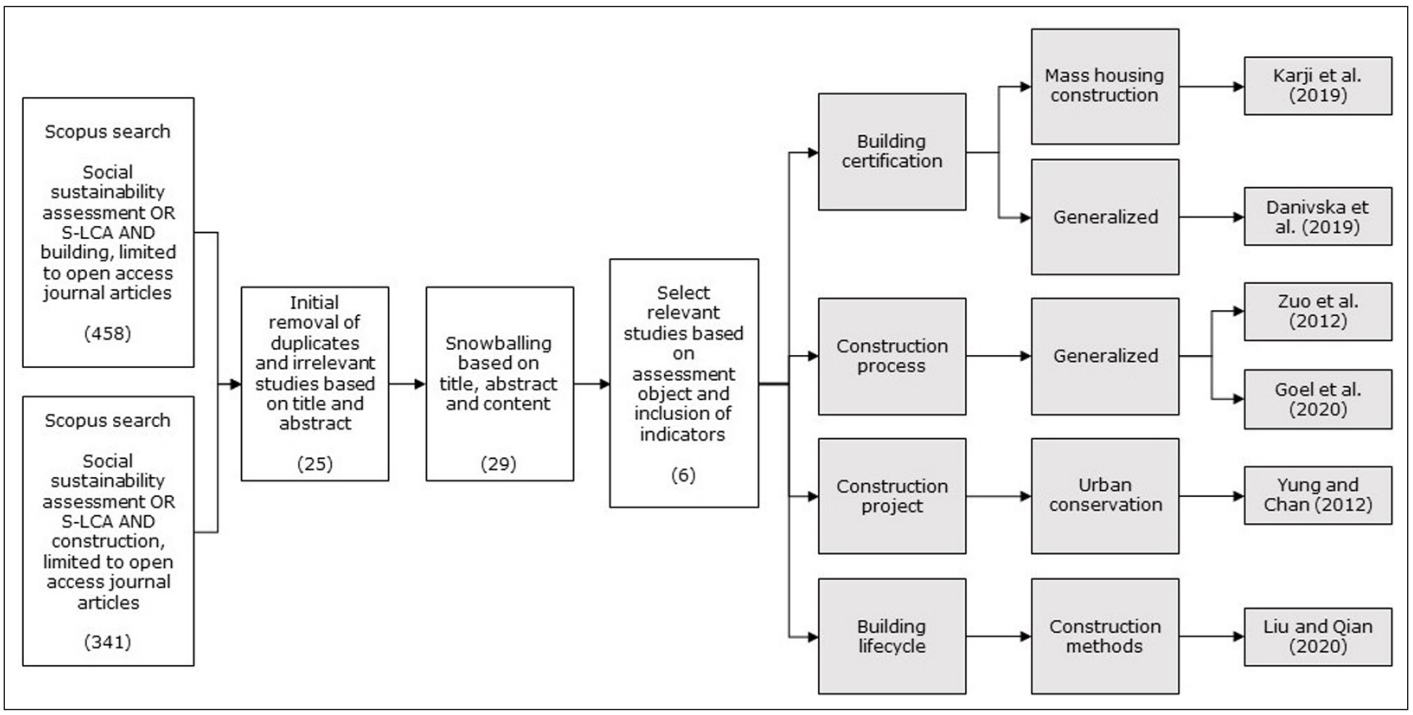
To find the appropriate studies, a literature search was first conducted using Scopus. A search was performed for open-access articles containing either the terms 'social sustainability assessment' or 'S-LCA' and 'building' or 'construction' in the title, keywords, or abstracts. This yielded a total of 799 articles. The titles, keywords, and abstracts were then reviewed, and those that included a social sustainability assessment or review of social sustainability assessment(s) in the built environment were deemed relevant (n = 25). A further four studies were found through snowball sampling from the relevant studies of the initial search. Of the 29 studies, six were selected that all included a list of the employed indicators. Further, they were believed to contain a variety of scope and indicators related to the life cycle stages included in this study, namely construction phase and use stage, as well as a variety of indicators not found in the S-LCA methodological sheets. The selected studies, namely Liu & Qian (2019), Danivska *et al.* (2019), Goel *et al.* (2020), Karji *et al.* (2019), Yung & Chan (2012), and Zuo *et al.* (2012), were, however, not all life cycle assessments and had different assessment criteria than those of the S-LCA. The selection process for built environment indicators to complement the S-LCA framework is outlined in Figure 3.

Figure 3: Literature review process to extract built environment indicators from the existing literature.

Note: The number of studies left after each step is shown in brackets.



Indicators added from the existing literature in the built environment related to all stakeholder categories, less children. This category was first introduced in the latest methodological sheets released in 2021, which can explain why previous studies have neglected this category. Some S-LCA indicators in the local community category, however, include the impact on children in the local community, which was also the case in some assessments in the existing literature in the built environment. For a full list of built environment-specific indicators extracted from existing studies, see Appendix A in the supplemental data online.

The methods employed for the selected studies vary and include differing and some limited perspectives. Danivska *et al.* (2019) consider wellbeing and social sustainability of buildings through assessments that result in building certification. Karji *et al.* (2019) extract social sustainability indicators from existing rating systems such as Leadership in Energy and Environmental Design (LEED) and Building Research Establishment Environmental Assessment Method (BREEAM) and apply these in an assessment of mass housing construction. The indicators are predominantly focused on the local community impact. Yung & Chan (2012) assess the social sustainability impact of an urban conservation project using social sustainability indicators from the international literature, which also has a dominant focus on local community impact.

Zuo *et al.* (2012) and Goel *et al.* (2020) explore the social sustainability issues of construction projects in general and suggest indicators to be used for assessments of such projects. Zuo *et al.*

(2012) employ indicators related to workers, local community, and macro-level impacts. Goel *et al.* (2020) study the considerations of social sustainability in feasibility reports, whilst Zuo *et al.* (2012) focus on the attitude of industry professionals towards social sustainability. The indicators employed by Goel *et al.* (2020) relate to employment, community involvement, end-users, and ethics.

Liu & Qian (2019) consider the social sustainability of the building life cycle using the S-LCA. However, they disregard value chain actors as stakeholders due to what they refer to as the 'ambiguity' of the category. The stakeholder category of children is also excluded due to this stakeholder category not included in the previous methodological framework (UNEP 2021) which was used in the study. The study focuses on a reduced number of subcategories from the framework and is applied to two new construction buildings of different construction methods with a strong focus on the material and construction method choice, whilst disregarding managerial practices (Liu & Qian 2019).

The supplemented S-LCA framework is used to evaluate the social impact of the selected case. The subcategories of the indicators were first reviewed in terms of generic analysis as recommended in the methodological sheets (UNEP 2021) using national and regional public data and industry reports. Some site-specific indicators were thus removed from further consideration through this process as per the methodological sheet recommendations (UNEP 2021). Site-specific indicators were then assessed using an ascending reference scale.

2.3 CASE STUDY

This study employs a qualitative single-case study approach to explore a phenomenon in depth in its real-life context (Yin 2009). True to qualitative research, it does not aim at statistical generalizability, but rather analytical generalization, identifying characteristics which may be transferable to other cases. Yet, as Flyvbjerg (2006) states, there is power in examples. Concrete, context-dependent knowledge may be more valuable than general theoretical knowledge (Flyvbjerg 2006).

Purposive sampling focuses on a single or a few unusual or special cases (Saunders *et al.* 2009). Flyvbjerg (2006) refers to this sampling strategy as information-oriented selection, and notes it works well to retract most information from a single case. One option is to choose an extreme case that is especially good or bad in some defined sense. This study follows the purposive, information-oriented sampling and focuses on a single, extreme case. The case is considered extreme due to its ambitious circular activities, on the one hand, and the location in a neighborhood with social issues, on the other.

The selected case is a former factory in Malmö, Sweden. The 6800 m^2 building was first built in 1901 and refurbished in 2022 when it was adapted to a new use of offices and workshops for the cultural sector. The building owner and developer (referred to as developer hereafter) is a non-listed company with over 350 employees. The turnkey contractor and the architect are local organizations. The adaptive reuse case includes individual, shared, and public spaces. Additional to the two core circular economy measures of adaptive reuse and shared spaces, other measures, *e.g.* a reuse depot for discarded building materials and components, and restoration of components such as light fixtures, were part of the project. Several social aspects were also included, *e.g.* collaboration with the local school and non-profit organizations. Since the decline of local industrial actors, the area has suffered from social issues and has been a place for migrants, legal and illegal. However, the area is currently undergoing wider development activities and gentrification (Hansen 2019).

2.4 SCOPE OF ASSESSMENT

The life cycle stages evaluated in the study are the construction process and use phase. The construction process relates to the refurbishment and reconfiguration of the building. The use phase relates to impact from the use of the building. The retention as opposed to the demolition of the building is included as it relates to, for example, the local community in terms of cultural heritage. This impact can be the same independent of whether or not the building is occupied.

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It is believed that the included stages, construction process, use stage, and the existence of the building will yield the most significant results in terms of the assessment hotspots, which is supported by previous studies in these life cycle stages (*e.g.* Goel *et al.* 2020; Karji *et al.* 2019; Liu & Qian 2019).

The included stages omit the evaluation of each building material's impact. The inclusion of product stage and related evaluations was not possible due to lack of data. Material choices in the project are, however, known to be in line with Swedish regulations relating to, for example, toxicity. Therefore, no issues are expected to incur for users and the local community. The demolition related to the adaptive reuse is included, however, as part of the construction process, as it was not possible to distinguish between the two processes. The social impact of demolition waste processing and disposal was not included due to unavailable data for these processes and related organizations.

The objects of study are the project itself and the two main project organizations: the developer and the turnkey contractor. The two key organizations are assessed both for their general organizational sustainability, as well as the specifics related to the project. The impact of the architect is also included in the assessment of the project. However, their organizational impact is not assessed as these data were not available. As the architects are also one of the tenant end-users of the building, they have a dual role. They not only have a sustainability impact through the project but are also impacted as end-users. The social impact of the project from a holistic view, including the main organizations, is assessed in relation to all S-LCA stakeholder categories (Figure 4), as recommended in the methodological sheets (UNEP 2021).

The site-specific indicators were employed to assess the two main organizations and the project itself using an ascending reference scale. However, as multiple organizations and processes, here in the form of a construction project, are involved and need to be considered, this study chose not to aggregate the score and instead assigned positive, negative, mixed, or neutral indicator ratings to provide a holistic impact assessment. Mixed was used when there was both a positive and a negative impact, which would risk being lost if a score of –1 and +1 was aggregated to 0, suggesting a neutral impact.

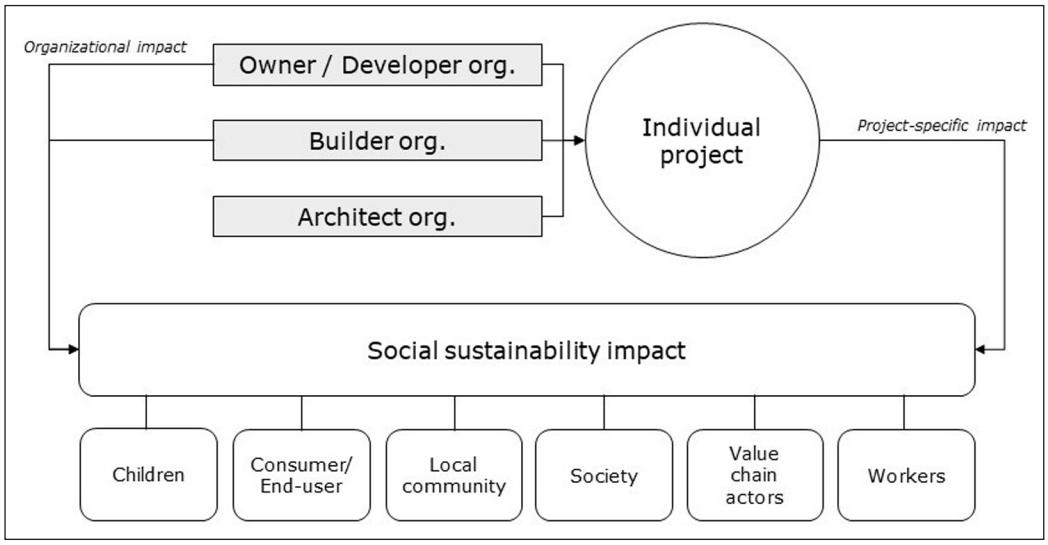

Figure 4: Included organizations and their connection to the social impact.

2.5 DATA COLLECTION AND ANALYSIS

Interviews were undertaken with stakeholders in 2022, and site visits were conducted both during construction in 2021 and upon project completion in 2022. Project and organizational documents were also reviewed as part of the data collection process. For a full list of conducted interviews and reviewed documents, see Appendix B in the supplemental data online. The interviews were undertaken in Swedish and transcribed. Quotations were translated by the author. The interviews were semi-structured, focusing on the themes of social impact. First, the respondents were

asked to describe what they believed were significant social impacts of the project and their organizations related to the S-LCA stakeholder categories. Second, the respondents were asked to further deliberate on the social impact related to the subcategories. Last, if not already covered, the impact related to a specific indicator was considered by the respondent. Not adhering strictly to the indicators in the first instance allowed richer data and allowed the respondents to freely consider the aspects most important to them. As a result, additional indicators could be extracted, *e.g.* when asked about social impacts on end-users that the architect saw as significant, the importance of usability and, in turn, the positive impact of the aesthetic experience combined with social connection emerged. This was not listed as an indicator, and so should the assessment only have been carried out indicator by indicator, this would have likely been missed.

The analysis of the collected data was conducted by coding the data using template analysis with the themes based on the subcategories of the adapted S-LCA framework. Data were first grouped in relation to the existing subcategories from the S-LCA framework supplemented with the existing built environment subcategories found in the existing literature. The data within the subcategories were then assigned to the existing indicators. Where data did not match any existing indicator, a new indicator was created.

3. RESULTS

3.1 GENERIC ASSESSMENT

Only those indicators deemed highly unlikely to be significant were excluded in the generic assessment. In total, 72 site-specific indicators were removed, of which some were indicators added from existing built environment literature, leaving 154 indicators for the site-specific assessment. Table 1 provides an overview of the site-specific indicators that were excluded from each subcategory. For a full list of excluded indicators and justification, see Appendix C in the supplemental data online.

Table 1: Site-specific indicators per subcategory excluded based on generic assessment.

	INDICATOR	EXCLUDED INDICATORS	JUSTIFICATION
Children	Children's concerns regarding marketing practices	All	No marketing to children
	Education provided in the local community	5/8	Not applicable
	Health issues for children as consumers	All	No children as consumers
Consumer/end-user	Consumer privacy	All	Business to business only
	End-of-life responsibility	All	Retained ownership
	Health and safety (H&S)	All	H&S requirements high in Sweden
Local community	Access to immaterial resources	All	Low risk
	Access to material resources	1/3	Low risk
	Respect of Indigenous rights	All	Not relevant in southern Sweden
	Safe and healthy living conditions	All	Low risk in Sweden
	Secure living conditions	All	Building permits demand security
Society	Ethical treatment of animals	All	No animals
	Prevention and mitigation of conflicts	All	Low risk of conflicts
Workers	Child labor	All	Low risk in Sweden
	Forced labor	All	Low risk in Sweden
	Smallholders including farmers	All	No smallholders part of the scope
	Social benefit/social security	All	Strong social security in Sweden

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3.2 SITE-SPECIFIC ASSESSMENT

The assessment of the case found 79 indicators to be neutral, split between all stakeholder categories. The outcomes for the indicators either merely complied with legislation or were not applicable. The remainder of the indicators were assessed as positive (n = 61) or mixed (n = 14). A mixed rating was given when there were conflicting impacts, *e.g.* indicators relating to fair salary were deemed to be positive; however, due to difficulties to follow-up, the implementation of some contractual clauses throughout the value chain, not adhering to a fair salary, were highlighted as a risk. No indicators were rated as entirely negative. An overview of the site-specific ratings per subcategory, excluding those rated neutral, is presented in Table 2. For a complete list of indicator ratings and justifications, see Appendix D in the supplemental data online.

Table 2: Overview of site-specific ratings per subcategory.

STAKEHOLDER	SUBCATEGORY	POSITIVE	MIXED
Children	Education provided in the local community	3	
Consumer/end-user	Accessibility	1	1
	Compensation	1	
	Delocalization		1
	Health and comfort		1
	Participation	1	
	Psychological comfort	1	1
	Safety		1
	Sustainability	1	
	Transparency	4	
	Usability	3	
Local community	Community development	11	
	Community engagement	4	
	Cultural heritage	3	
	Delocalization and migration		1
	Local employment	4	1
	Neighborhood characteristics	5	
Society	Public commitment to sustainability issues	4	
	Technology development	3	
Value chain actors	Knowledge-sharing	1	
	Promoting social responsibility	2	
	Stakeholder management	3	
	Supplier relationships		2
	Wealth distribution	1	
Workers	Equal opportunities	1	1
	Fair salary		3
	Fulfillment	2	1
	Knowledge-sharing	1	
	Working hours	1	

3.2.1 Children

The developer has organization-wide and project-specific community involvement programs as well as strong policies with related annual budgets for promoting community and student participation. A mural was created by a local artist in collaboration with children from the nearby

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school. The courtyard, which has been equipped with places in which to relax, play, and work, is open to the public during the day and children are welcome to use it. The organization also provides a swimming school and homework assistance for local children, as well as summer jobs for young adults. Many initiatives relating to children and young people are collaborations with local non-profit organizations:

> we have some large collaborations. For example, with a social center which is a non-profit that has worked in Malmö for 20 years with preventing social exclusion and creating positive role models for young and teens.
>
> (N4)

3.2.2 Consumer/end-user

The refurbishment of the building led to significant rental increases; however, the developer had several measures in place to minimize the impact on existing tenants:

> we have as a principle that the tenant shows the way. You try and make the best compromise. In this project it was a goal to keep as much as possible of the existing cultural sector businesses.
>
> (N1)

Assistance was provided to those who wanted or needed other facilities to find suitable ones within the pool of spaces available to the developer, both for those looking for temporary spaces whilst the refurbishment was undertaken and for those looking for permanent spaces with lower rents. For the returning tenants, rental increases have been gradual to assist in the adjustment to the new levels. Spaces were also made more efficient and divided into smaller spaces, which meant that the higher rents per area did not result in a much higher total rent, with the intent that the new spaces provided the same utility:

> most have managed to stay. Not in the exact same space. When it was that cheap it was easy to rent a bit too much space, and now we have created more manageable space sizes. And those who have had a cheap rent may have been able to get not such a big rental increase.
>
> (N3)

Despite these measures, some tenants chose to relocate and thus a mixed rating was assigned to delocalization of end-users. This mixed impact on existing users meant the delocalization indicator, which in the S-LCA methodological sheets relates to the local community, here also became significant for the end-user stakeholder category.

Another mixed rating was assigned to the health and comfort of the end-users. A refurbishment of an old building meant that some aspects were not as functional as in a new building. The dimensions of the ventilation and other services were kept as small as possible by choice, for both aesthetic value and environmental sustainability. This is seen as acceptable and even desired by the users due to the significance they put on sustainability and creating an atmosphere enabled by the aesthetics:

> there is actually very little installations compared to what it could have been. We have been working very carefully with it both looking a certain way, but also, we have made choices to accept that we don't have the same indoor temperature all year round. Because then you would need a more powerful cooling system, which in turn would have required more energy. Plus, it would have been a lot uglier, because the ducts would have been twice as big.
>
> (N3)

The shared spaces were seen as a key aspect enabling a more sustainable use of the building, which was important to the largest end-user. However, the users of the space wish to feel control, which is in part enabled in the building, *e.g.* lighting control, manual blinds, openable windows. Ventilation is, on the other hand, centrally controlled to ensure energy use is optimized regarding

environmental sustainability as well as comfort. Additional to the perceived environmental sustainability of shared spaces, they are also believed to create synergies and increase productivity. The open public places that enable social interaction and group formation are hoped to increase the safety in the area. The specific location of the case had positive safety aspects due to mixed use which means there is activity throughout the hours of the day and night:

> we wanted to be in a real city, in a city context so to speak, where we felt we could offer something. [...] When we were in our old offices, if you put it a bit meanly, you could say that we were in a consultant-ghetto.
>
> (N3)

3.2.3 Local community

The most significant impact was found in the local community stakeholder category, which was predominantly resulting from either the conservation of the existing building or the shared and public spaces. Community development was enhanced by public shared spaces open to everyone. More efficient use of the building has led to an increased number of users. It is likely to have a snowball effect where more businesses will open due to the increased activity, such as cafés, restaurants, and shops. Further, preservation of local characteristics through refurbishing the existing building is linked to positive community development impact:

> I think we probably have shown a very good example of how you can revitalize a property, whilst keeping and even enhancing its character. I mean, we get back the authority and character and fill it with content that spill out and is positive for the area.
>
> (N3)

The preservation of the local characteristics was also linked to the community keeping its strong cultural identity.

Moreover, many initiatives in the local community are often partnerships with local non-profit organizations. The local community partnerships strengthen the connection to the community, the shared and public spaces open opportunities for initiatives to take place, reflecting the art in the local community together with the nearby school through the mural. Keeping the strong local cultural identity through the preservation of the building and the selection of tenants in the cultural sector enhances place identity.

3.2.4 Society

A positive impact was found in both public commitment to sustainability issues and technology development. A sustainability report is published by the developer, despite not being required to do so. Sustainability targets are reported and followed up on through this report and other organizational documents. Further, the developer has pledged to comply with the global compact principles and to report on the progress. The turnkey contractor has not published a sustainability report as such; however, material describing their sustainability work has been published. Both the developer and the contractor have training and publications for staff to increase the awareness of social and environmental issues. The developer invests in technology development and transfer and is involved in technology transfer programs and partnerships in research and development, *e.g.* carrying out an LCA in a partnership with a research institute. Further, a partnership with the electricity provider testing new technology was undertaken:

> the goal we had before the project started was to create large-scale collaborations with large industry actors. And then we had another goal that was about trying to decrease the energy use. These two goals together sowed the seed to find something together with a large energy provider.
>
> (N1)

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3.2.5 Value chain actors

A positive impact was found relating to knowledge-sharing, as the policies and actions around transfer of knowledge have been strong both within the project group and externally:

> Then we get everything with us, what we can do for society, environment, sustainability, reuse, is a reoccurring theme at these meetings.
>
> (N2)

Additionally, the stakeholder management in the project is believed to have a positive impact on value chain actors. However, due to the nature of construction projects there can sometimes be insufficient lead time and volume fluctuations which can impact value chain actors negatively. There are, however, good communication lines in place to alleviate pressure. Further, instruments such as contractual clauses are in place to ensure distribution of value among the different actors.

3.2.6 Workers

The status of technical property managers and construction workers is believed to need improvement. Issues relate to, for example, people often having a view of technical property managers as 'simply janitors':

> So, that's discussed a lot, to try and get collaborations with the education institutes to somehow build a foundation that the professional position exists and that there is a pride to it.
>
> (N1)

In both the developer and turnkey contractor organizations training, skills development and transferring lessons learned between workers were considered positive for employees:

> We make each other good [...] we are encouraged to exchange and share knowledge with each other all the time.
>
> (N1)

Further, pride in your work emerged as significantly positive, and was enabled by conserving a heritage building, the aesthetic results, and the environmental sustainability measures which created a strong sense of pride in the project.

3.3 INDICATORS SUGGESTED TO SUPPLEMENT FUTURE S-LCA STUDIES

Six new and two adapted indicators emerged from the data when impact thought to be of importance by the respondents lacked an existing indicator. The new indicators related to the consumer/end-user and worker stakeholder categories. The indicators relating to delocalization are in the original S-LCA framework associated with the local community; however, in the case study the tenant end-users who relocated were considered significant. The knowledge-sharing indicator extracted from Karji *et al.* (2019) relates to value chain actors; however, in the case study, knowledge-sharing between workers within an organization was of significance.

Several indicators from the existing literature, additional to those from the S-LCA framework, were significant, *i.e.* a positive, negative, or mixed impact could be observed. Figure 5 presents the indicators from the existing literature together with the indicators that emerged from the case study data. Combined, these form a list of 40 suggested social sustainability indicators which can supplement the S-LCA indicators in built environment projects. The suggested indicators are predominantly in the end-user and local community stakeholder categories. Four indicators are added to the value chain actors and workers categories, respectively, with none added to the children stakeholder category.

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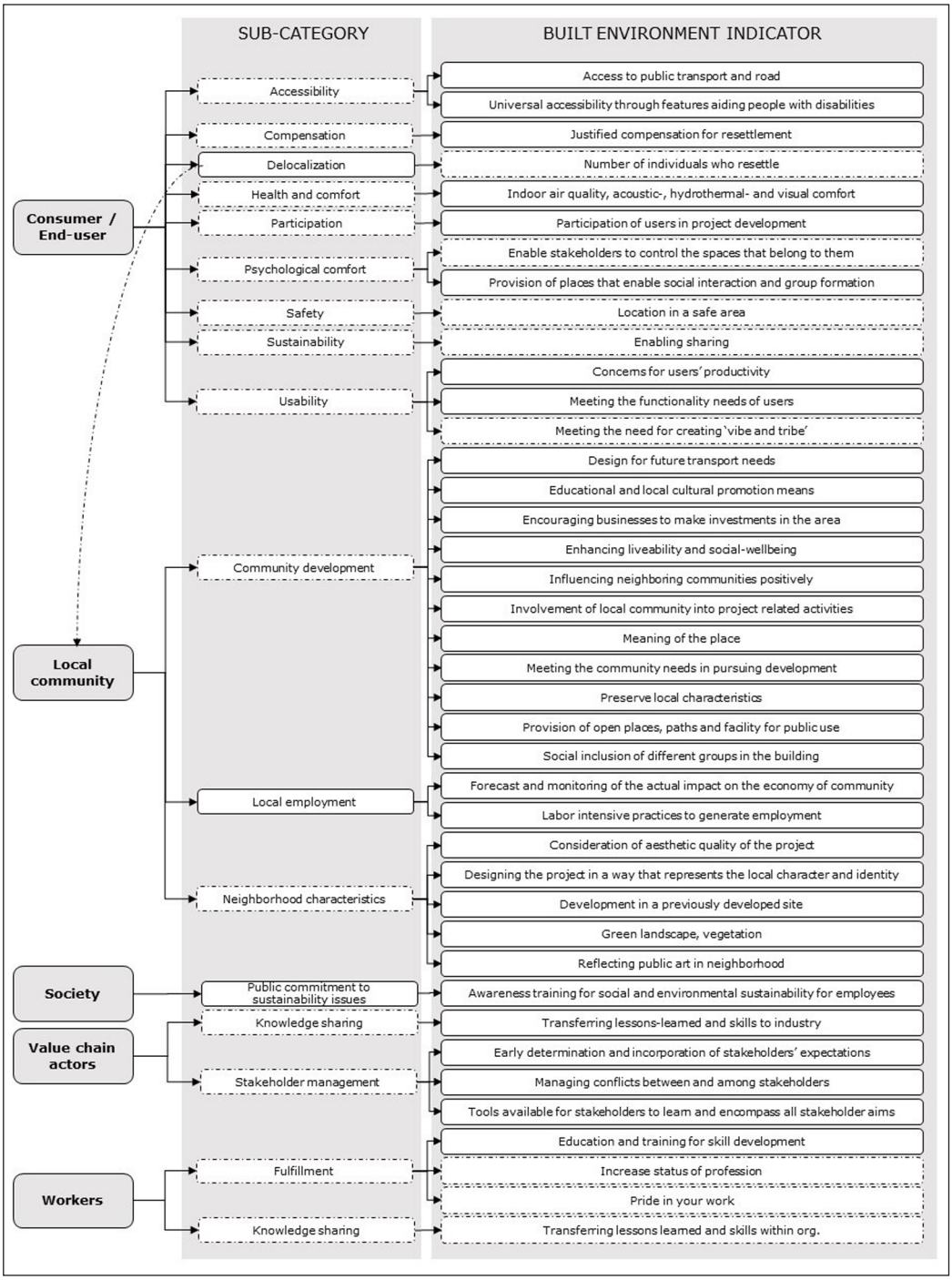

Figure 5: Suggested built environment indicators complementing the social life cycle assessment (S-LCA) framework.

Note: Dashed contours indicate a new subcategory or new/adapted indicator from case data; the dashed line shows the original stakeholder category in the S-LCA framework.

4. DISCUSSION

This study set out to evaluate the social impact of an adaptive reuse case with shared spaces, and additionally to test and adapt the general S-LCA framework to fit in the built environment context. The most significant impact of the case is on the local community in terms of increased economic activity in the area, increased security, and inclusion, with indicators suggested to be added to the S-LCA framework for the built environment relating to community development, local employment, and neighborhood characteristics. The area's deep-rooted cultural identity was considered valuable, and the preservation of the local characteristics affirm this identity. This was further enabled through partnerships with local organizations, which also made it easier to reach a wider community stakeholder base, especially regarding programs aimed at children.

Public shared spaces were believed to contribute to community development, and the more intensive use of space will likely lead to increased activity in the area, which in turn can lead to more activity. Additionally, the importance of sharing emerged for the end-users, both for

environmental sustainability reasons and for usability reasons. On the other hand, Weijs-Perrée *et al.* (2019) found that users of multi-tenant offices are the least satisfied with the personal control over the indoor climate, and this also emerged as a new indicator in the case assessment.

Another indicator that emerged from the data was the need for the space to establish 'vibe and tribe', a concept which Kyrö & Lundgren (2022) describe as a combination of aesthetic experience and social inclusion which conceptualizes the social circular economy in the built environment. This indicator can be considered a combination of several other indicators, *e.g.* vibe can relate to the feeling of a space that one might get from a cultural heritage building, and tribe can be enabled by spaces for social interaction. The concept as a whole was, however, considered significant by end-users and thus warrants having its own dedicated indicator.

A positive impact was observed in terms of public commitment to sustainability issues and technology development, which in the S-LCA methodological sheets is considered to impact society as whole. Sustainability awareness training was also considered beneficial to society by Goel *et al.* (2020) and was added to the built environment indicators. This indicator, together with some of the other society indicators, could, however, be considered to belong to other stakeholder categories. In the instance of this indicator it could belong in the workers stakeholder category. The partnerships in research and development could similarly be considered to impact society as a whole, but also more directly the value chain actors. In this case, an example is the energy provider who is impacted as a value chain actor; however, society might also be impacted as a result of this.

In the case assessment all stakeholder categories from the S-LCA framework (UNEP 2021) were included, as opposed to Liu & Qian (2019) who omitted value chain actors due to the ambiguity of this stakeholder category. According to Mehdikhani & Valmohammadi (2019), the collaboration and knowledge-sharing between value chain actors is imperative to increase the uptake of sustainability measures. The inclusion of value chain actors in the case assessment does show a significant impact. The case study data suggest that both positive and negative impacts can be found in this stakeholder category and no ambiguity was observed. Including the value chain actor stakeholder category in social sustainability assessments can thus provide an insight into impact which would otherwise be omitted from the assessment.

Including an abundance of indicators in assessments can slow the uptake of the framework as it can be considered too onerous. However, not including indicators that can show a positive impact could also discourage the use of a framework. Comparability between studies needs to improve as currently different selection of indicators, coupled with different weightings applied, means fragmentation is unavoidable. The S-LCA indicators functioning as inspiration rather than a complete set of indicators does present the risk of preferential selection of indicators by organizations and difficulties when comparing assessment results. Therefore, a consensus is required regarding which indicators should be included. Considering the vast number of indicators that serve as inspiration, and an expectation of expanding the list with industry-specific indicators (UNEP 2021), there might be a real need for agreed reduced scope assessments to increase the uptake of the S-LCA framework and to ensure comparability between assessment results.

4.1 EVALUATION AND IMPLICATIONS

The S-LCA framework was used and adapted to evaluate the social sustainability of an adaptive reuse case. The indicators suggested to supplement the S-LCA methodological sheets are specific to such cases. This can provide a useful tool for evaluating similar cases. The transferability of the findings is limited, as an extreme case was sought to gain rich data. Some indicators appear to be relevant in general built environment contexts; however, many will be significant only in specific contexts and geographical locations.

Although further indicators could have been included from the existing literature, too many indicators would become unmanageable in an assessment. Some indicators may have been overlooked, and this could in turn lead to impacts being neglected.

The selected indicators from existing studies have varying assessment methodology, with some having both quantitative and qualitative scales and some being systems for points sampling. All indicators from the S-LCA and existing literature, regardless of the original assessment methodology, were assessed on a generic ascending reference scale, as suggested in the S-LCA guidelines. This might distort the assessed impact of the indicator as intended in the original study or framework. However, the inclusion of such indicators increases the breadth of the assessment to a larger extent than if they are to be excluded.

Weighting the indicators has not been undertaken in this study as further research is required to first form a consensus on which indicators to include for built environment assessments if S-LCA assessment results are to be comparable between studies and benefit from weighting. Note: the assessment is of the intended impact, not the actual impact of the project, which is too early to assess. A future study comparing the intended and actual impact would be valuable as many S-LCA studies only assess the intended impact. Without knowing the gap between intention and outcome, it is difficult to say how worthwhile are front-end S-LCA studies.

Despite the limitations, the findings will still be valuable to researchers and industry professionals in evaluating or comparing the social impact of a construction, demolition, adaptation, or refurbishment project. The S-LCA framework has been further developed to better consider the context of the built environment. Planners, designers, and clients can employ the revised framework to evaluate projects pre- and post-construction or demolition. The impact assessment of the case study can generate ideas for creating social impact though future initiatives and projects in the built environment.

5. CONCLUSIONS AND RECOMMENDATIONS

The case study assessment revealed a significant positive social impact, especially to the local community and the end-users. Most of the impact relates to the adaptive reuse of existing buildings and shared spaces. Much of the positive social impact would be lost in the case of a demolition and new-build. A minor refurbishment without the added shared spaces would likewise lose most of the social impact. However, further comparative case studies of alternative built environment projects, such as demolition, new-build, and refurbishment without adaptive reuse, are needed.

The social life cycle assessment (S-LCA) framework, supplemented with indicators specific to the built environment, was found to be a useful tool to assess social impact, and could therefore be worthwhile in other built environment assessments. The generic assessment of subcategories provided an initial hotspot assessment that removed several site-specific indicators from consideration. The guidelines highlight the possibility of missing site-specific impacts if they are not picked up in the generic assessment. In the case assessment, only those very unlikely to be significant were therefore removed from further consideration. In the assessment of the site-specific indicators, an impact was found where the generic assessment did not. It is recommended that future assessments take a similar approach to not overlook site-specific significant issues and avoid a selection bias by organizations.

Considering the significant impact found through both the case study and the case data, these indicators can supplement the S-LCA framework when conducting assessments in the built environment. However, further assessments are required to establish whether these impacts are commonly occurring in building development projects in general, and adaptive reuse projects with shared spaces specifically. Future research should be focused on further developing the S-LCA framework and extending the applicability in the built environment by applying the framework to other types of building development projects.

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COMPETING INTERESTS

The author has no competing interest to declare.

DATA AVAILABILITY

The author confirms that a summary of the data supporting the findings of this study are available within the article and its supplementary materials.

ETHICAL APPROVAL

Informed consent to participate in the study was obtained from all respondents.

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SUPPLEMENTAL DATA

Supplemental data for this article can be access at: https://doi.org/10.5334/bc.314.s1. Appendix A: List of indicators from the existing literature. Appendix B: List of interviews and documents. Appendix C: List of indicators removed in generic assessment. Appendix D: Indicator ratings for case study.

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