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Adaptive reuse and shared spaces as circular business models

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TECHNOLOGY AND SOCIETY | FACULTY OF ENGINEERING | LUND UNIVERSITY

Adaptive reuse and shared spaces as circular business models

Adaptive reuse and shared spaces as circular business models

Rebecka Lundgren

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DOCTORAL DISSERTATION

Doctoral dissertation for the degree of Doctor of Philosophy (PhD) at the Faculty of Engineering at Lund University to be publicly defended on 7th of November at 13.00 in Room E1406, Department of Technology and Society, Ole Römers väg 3D, Lund.

Faculty opponent
Tove Malmqvist, Associate Professor, KTH Royal Institute of Technology

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Abstract:

Circular economy (CE) is still a nascent research field in the built environment, however, has gained traction in the last decade. Despite it being generally accepted that sustainability consists of three dimensions, namely, social, environmental, and economic, CE has been criticised for focusing on environmental and economic impact whilst neglecting the social aspect. Further, CE has been criticised for focusing on less efficient business models in terms of value retention, such as recycling. More efficient measures reduce demand and keep resources in use with less energy required, e.g., through repairing and refurbishing existing products. In the built environment two high efficiency CE business models are shared spaces and adaptive reuse. Shared spaces reduce the need for space, whilst adaptive reuse keep resources tied into the existing building stock in use. Further to environmental sustainability, these measures have also been linked to economic and social sustainability. This dissertation aims to steer focus beyond less efficient measures towards more efficient CE business models. Additionally, by including economic, environmental, and social sustainability the intent is to provide more balance within the CE concept in the built environment and insights on sustainability impacts. Adaptive reuse and shared spaces were chosen as foci CE business models as they represent efficient measures which have been connected to all three sustainability dimensions. The dissertation comprises a compilation of studies of quantitative, qualitative, and mixed method. The overarching methodology of the dissertation is thus mixed method. All appended papers and the studies employ a case study approach as a phenomenon was to be explored in a real-life context. The study concludes that incorporating shared spaces in adaptive reuse projects contributes positively to all three sustainability dimensions, predominantly through the creation of the so called ‘vibe’ and ‘tribe’. Additionally, adaptive reuse with major renovation and shared spaces was shown to be superior to a minor renovation without shared spaces in terms of value capture to the real estate development organisation. However, the major renovation had a larger absolute and per m^2 environmental impact, yet, when considering per person emissions the inverted was true, indicating trade-offs between different functional units. Further, the study finds that existing frameworks can with favour be used to evaluate CE business models in the built environment. Two main considerations have been put forward in this dissertation in order to improve life cycle assessments of CE business models in the built environment, namely additional functional units capturing space efficiency and social indicators specific to the built environment context. Further, this dissertation has contributed with advancing the characterisation of shared spaces and conceptualisation of social CE within the continuously developing field of CE in built environment. Findings are of interest to researchers as well as industry practitioners who aspire to improve sustainability in all three dimensions in projects in the built environment. Additionally, the assessment evaluations are useful for anyone wishing to conduct a life cycle assessment in the built environment. For the practitioners, the findings from the assessments provide awareness of how different CE business models impact the different sustainability dimensions.

Key words: Circular economy, shared spaces, adaptive reuse, sustainability, built environment

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Adaptive reuse and shared spaces as circular business models

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MADE IN SWEDEN

To my family.

Acknowledgements

"I have never tried that before, so I think
I should definitely be able to do that."

-Pippi Longstocking

I have always believed I can do anything I put my mind to, thanks to having people around me instilling that belief in me. I have however never believed I could do it all on my own, and I think that is clearer to me now, after this PhD journey, than ever.

I don't think I will ever be able to repay my mother for what she has done for me during this journey. Being my biggest supporter and making me believe in myself is something I am very grateful for, but also the physical support of helping me look after my son, Wilder, has given me the opportunity to travel to conferences and to do exchanges at other universities which otherwise would not have been possible. The rest of my wonderful family and friends have also supported me throughout with encouraging words such as *"I don't understand anything you have written"* spoken by my best friend, and the inspiring words of my brother; *"you research and research but you never get to the point"*. Well, hopefully, I have at least gotten to some kind of a point now. Having my family and friends around me has, despite (or because) of the sarcastic comments, kept me happy and engaged in my work, and life in general. I have tremendous love for you all, and I thank you for always being there for me, no matter what crazy antics I get up to.

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Cheers for all the laughs.

Rebecka Lundgren

Table of Contents

Abstract

Circular economy (CE) is still a nascent research field in the built environment, however, has gained traction in the last decade. Despite it being generally accepted that sustainability consists of three dimensions, namely, social, environmental, and economic, CE has been criticised for focusing on environmental and economic impact whilst neglecting the social aspect. Further, CE has been criticised for focusing on less efficient business models in terms of value retention, such as recycling. More efficient measures reduce demand and keep resources in use with less energy required, e.g., through repairing and refurbishing existing products. In the built environment two high efficiency CE business models are shared spaces and adaptive reuse. Shared spaces reduce the need for space, whilst adaptive reuse keep resources tied into the existing building stock in use. Further to environmental sustainability, these measures have also been linked to economic and social sustainability.

This dissertation aims to steer focus beyond less efficient measures towards more efficient CE business models. Additionally, by including economic, environmental, and social sustainability the intent is to provide more balance within the CE concept in the built environment and insights on sustainability impacts. Adaptive reuse and shared spaces were chosen as foci CE business models as they represent efficient measures which have been connected to all three sustainability dimensions. The dissertation comprises a compilation of studies of quantitative, qualitative, and mixed method. The overarching methodology of the dissertation is thus mixed method. All appended papers and the studies employ a case study approach as a phenomenon was to be explored in a real-life context.

The study concludes that incorporating shared spaces in adaptive reuse projects contributes positively to all three sustainability dimensions, predominantly through the creation of the so called ‘vibe’ and ‘tribe’. Additionally, adaptive reuse with major renovation and shared spaces was shown to be superior to a minor renovation without shared spaces in terms of value capture to the real estate development organisation. However, the major renovation had a larger absolute and per m^2 environmental impact, yet, when considering per person emissions the inverted was true, indicating trade-offs between different functional units. Further, the study finds that existing frameworks can with favour be used to evaluate CE business models in the built environment. Two main considerations have been put forward in this dissertation in order to improve life cycle assessments of CE business models in the built environment, namely additional functional units capturing space efficiency and social indicators specific to the built environment context. Further, this dissertation has contributed with advancing the characterisation of shared spaces and conceptualisation of social CE within the continuously developing field of CE in built environment.

Findings are of interest to researchers as well as industry practitioners who aspire to improve sustainability in all three dimensions in projects in the built environment. Additionally, the assessment evaluations are useful for anyone wishing to conduct a life cycle assessment in the built environment. For the practitioners, the findings from the assessments provide awareness of how different CE business models impact the different sustainability dimensions.

Populärvetenskaplig sammanfattning

Cirkulär ekonomi är ett framväxande hållbarhetskoncept inom fastighets- och byggsektorn. Typiskt sett anses hållbarhet bestå av tre dimensioner; sociala, miljömässiga och ekonomiska. Men i cirkulär ekonomi har fokus ofta legat på miljömässig och ekonomisk hållbarhet, medan social hållbarhet har försummats. Cirkulära affärsmodeller har varierande grad av effektivitet, där högeffektiva åtgärder kräver små eller inga utsläpp för att hålla material i cirkulation. Ett exempel på en lågeffektiv åtgärd är återvinning på grund av den höga energiförbrukning som krävs i processen. Högeffektiva åtgärder inkluderar de som minskar efterfrågan, såsom delning och renovering. Två cirkulära affärsmodeller relaterade till byggnader är delade ytor och adaptiv återanvändning. Delade ytor minskar behovet av utrymme genom att utnyttja det mer effektivt. Adaptiv återanvändning förlänger livslängden på befintliga byggnader och ger dem ett nytt användningsområde. Både delade ytor och adaptiv återanvändning har kopplats till alla tre hållbarhetsdimensionerna.

Denna avhandling fokuserar på kombinationen av adaptiv återanvändning och delade ytor och fann en positiv hållbarhetseffekt, främst genom skapandet av den så kallade "vibe" och "tribe". Där ”vibe” utgörs av byggnads estetik och kreativt innehåll, och ”tribe” innefattar engagemang i närsamhället och tillgänglighet, såsom delade ytor och hybridlösningar. Negativ miljöpåverkan vid adaptiv återanvändning minskar genom att spara mycket av byggnadsstrukturen, som brukar ha störst påverkan. Förutom positiv social påverkan på användare av adaptiva återanvändningsbyggnader med delade ytor, fanns också betydande positiva effekter för det lokala samhället. Vissa sociala hållbarhetsindikatorer som påverkar lokalsamhället har också starka band till den ekonomiska dimensionen, såsom ekonomisk utveckling och sysselsättning. Adaptiv återanvändning i kombination med delade ytor har därmed en positiv inverkan på alla hållbarhetsdimensioner.

Vidare fann studierna i avhandlingen också att befintliga ramverk och koncept kan användas för att både karakterisera och utvärdera cirkulära affärsmodeller i den byggda miljön, men vissa kräver viss anpassning för att vara lämpliga inom området. Resultaten av de tillämpade ramverken visade att för att optimera den miljömässiga hållbarhetseffekten av adaptiv återanvändning måste hänsyn tas till avvägningarna mellan utsläpp i produkt- och användningsfasen som har ett komplext samband som ytterligare kompliceras av hur resultaten presenteras. Användning av de funktionella enheterna utsläpp per m^2 och per person gav olika optimala alternativ i bedömningarna då den m^2 funktionella enheten inte svarade för den ökade utrymmeseffektiviteten som krävde mer totala utsläpp. Detta understryker behovet av att ta hänsyn till komplexitet och avvägningar i miljökonsekvensbedömningar.

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List of Papers

Paper I

Lundgren, R., Kyrö, R. and Jylhä, T. Access-Based Consumption in the Built Environment: Sharing Spaces. *Sustainability 2022, 14, 5550.* https://doi.org/10.3390/su14095550

Paper II

Kyrö, R. and Lundgren, R. Your vibe attracts your tribe – the adaptive reuse of buildings delivering aesthetic experience and social inclusion. *2022 IOP Conf. Ser.: Earth Environ. Sci.* https://doi.org/10.1088/1755-1315/1101/6/062014

Paper III

Lundgren, R., Kyrö, R. and Olander, S. Adapting for shared use – evaluating the life cycle carbon impact. *2023 IOP Conf. Ser.: Earth Environ. Sci. 1196 012038*. https://doi.org/10.1088/1755-1315/1196/1/012038

Paper IV

Lundgren, R. (2023). Social life cycle assessment of adaptive reuse. *Buildings and Cities, 4(1), pp. 334–351.* https://doi.org/10.5334/bc.314

Paper V

Lundgren, R., Kyrö, R. and Olander, S. (forthcoming). The life cycle impact and value capture of circular business models in the built environment.

Author's contribution to the Papers

Paper I

Lundgren and Kyrö initiated the paper. Lundgren and Kyrö conceptualised the paper. Lundgren, Kyrö and Jylhä conducted the data curation and analysis. Lundgren and Kyrö wrote the original draft. Lundgren created the visualisations. Lundgren, Kyrö and Jylhä reviewed and edited the final version of the manuscript.

Paper II

Lundgren and Kyrö initiated the paper. Lundgren and Kyrö conceptualised the paper and conducted the data curation and analysis. Kyrö wrote the original draft. Lundgren created the visualisations. Lundgren and Kyrö reviewed and edited the final version of the manuscript.

Paper III

Lundgren initiated the paper. Lundgren and Kyrö conceptualised the paper. Lundgren conducted the data curation. Lundgren, Kyrö and Olander conducted data analysis. Lundgren wrote the original draft. Lundgren, Kyrö and Olander reviewed and edited the final version of the manuscript.

Paper IV

Lundgren is the sole author.

Paper V

Lundgren and Kyrö initiated the paper. Lundgren, Kyrö and Olander conceptualised the paper. Lundgren, Kyrö and Olander conducted the data curation and analysis. Lundgren wrote the original draft. Lundgren, Kyrö and Olander reviewed and edited the final version of the manuscript.

Abbreviations

AHP	Analytic hierarchy process
CE	Circular economy
EC	European Commission
EU	European Union
LCA	Life cycle assessment
LCC	Life cycle cost assessment
LCP	Life cycle profit assessment
NPV	Net present value
S-LCA	Social life cycle assessment
SDGs	Sustainable Development Goals

1.Introduction

Climate change, primarily through greenhouse gas emissions, is causing increasing weather and climate extremes all around the world (IPCC 2023). The emissions continue to rise, and it is likely that global warming will exceed the target of 1.5℃ during this century, reducing the possibility of keeping the limit below the 2℃ critical point (IPCC 2023). The real estate and construction sector is a major contributor to climate change (Krausmann et al. 2017). An estimated 50% of all extracted material is in the built environment (European Commission 2020) and the sector accounts for 25-40% of global carbon dioxide emissions (World Economic Forum 2016), as well as over 35% of the EU's total waste generation (European Commission 2020). However, IPCC (2023) present a reduction potential of 66% of emissions from buildings, suggesting there is a possibility for the real estate and construction industry to significantly contribute to meeting the global warming target of 1.5℃.

The *'2030 Agenda for Sustainable Development',* and its 17 related Sustainable Development Goals (SDGs), were agreed and approved by the United Nation General Assembly in 2015 (United Nations General Assembly 2015). *SDG 11 Sustainable Cities and Communities* relates to making cities and other settlements inclusive, safe, resilient, and sustainable (United Nations General Assembly 2015). Filho et al. (2020) suggests there is a need to test and implement measures in order to reach the targets of *SDG11*.

At a European level the European Union (EU) has created an initiative which connects the European Green Deal to the built environment, namely the New European Bauhaus (European Union 2021). The initiative foci are environmental sustainability, inclusiveness, and aesthetics and quality of experience (European Union 2021). Further, the European Commission (EC) has focused much of sustainability efforts around CE, with the release of several reports in recent times, such as Roadmap to a Resource Efficient Europe (2011), EU Resource Efficiency Scoreboard (2014), Closing the Loop – An EU Action plan for the Circular Economy (2015), and A New Circular Economy Action Plan (2020).

CE aims to close or slow material loops (Ellen MacArthur Foundation 2013), meaning that less material should enter circulation and the material in circulation should stay in circulation for as long as it is viable. This enables a consumption model which decouples economic growth from resource consumption (Reike et al.

2018). Ellen MacArthur Foundation presents six action areas for moving towards a circular economy in the RESOLVE framework (Ellen MacArthur Foundation 2015b). The six action areas are regenerate, share, optimise, loop, virtualise, and exchange. Regeneration includes actions such as renewable energy, ecosystems, and returning biological resources to the biosphere. Sharing includes sharing assets, but also reusing and prolonging life of assets through maintenance and designing for durability. Optimising increases performance and efficiency, removes waste, and can leverage digitalisation. Looping includes actions such as remanufacturing and recycling, whilst virtualising dematerialises assets either directly, e.g., online banking, or indirectly, e.g., online shopping. Exchanging involves e.g., applying new technology (Ellen MacArthur Foundation 2015b).

The CE concept has a strong focus on value proposition (Ellen MacArthur Foundation 2013). General business models can be split into three sub-concepts, namely, value proposition, value creation and delivery, and value capture (Bocken et al. 2014). Value proposition concerns the product or service, as well as the customer segments and relationships. Value creation and delivery are the key activities, resources, channels, partners, and technology of the business model, whilst the value capture relates to cost structure and revenue streams (Bocken et al. 2014). CE business models incorporate CE principles into the value propositions (Manninen et al. 2018).

CE measures are frequently described in hierarchies of resource value retention potential relating solely to '*the conservation of resources closest to their original state*', as described by Reike et al. (2018, p.254). The hierarchies are often depicted as so-called R-imperatives, of which a common is the three Rs, namely, reduce, reuse, and recycle. Reike et al. (2018) however suggest 10 R-imperatives and group the CE measures in terms of loops size, where the shorter the loop the more effective it is in terms of value retention. According to Reike et al. (2018) the CE business models with the shortest loops should be prioritised.

CE in the built environment is still a nascent research field, however has gained traction in the last decade (e.g., Pomponi & Moncaster, 2017; Leising et al., 2018; Ness & Xing, 2017; Sanchez & Haas, 2018; Kyrö et al., 2019; Eberhardt et al. 2019b; Domenech & Bahn-Walkowiak, 2019; Kyrö, 2020; Dytianquin et al., 2021; Cruz Rios et al., 2021; Lange, 2022). Arup (2016) adapts the RESOLVE framework by Ellen MacArthur Foundation (2015b) to the built environment context, and Kyrö (2020) further adapts it to existing buildings and the individual building level. The action areas suggested by Kyrö (2020) are preserve, adapt, share, and rethink. Preservation includes maintenance, repair, and minor refurbishment. Adapt comprises adaptive reuse, open building, and flexible building. Sharing involves sharing spaces and co-location synergies. Finally, rethink could include relocatable leased modules and replaceable parts as a service (Kyrö 2020).

Sharing is mentioned as an action item in both the RESOLVE framework by Ellen MacArthur Foundation (2015b) and the adapted framework by Kyrö (2020), as well as being a short loop measure in the R-imperative hierarchy by Reike et al. (2018). In the built environment sharing can take the form of shared spaces and access-based consumption (e.g., Kyrö, 2020; Brinkø et al., 2015). Other short loop measures in the built environment are digitalisation (e.g., Antikainen et al., 2018; Agrawal et al., 2022), as well as repair according to the general hierarchy presented by Reike et al. (2018). Medium loops optimise existing buildings through e.g., refurbishment and adaptive reuse, whilst recycling and measures relating to new construction are typical long loop measures (Lundgren et al. 2023).

It is generally accepted that sustainability consists of three dimensions, namely social, environmental, and economic (e.g., The World Commission on Environment and Development 1987). The three dimensions are at times of competing interests (Bañon Gomis et al. 2011; Fischer et al. 2020). Bañon Gomis et al. (2011) argue that the conflicts between the dimensions are caused by different groups inserting their own interests in the discussion and thus the conflict can, and should, be resolved through ethical considerations. In business, Fischer et al. (2020) suggest stakeholder expectations complicate the relationship between the sustainability dimensions as the dimensions are reprioritised based on stakeholder interests.

Sustainable development is concerned with inter-generational equity, i.e., meeting the needs of people today and in the future, and intra-generational equity, i.e., meeting the needs between people in the same generation (Murray et al. 2017). The renewal and survival of ecology inherent in CE will benefit both these equity concerns (Murray et al. 2017). However, despite a strong link to sustainable development (Ghisellini et al. 2016; Murray et al. 2017) CE has been criticised for excluding social sustainability, instead focusing on the environmental and economic dimensions (e.g., Kirchherr et al. 2017; Murray et al. 2017; Reike et al. 2018; Padilla-Rivera et al. 2020a). Kirchherr et al. (2017) analysed 114 definitions of CE and found the aim of CE firstly to be economic prosperity, followed by environmental sustainability, however, the definitions rarely included mention of the social dimension. Further, Padilla-Rivera et al. (2020) find that there has been a lack of consideration of the social dimension in CE, but also find this dimension to be of importance to provide an overview of how CE business models impact society.

Even though awareness of the CE concept is increasing in the built environment industries, adoption of CE business models is still slow and fragmented (Malabi Eberhardt et al. 2022). Malabi Eberhardt et al. (2022) suggest the slow and fragmented uptake is due to lack of knowledge regarding the environmental impact and related benefits. This can be alleviated by improving impact assessments which can help prioritise the implementation of CE business models (Malabi Eberhardt et al. 2022).

Existing evaluations of CE initiatives were often carried out utilising a life cycle assessment (e.g., Nasir et al. 2017; Deschamps et al. 2018; Eberhardt et al. 2019a; Minunno et al. 2020; Fufa et al. 2021). Nonetheless, there is no life cycle framework specific for the evaluation of CE (Hossain et al. 2020). Manninen et al. (2018) present a framework for evaluating the environmental value propositions of CE business models, where the life cycle assessment (LCA) is suggested as a possible imbedded method. The LCA is also the most common environmental evaluation method in the built environment (Ghisellini et al. 2018), however variations in scope and system boundaries (Pomponi and Moncaster 2016), as well as application of different tools makes comparisons difficult (Peuportier et al. 2004; Azevedo et al. 2011; Bueno and Fabricio 2018).

Another common life cycle assessment in the built environment is the life cycle cost assessment (LCC) (Larsen et al. 2022), however as opposed to the life cycle profit assessment (LCP) this does not account for generated income (Bejrum 1991). Several assessment methods have been employed for social sustainability in the built environment (e.g., Goel et al., 2020; Liu & Qian, 2019; Zuo et al., 2012). Social sustainability is often assessed mainly in terms of employment (Padilla-Rivera et al. 2020; Mies and Gold 2021; Walker et al. 2021), arguably also connected to economic sustainability. A social life cycle assessment (S-LCA) framework with a broader scope exists (UNEP 2020) and has previously been employed in built environment assessments (e.g., Liu & Qian, 2019). However, uptake of evaluating CE initiatives with the S-LCA framework has been slow (Padilla-Rivera et al. 2020).

CE research in the built environment has to date had a strong focus on new construction and recycling (Pomponi and Moncaster 2016; Eberhardt et al. 2019b; Cruz Rios et al. 2021) which goes against the basic waste hierarchy (Kyrö 2020). This has also been the case in general CE research and the concept has therefore received criticism (Ranta et al. 2018). The focus on recycling is seen as less challenging on a general policy level than aiming at input focused measures such as decreasing demand (Domenech and Bahn-Walkowiak 2019). This could provide insight as to why there has been a lack of focus on more efficient measures at a policy level as found by Lundgren et al. (2023) in a review of CE policies in the Nordic real estate and construction industry.

Conceptually, in terms of CE hierarchies such as loops and R-imperatives, reducing demand, reusing, and repurposing are efficient measures (e.g., Ellen MacArthur Foundation 2015b; Reike et al. 2018). Sharing space can, according to a Swedish industry report, reduce the climate impact with up to 70% (IVL Svenska Miljöinstitutet 2019) as increased utilisation decreases the overall demand for space (Ness and Xing 2017). Whilst CE is often focused on the economic and environmental dimension of sustainability, the sharing economy is instead often linked with the social dimension (Henry et al. 2021). Much of the existing research on shared spaces also relate to social effects (e.g., Spinuzzi 2012; Brown 2017;

Jakonen et al. 2017; Waters-Lynch and Potts 2017; Orel and Alonso Almeida 2019).

Adaptive reuse, another built environment CE business model, is the process of extending a building's life and giving it a new use (Yung and Chan 2012b) and is thus a medium loop measure (Foster 2020). Adaptive reuse saves much of the embodied carbon (Ness and Xing 2017) which make up a significant proportion of a building's total life cycle emissions (Ibn-Mohammed et al. 2013). Similar to shared spaces, the social dimension has been highlighted in adaptive reuse research (e.g., Power 2008; Yung and Chan 2012a; Çimen 2021). However, in the case of adaptive reuse the environmental impact has also been explored (e.g., Munarim and Ghisi 2016; Assefa and Ambler 2017; Fufa et al. 2021), at times including the economic impact (e.g., Sanchez et al. 2019). Cultural heritage preservation was only recently linked with CE (Huuhka and Vestergaard 2020), however has previously been discussed in relation to both space utilisation (e.g., Lentini & Decortis, 2010) and adaptive reuse (e.g., Yung and Chan 2012a; Munarim and Ghisi 2016). Studies of the two CE business models of sharing and adaptive reuse in combination has received limited attention. Similarly, a holistic perspective of the three sustainability dimensions is lacking.

The aim of the research presented in this dissertation is three-fold. Firstly, it aims to steer focus beyond new build and recycling towards more efficient CE business models, namely, adaptive reuse and shared spaces in the context of workspaces. Secondly, by including economic, environmental, and social sustainability the intent is to provide more balance within the CE concept in the built environment. This is done through case studies where the CE business models of sharing and adaptive reuse are being tested and implemented, using mixed methods. Lastly, the assessments carried out in the case studies aim to provide insights to enhance the methods of sustainability assessments of CE business models in the built environment.

1.1. Research aim

CE implementation in the built environment is fragmented and slow (Çimen 2021). Focus in CE has been on less effective, long loop, measures (Ranta et al. 2018), without a holistic perspective of the three sustainability dimensions (Henry et al. 2021). **The overall aim of the research presented in this dissertation is therefore to provide insights of how small and medium loop CE business models in the built environment can be assessed to include all three sustainability dimensions and optimise value proposition.** The focus is on two CE business models, namely, adaptive reuse and shared spaces. These business models have shown to have significant impact on all three dimensions (Power

2008; Yung and Chan 2012a; Conejos et al. 2015; IVL Svenska Miljöinstitutet 2019; Baker et al. 2021; Çimen 2021) and are short and medium loop measures, as opposed to long loop according to the R-imperatives presented by Reike et al. (2018).

The research in the dissertation focuses on the workplace context. A workplace is in this dissertation defined as a space where people work, however can also have other functions connected to the workspaces, e.g., courtyards, cafés, restaurants, and galleries. The workspaces themselves are in this dissertation limited to office spaces and cultural sector studios.

The research aim is divided into three research questions which are closely linked. The first research question relates to the characterisation of the CE business models of adaptive reuse and shared space in the built environment and reads as follows:

RQ1: What are the characteristics of adaptive reuse and sharing?

The first research question is discussed in Papers I and II. Paper I identifies the characteristics of shared spaces by adapting an existing access-based consumption framework to the spatial context. Paper II conceptualises social CE and identifies several characteristics of adaptive reuse and sharing spaces.

The second research question addresses the assessment of CE business models, as follows:

RQ2: How should the sustainability impact of adaptive reuse and shared spaces be assessed?

Paper III evaluates different LCA tools applied to an adaptive reuse case and suggests issues and possibilities from the employed methods. The environmental impact assessed through an LCA in Paper III relates to energy consumption and greenhouse gas in the production and use stages. Further, Paper IV employs an S-LCA framework and provides improvement suggestions for the framework to better suit assessments in the built environment. Paper V assesses the environmental and economic impact in the production and use stages through several methods, including LCA and LCP, however, the paper focuses less on the assessment method and more on the impact. Papers III-V together provides insights of how all three dimensions of sustainability could be assessed for the CE business models of adaptive reuse and sharing.

The final research question addresses the optimisation of CE business models in relation to all three sustainability dimensions, and reads:

RQ3: How do we optimise the value capture from adaptive reuse projects?

Finally, Paper V compares two adaptive reuse options to find the optimal solution defined through value propositions. Paper V employs several impact assessments, namely, vacancy rate, space efficiency, circular activities, waste generation, energy, and greenhouse gas emissions, as well as the economic impact of the investment options, which give insight into the relationship between impacts and how adaptive reuse can be optimised. Additionally, findings from Papers III and IV provide some insight into how value proposition and capture can be optimised in terms of environmental and social impact, respectively, in adaptive reuse cases.

A summary of the appended papers and their main relation to the research questions is presented in Table 1.

Table 1. Summary of papers and their main relation to the research questions.

	Paper I	Paper II	Paper III	Paper IV	Paper V
Title	*Access-based consumption in the built environment: sharing spaces*	*Your vibe attracts your tribe – the adaptive reuse of buildings delivering aesthetic experience and social inclusion*	*Adapting for shared use – evaluating the life cycle carbon impact*	*Social life cycle assessment of adaptive reuse*	*The life cycle impact and value capture of circular business models in the built environment*
Addresses	RQ1	RQ1	RQ2 (Partially RQ3)	RQ2 (Partially RQ3)	RQ3 (Partially RQ2)

1.2. Research process

This dissertation is a compilation of five research papers (I-V), peer-reviewed and published in scientific journals and conference proceedings. Four of the papers are collaborations with other researchers, whilst Paper IV is produced solely by the dissertation author. The contribution of the author to the appended papers is outlined in the beginning of the dissertation on Page 17. The research process took place between spring 2021 and autumn 2023.

The research process commenced in the spring of 2021 with data gathering. However, due to the Covid-19 situation most data collection in the following months was carried out online through online interviews, electronic document reviews, and reviews of websites and social media. Later the same year it was possible to carry out the first site visits. The data gathered throughout 2021 was the main data sets used for Papers I-III and V. Papers I and II were published in the first and second half of 2022, respectively. Supplementary data was collected

for Papers III and V during 2022. The data collected for Papers I-III and V acted as supplementary data to Paper IV, with the main data sets collected at the end of 2022. At the autumn of 2022 a second site visit was also undertaken which contributed to Papers III-V. Paper IV was published in the first half of 2023, Paper III was published in the second half of 2023, and paper V is in a review process.

The research process for Papers I and II started at the same time. Paper I views CE in the built environment from the perspective of an existing access-based consumption framework. The rich data emerging from the dataset collected for Paper I relating to social sustainability resulted in Paper II being produced which focused on the conceptualisation of social CE in the built environment. Paper IV was initiated as a result of the social dimension highlighted in Paper II. When designing the study for Paper II it was evident from previous research that there was a need to consider how social sustainability is measured in circular initiatives in the built environment. Paper III emerged through the discovery of varying outputs from different life cycle analysis tools highlighting the need to consider how the environmental impact of circular initiatives in the built environment should be assessed. Finally, Paper V compares two options for adaptive reuse, incorporating economic aspects in addition to the environmental and social dimensions and introduces the business model value proposition perspective. Figure 1 presents an overview of the research process flow.

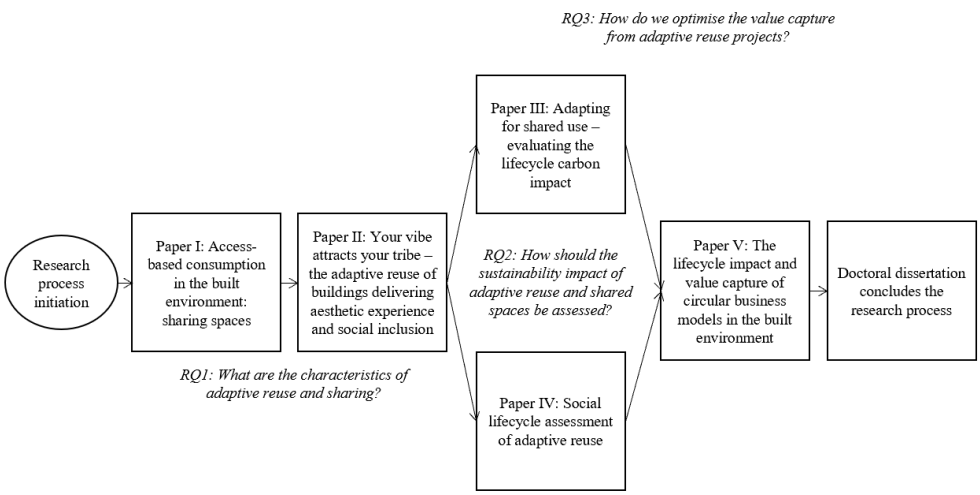

Figure 1. Research process flow.

1.3. Structure of dissertation

The dissertation includes this summary and five appended papers, referred to with roman numerals I-V indicating their chronological order as well as their place in the research process. The summary is divided into six sections. The first section provides an introduction, as well as the research aim and research process. The following Section 2 presents the theoretical concepts employed in this dissertation. Section 3 presents the research design, including research philosophy, methodology, strategy, and methods. Section 4 provides a summary of the appended papers with their main findings relating to this dissertation. The findings, contribution and evaluation of the dissertation are discussed in Section 5. The final section concludes the dissertation and presents future research needs together with some final remarks.

2. Theoretical concepts

Several existing concepts and frameworks were employed in the studies comprised in this dissertation and are presented in the following sub-sections.

2.1.1. Circular Economy

CE is a sustainability concept which has been around since the late 1970s (Geissdoerfer et al. 2017) and has received increasing attention from policy makers, the research community, and industry in the last 15 years (Reike et al. 2018). CE shares a history with Industrial Ecology, however in the 1970s economic growth was incorporated into the environmental management aspect in CE (Murray et al. 2017). The CE concept changes the previous material and product flow of make, use, and dispose to a circular alternative (Korhonen et al. 2018; Reike et al. 2018; Munaro et al. 2020), where material and products which enter into circulation are firstly reduced, and secondly, those materials which do enter are kept in circulation whilst value is retained (Ellen MacArthur Foundation 2013).

There are several differing CE definitions. Kirchherr et al. (2017) reviewed 114 CE definitions to establish a coherent definition. In this dissertation the definition presented by Kirchherr et al. (2017, p.224) is employed, namely, *'A circular economy describes an economic system that is based on business models which replace the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes, thus operating at the micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation and beyond), with the aim to accomplish sustainable development, which implies creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations'.*

There are several ways in which CE measures are organised, however, both the Ellen MacArthur Foundation (2013) and Reike et al. (2018) choose loop sizes to portray the value retention of these measures and business models. In both cases shorter loops are more effective in their value retention than longer loops. Figure 2 presents the loops by Reike et al. (2018) developed through a literature review of existing CE research.

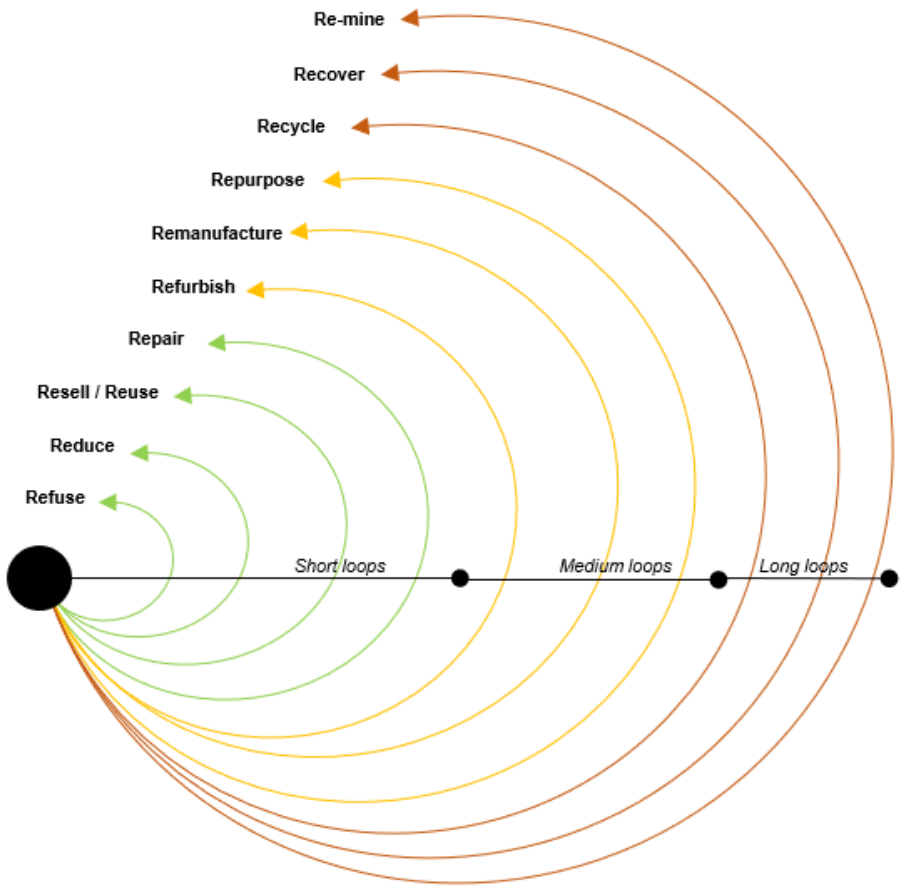

Figure 2. CE loops, based on the hierarchy of Reike et al. (2018).

2.1.2. The three sustainability dimensions in CE

Economic prosperity was found by Kirchherr et al. (2017) to be the main aim of CE in a review of CE definitions. The environmental dimension is prominent in CE, however not considered the main aim (Kirchherr et al. 2017). The most common CE business model in CE definitions is recycling (Kirchherr et al. 2017), something the concept has been criticised for as it goes against the waste hierarchy (Ranta et al. 2018) and is a long loop measure (Reike et al. 2018). Kirchherr et al. (2017) suggest a reason for the focus on measures which do not reduce demand is the practitioners' lack of interest in curbing consumption and economic growth unless they are able to introduce a product-as-a-service business model simultaneously.

The social dimension is often omitted in CE research (Kirchherr et al. 2017; Murray et al. 2017). Social CE is a concept created to unite CE and social enterprise, i.e., businesses with a social objective. The definition of social CE and its related aspects vary and can be seen as not fully developed. For example, Padilla-Rivera et al. (2021) present 43 indicators for social CE. The indicators relate to a wider range of categories, for example employment and labour standards, inclusion, and sharing economy. The indicators employed by Padilla-Rivera et al. (2021) are similar, although more limited, to those in the S-LCA guidelines for social life cycle analysis produced by UNEP (2020) (see Section 3.4.4 for more details). Schröder et al. (2020), Mies and Gold (2021), and Pitkänen et al. (2023) all focus on the social impact of CE, however, without referring to it as social CE. Schröder et al. (2020) consider the social impact of CE in the perspective of human development, whilst Mies and Gold (2021) suggest social aspects which characterises social sustainability in CE. These aspects cover a range of impacts such as employment, economic welfare, and awareness. Similarly, Pitkänen et al. (2023) investigates the possibility to evaluate the social sustainability of CE and use indicators related to the SDGs, such as culture, community, and well-being.

2.1.3. CE in the built environment

CE has a high promise of positive sustainability impact in the built environment (Pomponi and Moncaster 2017). However, focus has been on macro-scale or product level in the built environment, which neglects the impacts on an individual building level (Pomponi and Moncaster 2017). Pomponi and Moncaster (2016) also note that focus has been on new construction. Lundgren et al. (2023) grouped CE measures in the built environment context according to the loop sizes presented by Reike et al. (2018) when conducting a CE policy review. However, an established framework for connecting and ordering CE business models in the built environment is lacking. Akhimien et al. (2021) carried out a literature review of CE strategies in buildings and found seven aspects, namely, design for disassembly, design for recycling, building materiality, building construction, building operation, building optimisation, and building end of life. However, no hierarchy of efficiency is presented. Both design for disassembly and design for recycling aim to reduce future waste. Building materiality consider waste reduction from material design, as well buildings as material banks (Akhimien et al. 2021). Design measures tend to be connected to new construction which was considered a long loop by Lundgren et al. (2023), as it is less effective than refurbishment or adaptive reuse (Itard and Klunder 2007). Additionally, using buildings as material banks is less effective than reusing a building as a whole, e.g., through refurbishment or adaptive reuse (Yung and Chan 2012b). In the study by Akhimien et al. (2021) building construction mostly related to enabling design for disassembly. Similarly, building operation was connected to how the building

was used in order to make reuse and recycling of materials possible. Optimisation on the other hand comprises maintenance, repair, replacement, and refurbishment in the study, and how these can be optimised to eliminate waste and maximise efficiency. The end of life is however again connected to design for disassembly and recycling.

The CE strategies proposed by Akhimien at el. (2021) are all long or medium loops, with optimise being the only medium loop according to the hierarchy used by Lundgren et al. (2023). Short loops are missing from the proposed CE strategies for buildings presented by Akhimien et al. (2021), however, Kyrö (2020) include sharing spaces in a framework proposed for the built environment. Sharing space is considered a short loop measure in the hierarchy employed by Lundgren et al. (2023).

2.2. Business models

A business model expresses the business logic of an organisation, including objects, concepts, and their relationship (Osterwalder et al. 2005). Value proposition, value creation and delivery, and value capture are sub-parts of a business model, although different groupings and labels exist (Bocken et al. 2014).

2.2.1. Value

Osterwalder et al. (2005) suggests value proposition is an overview of a company's bundle of products and services. However, Bocken et al. (2014) adapt the definition to include customer segments and relationships. Typically, the products or services offered will generate an economic return, it is this measure of economic return which is the main concern of the value proposition in a typical business model (Bocken et al. 2014).

The value creation and delivery is the part of the business model where the economic return is enabled through new business opportunities, new markets, and new revenue streams (Bocken et al. 2014). Value capture concerns the earning of revenue of products or services and is the materialisation of the value proposition (Bocken et al. 2014). Both cost structure and revenue model are included (Bocken et al. 2014), with cost comprising the monetary consequences of funds and assets in the business model and revenue describing the business model revenue flows and their consequences (Osterwalder et al. 2005).

2.2.2. Sustainable and CE business models

Increased global attention on sustainability has caused corporations to focus on sustainable business models, however there is also a strong link between sustainable business models and economic value creation (Ritala et al. 2018), so-called shared value which combines profits with social and environmental value (Porter and Kramer 2011). Sustainable business models consider the trade-off between different value propositions such as profits and environmental impact (Boons and Lüdeke-Freund 2013). CE business models expand this concept by including CE principles into these value propositions (Manninen et al. 2018).

Bocken et al. (2014) present sustainable business model archetypes which are grouped in terms of the main innovation type, namely, technological, social, and organisational. The technological grouping includes the archetypes of maximising material and energy efficiency, create value from waste, and substitute with renewables and natural processes. The social grouping on the other hand includes deliver functionality rather than ownership, adopting a stewardship role, and encouraging sufficiency. Finally, the organisational grouping archetypes aims to repurpose for society/environment and developing scale up solutions. These archetypes are however not prioritised based on their effectiveness in terms of value retention, as is the case for CE measures.

Leising et al. (2018) found several CE business models in the built environment context, namely, optimise material and energy efficiency, create value from waste, substitute with renewables, deliver functionality, adopt a stewardship role, encourage sufficiency, inclusive value creation, repurpose for society, and develop scale up solutions. The archetypes were built on those presented by Bocken et al. (2014) and later updated by Ritala et al. (2018) who added the inclusive value creation business model.

2.3. Sharing economy

The most efficient CE measure is to reduce, often linked to the sharing economy (Reike et al. 2018). Further, the sharing economy is considered a sub-set of CE (Henry et al. 2021). Sharing economy research is often focused on the social dimension, as opposed to CE which has had a focus on economic and environmental impact (Henry et al. 2021). Therefore, the sharing economy concept can be a way of addressing this shortcoming of CE (Henry et al. 2021).

The sharing economy is the business model of consumers paying for the function, or utility, of a product as opposed to the ownership (Ranjbari et al. 2018). This collaborative consumption can reduce the need for products as products are more efficiently utilised (Ranjbari et al. 2018). Curtis and Mont (2020) note that for a

sharing business model to be sustainable, the shared assets should be existing, as the production of new assets to be shared weakens the negative environmental impact reduction potential.

2.3.1. Access-based consumption

Access-based consumption is facilitated by the sharing economy and has become a concept of its own (Curtis and Lehner 2019), defined as transactions where no transfer of ownership takes place (Bardhi and Eckhardt 2012). Bardhi and Eckhardt (2012) developed a framework to evaluate access-based consumption of a car-sharing service from a user perspective. They identify six overarching dimensions of access-based consumption which they use to assess the consumers' relationship with the accessed object, in this case cars. Some of the dimensions consider different aspects within the same dimension and are then split into separate dimensions, giving a total of nine dimensions. The dimensions and the extremes at each end of the continuum are presented in Table 2.

Table 2. Access-based consumption framework by Bardhi and Eckhardt (2012).

One-off transaction	Temporality (access)	*Longitudinal*
Short-term	Temporality (duration)	*Long-term*
Anonymous	Anonymity (interpersonal)	*Prosocial motivations*
Intimate context	Anonymity (spatial)	*Less intimate context*
Profit business model	Market mediation	*Non-profit business model*
Self-serviced	Consumer involvement	*Serviced*
Physical	Type of accessed object (material)	*Virtual*
Functional	Type of accessed object (function)	*Experiential*
Non-political	Political consumerism	*Signalling sharing as sustainable and antimarket*

2.3.2. Access-based consumption in the built environment

Many transactions of space can be considered access-based, such as all leased space. However, in this dissertation long leases with a single tenant are considered to resemble an ownership model rather than access-based. Access-based in this dissertation is instead seen as short-term or flexible leases or spaces with some form of shared space. Moreover, the term is limited to cover workplaces, and exclude housing and other commercial facilities. However, spaces with other functions connected to the foci workspaces of offices and cultural sector studios can be included, e.g., courtyards, cafés, restaurants, and galleries.

Shared spaces are in this context a sub-set of the sustainable business model archetypes presented by Bocken et al. (2014) of creating value from waste and deliver functionality rather than ownership. However, space efficiency measures in general can be considered a sub-set of the maximise material and energy efficiency archetype through increased functionality. Francart et al. (2018) propose

space sharing and space optimisation as key to reduce floor area and reach climate targets, whilst Ness & Xing (2017) combine digitalisation and increased utilisation of spaces as a means to decrease demand.

Brinkø et al. (2015) provide a typology of shared spaces and include variations of sharing facilities such as desks, sharing physical space in a building, and sharing a network of buildings These sharing types can further be divided into what is being used, when and why it is being used, who it is being used by, and how the sharing is organised. Sankari (2019) classifies space sharing business models into typologies based on the level of user access and whether it is provided by a non-profit or a for-profit organisation. Brinkø and Nielsen (2018) highlight several difficulties which arise when spaces are shared that need to be resolved. These issues were found to differ between the type of space, however, relate to the topics of territoriality, involvement, and practicalities.

2.4. Workplaces

Workplaces are here limited to office spaces and cultural sector studios. In this dissertation two main workplace concepts are of interest, namely, collaborative workspaces and hybrid and virtual workspaces.

2.4.1. Collaborative workspaces

Workers are increasingly using public and semi-public spaces as alternatives to traditional offices (Di Marino and Lapintie 2017). Although a variety of shared space typologies exist (Brinkø et al. 2015), the business model of coworking has received much attention in recent times (e.g., Brown, 2017; Durante & Turvani, 2018; Jakonen et al., 2017; Orel & Alonso Almeida, 2019; Spinuzzi, 2012; Waters-Lynch & Potts, 2017). Coworking is one type of access-based consumption in the built environment that has the possibility of increasing space utilisation (Durante and Turvani 2018), and it also has links to the so-called social economy which includes trends such as independent knowledge work (Waters-Lynch and Potts 2017).

Coworking is a workplace concept mainly aimed at knowledge workers (Kojo and Nenonen 2016) where offices are shared between workers often with the aim of collaborative work (Spinuzzi 2012). Kojo and Nenonen (2016) conclude that coworking has the capability of making the built environment a service rather than simply a place. Similarly, general workplace business models include elements of servitization, and the physical space is only a component of the service (Petrulaitiene et al. 2018).

2.4.2. Hybrid and virtual workspaces

Information and communication technologies services are one of the aspects considered when knowledge workers choose their workspaces, although the physical space is still of importance (Di Marino and Lapintie 2017). A virtual space is a space where users communicate primarily through the use of information and communication technologies (Gressgård 2011) and a hybrid space is a physical space where it is possible to join a virtual space. Agrawal et al. (2022) suggests digitalisation is one of the key enablers to CE as it provides organisations the opportunity to minimise resource consumption. Additionally, a virtual presence has been suggested as a means to create a dynamic and innovative organisation (Gressgård 2011) and the camaraderie found in physical spaces have also been found online (Belk 2014a).

2.5. Adaptive reuse

Adaptive reuse is the process of extending a buildings life by adapting it for a new use when the building is wholly or partly vacant (Armstrong et al. 2023), usually including refurbishment (Yung and Chan 2012a). Adaptive reuse is considered an essential measure in terms of sustainable development (Yung and Chan 2012a) as it takes into consideration embodied carbon (Ness and Xing 2017) which may represent up to 70% of the total life cycle energy of a building (Ibn-Mohammed et al. 2013). The process can in this context be considered a sub-set of the sustainable business model archetype of creating value from waste presented by Bocken et al. (2014).

2.5.1. Sustainable adaptive reuse

Refurbishment is superior to reusing building materials from one building being demolished in another being constructed as it avoids the process of demolition, deconstruction, and reconstruction (Yung and Chan 2012b). Further, adaptive reuse extends the life of buildings where there is no, or less, demand for the current use of the building, by giving it a new use of which there is a demand. Additionally, adaptive reuse has been identified to improve not only environmental sustainability, but also social and economic (Conejos et al. 2015).

Despite the possibilities of adaptive reuse contributing to sustainable development barriers exist which hinder uptake. Sanchez et al. (2019) highlight issues relating to difficulties in budgeting and complexity, whilst Yung and Chan (2012b) emphasise the need for all three dimensions of sustainability to be considered in adaptive reuse in order for it to be considered sustainable. It is common for adaptive reuse studies to be linked with cultural heritage. Research of adaptive

reuse in conservation of cultural heritage fall under three main approaches, namely, typological, technical, and strategic (Plevoets and Van Cleempoel 2011). In the typological studies a specific building type is studied, e.g., industrial buildings. In the technical approach studies tend to pose technical questions, whilst the strategic approach foci are processes and strategies.

Cultural heritage has been studied in relation to all three sustainability dimensions. For example, Sanchez et al. (2019) consider the environmental and economic dimension in the renovation of a cultural heritage courthouse, whilst Yung and Chan (2012a) consider the social dimension in the conservation of a police station. Further, Munarim and Ghisi (2016) explore the feasibility of heritage building rehabilitation in terms of the environmental dimension, however, conclude that for a rehabilitation to be considered sustainable it needs to be feasible for all three dimensions, supporting the findings of Yung and Chan (2012b).

2.5.2. Adaptive reuse as part of CE

A medium loop CE measure is to refurbish and reuse existing products (Reike et al. 2018). Medium loops consist of refurbish, remanufacture and repurpose (Reike et al. 2018). Lundgren et al. (2023) therefore places adaptive reuse as a medium loop in the hierarchy presented by Reike et al. (2018), considering a building in its entirety as the product. Building stock renews itself slowly (Pomponi and Moncaster 2017) and as adaptive reuse saves more emissions compared to new construction (Itard and Klunder 2007) it is imperative to focus on existing building stock.

Cultural heritage was only recently linked with CE (Huuhka and Vestergaard 2020) despite previously being linked to general sustainability. Value retention is central to the CE concept and cultural heritage alike as both concepts aim to minimise intervention to material (Huuhka and Vestergaard 2020). Huuhka and Vestergaard (2020) also found barriers were similar for the two concepts in Western societies, namely, low cost of virgin materials and waste management, and high cost of labour.

Foster et al. (2020) propose a comprehensive framework with indicators for measuring the circular environmental impact of cultural heritage buildings and is meant to bridge the gap between macro and micro environmental management levels. However, the framework is not intended to replace existing methods such as the LCA. The framework links cultural heritage and CE, however predominantly through the environmental dimension.

Foster (2020) present a list of strategies for increasing circularity in adaptive reuse of cultural heritage buildings. These are grouped in three categories. The first, smarter building use and manufacture category, include reducing raw material use as well as sharing and multifunctional uses. The second category, extend lifespan

of building and its parts, include reuse, repair, refurbish, remanufacture, and repurpose, all relating to the materials and components of the existing building. The third category, useful application of materials, includes recycle and recover. The categories are grouped around the R-imperatives, which Reike et al. (2018) organised into loops. Based on the R-imperative loops by Reike et al. (2018) the first category presented by Foster (2020) include short loop measures, the second short and medium loop, and the third long loops.

2.6. Theoretical concept summary

Table 3 presents the primary concepts and the main authors contributing to existing literature.

Table 3. The primary concepts in this dissertation.

Topic	Description	Main author(s)
Circular economy	The CE concept changes the previous material and product flow of make, use, and dispose to a circular alternative, where materials and products which enter into circulation are firstly reduced, and secondly, those materials which do enter are kept in circulation whilst value is retained.	Ellen MacArthur Foundation (2015a), Kirchherr et al. (2017), Pomponi and Moncaster (2017), Geissdoerfer et al. (2017), Reike et al. (2018), Korhonen et al. (2018), Ranta et al. (2018), Ghisellini et al. (2018), Kyrö (2020), Munaro et al. (2020), Henry et al. (2021), Dytianquin et al. (2021), Malabi Eberhardt et al. (2022)
Sustainable and CE business models	Consider the trade-off between different value propositions such as profits and environmental impact. CE business models include CE principles into these value propositions.	Manninen et al. (2018), Bocken et al. (2014), Boons and Lüdeke-Freund (2013)
Sharing economy	The business model of consumers paying for utlity of a product rather than ownership, enabling collaborative consumption with the ability to reduce overall production of goods as produced goods are used more efficiently.	Wu and Zhi (2016), Belk (2014a), Eckhardt and Bardhi (2015), Daunorienė et al. (2015), Böcker and Meelen (2017), Ranjbari et al. (2018), Curtis and Lehner (2019), Henry et al. (2021)
Access-based consumption	Transactions where no transfer of ownership takes place. The sharing economy is said to facilitate access-based consumption.	Bardhi and Eckhardt (2012), Belk (2014b), Brinkø et al. (2015), Baden et al. (2020), Lawson et al. (2021), Curtis and Lehner (2019)
Shared spaces	In the built environment context the sharing economy can take the form of shared spaces, where space is efficiently utilised by users, both simultaneously and over different times.	Brinkø et al. (2014), Brinkø et al. (2015), Brinkø and Nielsen (2017), Francart et al. (2020), Geissdoerfer et al. (2020), European Commission (2020), Nußholz et al. (2023)
Collaborative workspaces	Although a variety of shared space typologies exist, the business model of coworking has received much attention in recent times.	Brinkø et al. (2015),Orel & Alonso Almedia (2019), Spinuzzi (2012), Waters-Lynch & Potts (2017), Jakonen et al. (2017)
Hybrid and virtual spaces	A virtual space is a space where users communicate primarily through use of ICT. A hybrid space is a physical space where it is possible to join a virtual space.	Belk (2014a), di Marino & Lapintie (2017), Gressgård (2011), Agrawal et al. (2022)
Adaptive reuse	Adaptive reuse of buildings is the process of extending a buildings life by refurbishing and adapting it to a new use. The process saves embodied carbon.	Bullen (2007), Langston (2008), Langston et al. (2008), Bullen and Love (2010), Bullen and Love (2011), Yung and Chan (2012b), Conejos et al. (2015), Sanchez and Haas (2018), Sanchez et al. (2019), Foster (2020)

3.Research design

This section first presents the research philosophy and the approach to theory employed in this dissertation, followed by an in-depth description of the research methodology, strategy, and methods.

3.1. Research philosophy and approach to theory

Research philosophy concerns the beliefs and assumptions about knowledge development (Saunders et al. 2009). The author of this dissertation adopts a postmodern research philosophy. As postmodernism is value-constituted (Saunders et al. 2009) it is considered important to reflect on ones underlying values when undertaking research (Heron 1996). The values held by the author of this dissertation is that of social and environmental justice with a transformation view on sustainable development. This implies there is a belief that there is a need for a large transformation which alters the basis of society and how it is constructed (Persson et al. 2018). This view aligns with postmodernism in the way that the current dominant power relations and ideologies are not necessarily the most appropriate, and that alternative views can be just as valuable (Saunders et al. 2009).

Additionally, social wellbeing and equality are valued equally to environmental concerns by the author, with a strong belief that sustainability measures should, and can, positively impact both dimensions at the same time as they create value for organisations making the investments. These values led, together with the gap shown in previous research (e.g., Kirchherr et al. 2017), to the inclusion of all sustainability dimensions in this dissertation and the selection of CE business models of adaptive reuse and sharing which had shown promise to deliver positive impact in all dimensions.

Whilst the underlying philosophies of built environment research varies, the importance of being aware of one's values as a researcher is important and that the methodological choices are rational based on these (Amaratunga et al. 2002). In postmodernism the researcher should be open to many types of data sources, both of a qualitative and a quantitative nature. This is therefore one of the reasons why this dissertation employs mixed methods as a methodology.

The dissertation takes an abductive approach to theory development, which generates or modifies theories and incorporate existing theory when doing so (Saunders et al. 2009). The goal in abductive research is not to prove anything, but rather to understand a phenomenon (Persson and Sahlin 2013). Further, Folger and Stein (2017) argue abduction is more interested in the potential findings than the initial assumption. For example, in paper V the initial assumption was, when two refurbishment options were compared, that the option that included shared spaces would be considered the better option in relation to environmental impact based on previous knowledge about shared spaces. However, when considering the overall impact and impact per lettable area this was not the case. Only when the impact per person was consider was it the option with the lower impact.

Data in an abductive approach can also be used to identify themes (Saunders et al. 2009), such as the template analysis employed in the papers with a qualitative methodology (see Section 3.4.1). Further, data in abductive research can locate themes in conceptual frameworks (Saunders et al. 2009), as was done in Papers I and II.

3.2. Mixed methods approach

This dissertation employs a mixed methods approach, described by Amaratunga et al. (2002) as a desired methodology in built environment research. Mixed methods integrate quantitative and qualitative approaches (Saunders et al. 2009). This dissertation comprises studies employing purely quantitative and qualitative approaches as well as mixed methods approaches. The dissertation is thus in its entirety employing a mixed methods approach. Additionally, in the appended papers both Papers IV and V employ concurrent mixed methods approaches within the contained studies, which involves the use of quantitative and qualitative methods in the same data collection and analysis phase (Saunders et al. 2009). In mixed methods approaches the results from the various methods can be interpreted together and therefore this approach is suitable when richer and more comprehensive data is required (Saunders et al. 2009). Issues with mixed methods can arise when there are conflicting results which need to be interpreted, however Abowitz and Toole (2019) consider conflicting results an opportunity to critically examine the theoretical assumptions made and to evaluate the research design, which was the approach taken in the studies in this dissertation.

A qualitative approach is employed in Papers I and II, where meaning was derived from words and images as opposed to numbers, as described by Saunders et al. (2009). The methodology was chosen for the studies in Paper I and II due to the ability to interpret subjective and socially constructed meanings, e.g., the characteristics of CE business models. The qualitative approach enabled concepts

to be explored based on respondents lived experience and expectations which would not be possible if a quantitative approach was employed.

In Paper V a qualitative approach was taken when there were data gaps in the quantitative data, which allowed for a comprehensive view despite the data gaps. Similarly, Paper IV carried out an S-LCA which evaluates the social impact through the assessment of numerous pre-determined indicators, of which some are of quantitative nature and some of qualitative nature. Qualitative indicators allow data to be collected where there are difficulties in quantifying (Padilla-Rivera et al. 2020). Additionally to covering data gaps, the combination of methods allows for concurrent triangulation design where the data can be compared to corroborate or contradict findings from the other data set as described by Saunders et al. (2009).

The multi-method approach, both within papers and across papers, is the necessary overarching approach for this dissertation. The dissertation characterises, assesses, and optimise CE in the built environment, whilst considering all three sustainability dimensions. Characterising in Papers I and II was enabled mainly through exploring subjective and socially constructed meanings of different stakeholders in adaptive reuse and shared spaces, which called for a qualitative approach. Meanwhile, when measuring the sustainability impact of CE business models in Papers III-V a quantitative approach was favoured, however there were indicators where quantitative data was unavailable and qualitative data filled the gaps, as well as some unquantifiable indicators. Adding the qualitative data to the quantitative data in the analysis also enabled data triangulation. The dissertation as a whole can thus in the same way be triangulated across the appended papers.

The appended Papers III and V employ a multi-method quantitative approach, where more than one data collection technique was used (Saunders et al. 2009), namely, observations and document reviews. Two quantitative assessment methods were employed to examine the relationship between variables, as suggested by Saunders et al. (2009), in the papers appended to this dissertation, namely, economic life cycle assessment (Paper V), and environmental life cycle assessment (Papers III and V). Paper V only partly employs a quantitative approach, as it also contains a qualitative part.

Despite no methodological life cycle framework existing for the evaluation of CE in the built environment (Hossain et al. 2020), economic and environmental life cycle assessments are commonly used for the evaluation of general CE initiatives (e.g., Nasir et al. 2017; Deschamps et al. 2018; Eberhardt et al. 2019a; Minunno et al. 2020; Fufa et al. 2021) and were therefore employed for the quantitative assessment of CE initiatives in the case study included in Papers III and V. Paper IV employs an S-LCA, however, this is considered a mixed methods approach and is further described in Section 3.4.4. The circular transition can be assisted from integrating different life cycle assessments which will increase the CE maturity in the sector (Larsen et al. 2022). This integration also provides a more holistic

approach (Ghisellini et al. 2018), as was intended in this dissertation by including environmental, social, and economic life cycle assessments.

Table 4 provides an overview of the research design. The following sub-sections provide details on the research design choices.

Table 4. Summary of research design based on categorisation by Saunders et al. (2009).

	Methodology	Strategy	Data collection technique	Method
Paper I	Qualitative	Case study – multi	Multi-method	Template analysis
Paper II	Qualitative	Case study – multi	Multi-method	Template analysis
Paper III	Quantitative	Case study – single	Multi-method	LCA
Paper IV	Mixed methods	Case study – single	Concurrent	S-LCA
Paper V	Mixed methods	Case study – single	Concurrent	LCA & LCP

3.3. Case study strategy

The papers appended to this dissertation are conducted with varying research methods, however all share the same strategy, namely, case study. Papers I and II are multiple-case studies whilst Papers III-V are single-case studies. This section presents the justifications for employing a case study strategy and further elaborates on the selection of cases and data collection.

All papers in this dissertation explore a phenomenon in its real-life context, leading to the selection of a case study strategy in all instances, where the chosen cases exhibit the foci phenomenon, i.e., adaptive reuse or shared spaces. Further, this dissertation seeks to explain contemporary circumstances, by asking "how" questions which require extensive insights, where Yin (2009) suggest case studies are relevant as strategies. The case study has many advantages, such as being able to explore real-life situations and phenomena take place in practice (Flyvbjerg 2006). However, the hierarchical view of research strategies has reinforced an idea of the case study as inferior, with conceptions of it only being useful as a preliminary mode of enquiry, as opposed to describing phenomena and test position (Yin 2009). Contrarily to this view, Flyvbjerg (2006) argues that the case study is a necessary method which holds up when compared to other methods. For example, Flyvbjerg (2006) suggest that there is power in examples and that concrete, context-dependent knowledge may be more valuable than general theoretical knowledge. A substantial narrative can be a good approach to capture complexities and contradictions of real-life situations (Flyvbjerg 2006), which has also been the case in the appended papers which all have a thorough narrative in the findings with verbatim quotations from respondents included, where a qualitative or mixed approach was taken, to further enrich the narrative.

The aim of the studies in this dissertation was not statistical generalisation, but rather analytic generalisation, where theories are expanded and generalised without probabilities, and characteristics are identified which may be transferable to other cases, as explained by Yin (2009). Findings which are not generalisable can still be of value and add to knowledge within a field and can lead to scientific innovation (Flyvbjerg 2006). For example, in the case of Paper IV this contribution can be seen as highlighting the possibilities of CE business models to create or enable positive social impact in order for them to be implemented in future projects. The appended papers advance existing theoretical concepts and findings from existing literature as well as developing new characterisation, e.g., advancing the framework for access-based consumption to be applicable in the built environment in Paper I and developing the concept of social CE with elements such as 'vibe & tribe' in Paper II. Both advancing and developing concepts are part of analytic generalisation (Yin 2009). Further, as the cases are not sampling units and too few to represent any larger population there was no attempt to generalise the findings statistically, something that is described as a fatal flaw by Yin (2009).

A preconceived notion of case studies is that the researcher may be biased to verify predetermined views as there allegedly is more room for subjective judgements and less rigor compared to other methods. However, Flyvbjerg (2006) suggests that the opposite is more likely as falsification is also prevalent in case studies and that case studies have their own rigour. Similar to the qualitative method, the case study strategy also relies on identifying and discussing rival and alternative findings (Yin 2009). There were several such findings in the appended papers. For example, one case in Paper I was consistently on the other end of the spectrum than the other cases in relation to the dimensions in the applied framework. This was discussed and a suggestion was made that one of the dimensions, e.g., political consumerism, could be affecting the position of the other parameters.

Single- and multiple-case studies are variations of case study design (Yin 2009) and the purpose of the two approaches are different (Saunders et al. 2009). A single-case study is a case study containing a single case and is preferred when the case is chosen based on the attributes of the case and it is usually either critical, unique, or typical and can be a case where a phenomenon can be observed which few have considered in the past, e.g., extreme cases (Saunders et al. 2009; Yin 2009). A multiple-case study is a case study containing multiple cases and can be chosen to allow cross-case analysis to take place (Saunders et al. 2009). Multiple-case studies have been viewed as superior to single-case studies, however single-case studies can be multiple in the sense that data can be linked in many different ways (Saunders et al. 2009). Further, Saunders et al. (2009), like Flyvbjerg (2006), highlight the importance of examples which the single-case study can provide.

A multi-case strategy was chosen for Papers I and II, as finding characteristics required cross-case analysis, mainly to analyse and discuss rival and alternative findings which brought a solid foundation to the characterisation which would not be possible from a single-case. In Papers III-V however, a single-case approach was taken as they considered an extreme case which was chosen based on the multiple and varying CE and social initiatives (see Section 3.3.1 describing the case selection).

Holistic and embedded case studies. A holistic case study is concerned with the case as a whole, without examining sub-units as with the embedded case study (Saunders et al. 2009). For example, a holistic case study might study an organisation, whilst an embedded case study might study the different departments of an organisation. It is however likely that cases include more than one unit of analysis and thus the embedded case study will be the most common (Saunders et al. 2009). Although some of the cases in the appended papers are separated into sub-units in a much more prominent way, such as the organisations and project separated out in terms of their social impact in Paper IV, all cases incorporated in this dissertation were embedded as several units were always analysed, e.g., different stakeholders and actors in Paper I.

3.3.1. Case selection

In case studies, case selection should be made based on those cases which best answer the research question and where there is sufficient access to data (Yin 2009). Cases can be selected based on strategic information-oriented sampling, in other words, cases are selected based on certain characteristics that give promise of their information content (Flyvbjerg 2006). The strategic choice of cases can increase the ability to theorise from case studies (Flyvbjerg 2006). Extreme cases can be chosen when information is sought on unusual cases which exhibit some problematic or excellence in a pre-defined sense (Saunders et al. 2009). Maximum variation cases can instead be chosen if information in sought providing insights on the significance of one or more circumstances. Maximum variation cases are cases which are very different in one dimension (Saunders et al. 2009). Papers I and II use the maximum variation case selection strategy, whilst Papers III-V employ the extreme case selection strategy.

For Paper I, all cases were shared spaces, however, selected based on their differences in certain characteristics, e.g., niche, type of sharing presented by Brinkø et al. (2015), and business models presented by Sankari (2019). Further, Saunders et al. (2009) suggest cases can be selected based on different contexts. The context of the cases differed, as the cases were located in different parts of Sweden, Finland, and the Netherlands.

For Paper II two cases were lifted from Paper I which were similar in many aspects, such as shared and collaborative spaces, however differed widely in their context, e.g., the location of one in a large city and prosperous neighbourhood and the other in an industrial town with declining industries. To conceptualise social CE, having both contexts was important as to not limit the concept to one of the contexts. The contexts being widely different, however both in the Nordics, allowed for contradictory findings which could be analysed and discussed in order to present a more holistic concept than if only one case was included.

The case is the same for all three Papers III-V and was selected as an extreme case based on findings from Paper I. The case was first selected for Paper III and then iteratively for the remaining papers as findings emerged making the case suitable for further exploration. An extreme case is selected as it tends to be high in information content (Flyvbjerg 2006). The case is considered extreme due to its ambitious circular activities, its location in a neighbourhood with social issues, and extensive social sustainability initiatives, compared to other adaptive reuse cases reviewed in an initial search for a suitable case. The single-case studies thus provided insights on sustainability impacts from an extreme case to highlight possibilities of positive impact to be implemented in future projects, but also highlighted issues which still need consideration, and optimisation. One of the single-case studies do, however, consider different options within the case. The availability of substantial amounts and quality of data further supported the case selection. Table 5 provides a summary of the cases and the case selection.

Table 5. Summary of cases and case selection strategy.

	Case(s)	Case selection strategy
Paper I	Case Arts (SWE), Case Creator (NL), Case Embassy (SWE), Case Fabrik (SWE), Case Nest (FIN), Case Station (SWE), and Case Unicorn (SWE).	Information-oriented sampling strategy: Maximum variation. Selected due to having certain characteristics, which were similar in some aspects and unique in others, that gave promise of their information content.
Paper II	Case Art Factory (Southern Sweden) and Case Park Palace (Helsinki, Finland).	Information-oriented sampling strategy: Maximum variation. Extreme cases with unique characteristics. Both cases capture CE through adaptive reuse and sharing.
Paper III	A former textile manufacturing facility, adapted to modern offices, studios, workshops, and coworking spaces (SWE).	Information-oriented sampling strategy: Extreme case. Selected due to including many CE initiatives.
Paper IV	A former textile manufacturing facility, adapted to modern offices, studios, workshops, and coworking spaces (SWE).	Information-oriented sampling strategy: Extreme case. Selected due to including many CE and social initiatives, and its location.
Paper V	A former textile manufacturing facility, adapted to modern offices, studios, workshops, and coworking spaces (SWE).	Information-oriented sampling strategy: Extreme case. Selected due to including many CE initiatives.

3.3.2. Data

The studies in the appended papers were multi-method, where more than one data collection technique was utilised which enabled rich data to be collected. The use of multi-method also allowed the data to be triangulated to increase validity (Saunders et al. 2009). In order to understand effects and implications related to a phenomenon, case studies make use of data from a variety of sources which provide insights on the dynamics within a case (Saunders et al. 2009). All studies in the appended papers utilise a variety of data sources for this purpose, e.g., interviews, observations, and document reviews. The combination of these data sources is common in case study research (Saunders et al. 2009). Document reviews can be used to corroborate and augment findings from other data sources, however, care needs to be taken as even documents can be biased and inaccurate (Yin 2009). The document reviews in the studies of the appended papers were employed as main data sources, as well as to fill data gaps and to corroborate and augment findings from the interviews. The observations were used in the same manner. Internet searches of e.g., webpages, social media accounts, and news articles were used for preparation prior to engagement with the case in the form of e.g., interviews. Firstly, to ensure that the case was suitable for selection, and secondly, to provide further insights throughout the data collection period.

One of the most important data sources for case studies is however the interview as it assists in answering "how" questions (Yin 2009), and thus appropriate for this dissertation as all research questions looks to answer the question of "how". All papers including a qualitative approach (I, II, IV and V) therefore include interviews, in a semi-structured manner which is recommended for "how" questions (Yin 2009). Paper III employs a quantitative approach and therefore does not include interviews. However, the data is from different sources, e.g., observations and document review, and is thus data triangulated. For instance, the observations assisted in verifying that the scope listed in the documents was the actual work carried out. Table 6 provides a summary of data sources for each paper.

Table 6. Summary of case study data sources.

	Data source(s)
Paper I	Interviews (1,167 min), observations (site visits), secondary data sources (e.g., reports, social media accounts, websites).
Paper II	Interviews (703 min), observations (site visits and online events and videos) and document review (e.g., photos, social media, reports, newspapers).
Paper III	Observations (site visit) and document review (e.g., project reports, sustainability reports).
Paper IV	Interviews (223 min), observations (two site visits), document review (e.g., sustainability reports, procurement documents, webpage).
Paper V	Interviews (72 min), observations (two site visits), document review (e.g., project reports, sustainability reports, webpage).

The data collected from the different case studies were at times contributing to other case studies within the dissertation. Paper I and II can be considered the same case study with the majority of data collected being used for both studies, however only two of the seven cases from Paper I was part of Paper II. Paper III and V also utilise the same core datasets and can also be seen as one case study. In Paper IV, however, the majority of data collected was done independently of the other case studies and data crossing over several case studies tended to be supplementary in most instances and is thus considered an independent case study. Figure 3 presents an overview of the connection between cases, case studies, and appended papers.

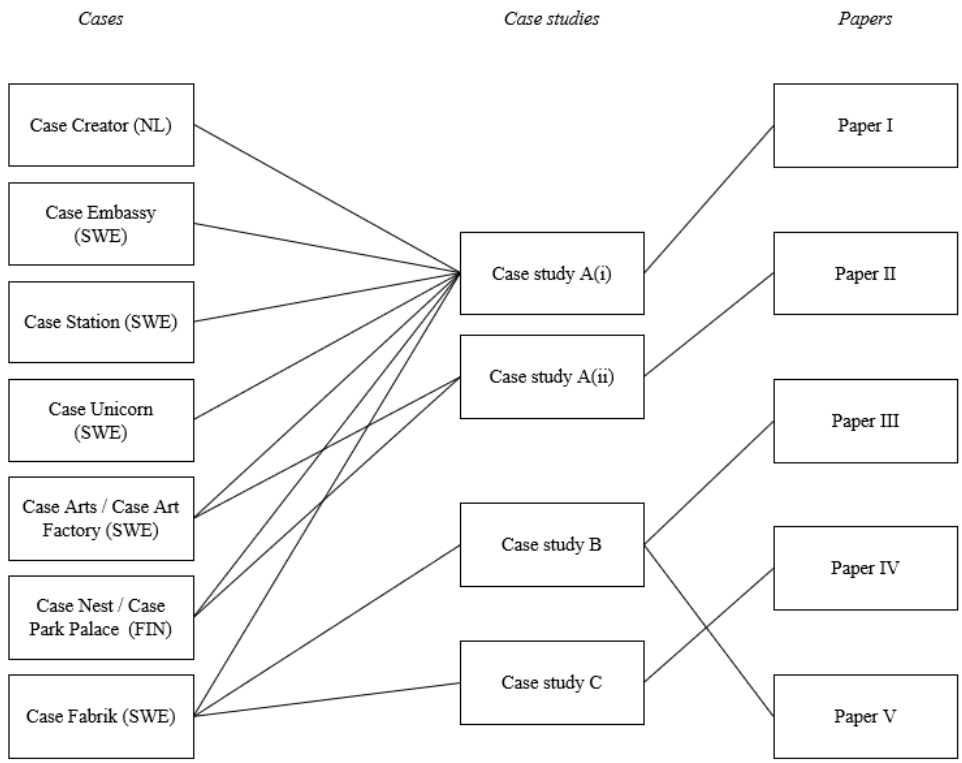

Figure 3. Connection between cases, case studies, and appended papers.

3.4. Methods

The following sub-sections provide an overview of the primary methods employed in this dissertation, namely, template analysis, LCA, LCP, and S-LCA.

3.4.1. Template analysis

The qualitative data was analysed using a type of thematic analysis, namely, template analysis. The purpose of the analysis is to discover themes and patterns across a data set using a priori and in vivo codes (Saunders et al. 2009). A priori codes are codes from outside of the data set, e.g., from existing literature. In vivo codes are codes which emerge from the data (Saunders et al. 2009). A priori codes identified in existing literature were first used to organise the first set of data, e.g., Paper II used several a priori codes, including cultural heritage, environmental sustainability, social sustainability, economic sustainability, value delivery, shared spaces, physical space, site surroundings, community buildings, and synergies. In accordance with the template analysis process (Saunders et al. 2009), a proportion of data was first coded before developing in vivo themes. Subsequently coded data was then arranged within the a priori and in vivo themes and further in vivo themes added. Using initial themes, both a priori from existing literature and in vivo from the first coded data, provides a higher level of structure than in thematic analysis (Saunders et al. 2009). A higher level of structure was favoured as emergent issues, which may not have been the original focus, were considered positive contributions to the study. Additionally, as described by Saunders et al. (2009), establishing themes early on in the process allows for a flexible and holistic analysis.

In searching for themes, the coded data was analysed to consider how they fit together as suggested by Saunders et al. (2009). For example, in Paper I an existing framework was used to create the a priori themes, of which the initial codes relating to one theme suggested the theme should be split into two different themes. In the same paper, one case was consistently different to the other cases, suggesting it was a negative case, i.e., a case differing from the others in one or more aspects. According to Saunders et al. (2009), a negative case should be considered in a positive light as it helps refine explanations and avoid research bias.

There are several computer-assisted tools which help code data, e.g., from transcripts and documents in a document review (Yin 2009). However, in thematic analysis it is imperative to be familiar with the data in order to carry out the analysis (Saunders et al. 2009). Familiarisation with the data was considered easier if the data was coded manually from transcripts and documents into Excel, as opposed to using a computer-assisted tool. Additionally, scholars have expressed

concern over the ability to find new themes when employing the tools (Patton 2015), which was a significant part of Paper I and II. Therefore, in the cases of template analysis employed in this dissertation, all coding was done manually in Excel.

3.4.2. Environmental life cycle assessment (LCA)

LCA is a methodology for assessing the environmental impact for the life cycle of a product or service (ISO14044 2006). When undertaking an LCA there are two main types of methods to employ, namely process and input-output analysis. Process analysis utilises process, product and location-specific data whilst input-output analysis is a top-down technique based on sector transactions (Crawford 2013). An issue with the process method is that it can cut off parts of the product system, which the input-output method does not. However, this issue with the process method can be lessened by establishing detailed cut-off criteria which ensures the results are transparent. Issues with the input-output method relate to the availability and use of statistics complicating aggregation, something which is lesser for the process method. On the other hand, the input-output method has the benefit of being fast and comprehensive and can thus be a good tool for initial screening purposes (Hauschild et al. 2018).

The LCA framework is outlined in ISO 14040:2006 and is thus a recognised international assessment method for environmental impact. LCAs on a building level are however complex (Bragança et al. 2010). Despite these limitations LCAs are considered a reliable approach to assessing environmental impact in the built environment (Munarim and Ghisi 2016). Several LCA studies have been undertaken at different levels in the built environment. For example, on the material level Dabaieh et al. (2020) carry out a comparative study of two types of bricks and Deschamps et al. (2018) employ an LCA to review the environmental impacts of two concrete options of which one is open-loop recycling of glass powder. On a component level Berglund et al. (2018) compare the environmental impact of sewerage systems in renovations and Eberhardt et al. (2019a) compare LCA modelling of linear and circular building components. At a building level Dabaieh et al. (2020) assess the carbon impact of a refugee house in Sweden, whilst Zimmermann et al. (2023) compare the environmental impact of renovations and new construction. Further, Minunno et al. (2020) conduct an LCA of a modular building in order to explore the environmental impact of reuse and recycling and Fufa et al. (2021) employ an LCA to study how existing buildings can contribute to environmental targets. Taking a value chain perspective, Nasir et al. (2017) employ an LCA to compare linear supply chains to circular through a case study from the construction sector. The most common mid-point category for CE assessments in the built environment employing an LCA is global warming

(Andersen et al. 2022). Further, the most common lifespan for a building in life cycle assessments is 50 years (Pomponi and Moncaster 2016).

There are however two re-occurring issues in existing literature related to the environmental impact from buildings and assessment of the same, namely, life cycle phase and functional unit. Varying importance of embodied carbon, i.e., emissions from the material and construction phase, and operational emissions from when the building is in use have been found in previous studies (e.g., Andersen et al., 2022; De Wolf et al., 2017; Pomponi & Moncaster, 2016; Röck et al., 2020). The choice of functional unit makes comparison across studies and cases difficult, as the most common functional unit of emissions per m^2 disregards space efficiency and has therefore been considered not to include a view of the full impact (Munarim and Ghisi 2016). Papers III and V thus include both emissions per m^2 and per person as functional unit in the environmental impact assessment, as well as considerations between the life cycle stages. A further issue with LCAs pertains to the use of online tools, where Peuportier et al. (2004), Bueno and Fabricio (2018), and Azevedo et al. (2011) all found inconsistencies in output between LCA tools.

3.4.3. Economic life cycle assessment (LCC/LCP)

LCC is an assessment of the cost of a product or system overs its life (Larsen et al. 2022). LCC is a recognised international standard for assessing the cost of building and construction assets (ISO 15686-5:2017). It is a common method often combined with an LCA (Giorgi et al. 2019; Larsen et al. 2022). For example, Ferreira et al. (2015) and Sanchez et al. (2019) use LCCs and LCAs to cross-compare the impacts of refurbishments. However, when considering the financial impact, the income generated from the investment is disregarded in an LCC. An LCP assessment on the other hand includes this impact (Bejrum 1991), and provides a more complete financial impact assessment, as opposed to only considering costs. Further, the LCP resembles the description of value capture better than the LCC, considering value capture includes both cost and revenue implications as described by Bocken et al. (2014). Therefore, the LCP was employed in Paper V instead of the more common and standardised LCC.

The LCP considers all costs associated with a project or asset, as well as the generated income and any residual value (Bejrum 1991). However, if the residual value is relevant for renovation projects is not certain (Sundling 2019). The LCP is similar to a cashflow analysis and can be used either to assess the whole building before and after the project or just the project in itself (Bejrum 1991). The assessment takes into consideration income, costs, discount rate, analysis period, acquisition cost, and residual value, to provide a net present value which can be compared between options, where the higher the value the more profitable the investment is (Bejrum 1991).

3.4.4. Social life cycle assessment (S-LCA)

S-LCA is less developed than its environmental and economic counterparts. Although not yet an ISO-standard, UNEP (2020) has released a framework for S-LCA assessments. 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 social sustainability indicators grouped within sub-categories relating to six stakeholder categories, namely, children, consumer/end-user, local community, value chain actors, society, and workers (UNEP 2021). The content of the methodological sheets should however evolve over time and will be expanded as the field advances (UNEP, 2021).

The S-LCA evaluation process is as follows. Sub-categories in the framework are first evaluated using generic country and industry level data which can assist in effectively identifying high risk or opportunity areas within stakeholder categories. The site-specific indicators suggested as high risk or high opportunity areas in the generic assessment are then evaluated with data from the specific case (UNEP 2021). Both positive and negative impacts are included in the assessment, thus a positive impact can be stated without comparison to other cases. The 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 compliance level (UNEP 2020).

4.Summaries of Papers

The five appended papers all address CE business models in the built environment which are efficient in terms of value retention according to CE loop sizes. The contributions of the individual appended papers to the overall dissertation aim are outlined in Table 7.

Table 7. Contribution of appended papers.

	Main sustainability dimension	Main CE business model(s)	RQ	Finding
Paper I	All	Sharing	RQ1	Presents an access-based framework for shared spaces. There was a duality found in the political consumerism dimension, namely antimarket and sustainability. These dimensions might drive the intent for the other dimensions in the framework. The temporality of the organisation towards hybrid and virtual spaces allows shared space organisations to be fluid.
Paper II	Social	Reuse and sharing	RQ1	Shared spaces and adaptive reuse capture some key social dimensions of CE, such as social inclusion and aesthetic experience.
Paper III	Environmental	Reuse and sharing	RQ2	When measuring CO_2e evaluation tools give different results and the timeframe of the use-phase is critical to be able to compare life cycle stages.
			RQ3	Emphasis is required for both the product and the use stage simultaneously to weigh up any trade-off effects.
Paper IV	Social	Reuse and sharing	RQ2	The S-LCA framework supplemented with indicators specific for the built environment was found to be a useful tool to assess social impact.
			RQ3	A minor refurbishment, as opposed to adaptive reuse with shared spaces, would not deliver much of the positive social impact. Significant impact was found in all stakeholder categories, however especially impact on end-users and the local community.
Paper V	All	Reuse and sharing	RQ2	Important to include space efficiency, m^2 and per person used in combination. Economic indicators important to include the business rationale from the owner/developer perspective.
			RQ3	Trade-offs between operational and embodied energy and carbon exist. The minor refurbishment had less environmental impact in absolute terms, whilst the major refurbishment with space optimisation performed better when impact per person was considered.

Two of the papers (I and II) focus on characterising CE in the built environment in order to better understand aspects and impacts of circular business models. The final three papers (III-V) explore the assessment and measurement of effectiveness of CE business models in the built environment, as well as how these business models can be optimised with the intention to both increase implementation and to align investments to sustainable development. All papers address the CE business models of reuse and sharing, apart from Paper I which only focuses on sharing, although many of the shared spaces in the cases are in adaptive reuse buildings. All three sustainability dimensions are addressed in this dissertation through the inclusion of the social dimension in Papers I, II, IV, and V, the environmental in Papers I, III and V, and the economic in Papers I and V.

The following sub-sections describe the appended papers and their findings in more detail, with emphasis on the conclusions which are most relevant to the aim of this dissertation.

4.1. Paper I: Access-based consumption in the built environment: sharing spaces

The first paper seeks to provide a holistic framework for access-based consumption in the spatial context, e.g., shared spaces. An existing access-based consumption framework is utilised and further developed to suit the spatial context. The paper has a broad perspective and includes both the space itself and the different stakeholders' views. The research design is a qualitative case study and comprises seven cases from Sweden, Finland, and the Netherlands. The cases were selected due to their promise of high information content and although all had shared spaces these differed in terms of niche, type of sharing, and business model for maximum variation. The niche was to be different types of workspaces, such as office hotel and co-working with different target groups of artists, sustainability entrepreneurs or local small businesses and self-employed. The type of sharing was based on the typology presented by Brinkø et al. (2015) and business models suggested by Sankari (2019) (see Section 2.3.2).

The data was collected mainly through interviews, with respondents represented in various roles, such as owners, developers, project managers, architects, construction consultants, service providers, public officials, and end-users. Document review and observations complemented the data collected from the interviews. The main contribution of Paper I towards this dissertation is the access-based framework in the spatial context which can be used to identify the typical characteristics of shared spaces in the built environment. The dimensions found to be relevant in the spatial context are presented in Table 8.

Table 8. Access-based consumption in the spatial context.

Drop-in space	Temporality (access)	*Membership or lease usage*
Flexible and short lease	Temporality (duration)	*Long lease*
Fixed	Temporality (organisation)	*Fluid*
Serial sharing	Anonymity (interpersonal)	*Community and collaboration*
Satellite location	Anonymity (spatial)	*Central location*
Profit business model	Market mediation	*Non-profit business model*
Self-service space	Consumer involvement	*Serviced space*
Physical space	Type of accessed object (material)	*Virtual or hybrid space*
Functional space	Type of accessed object (function)	*Experiential space*
Commercial space	Political consumerism (antimarket)	*Decommercialised space*
No sustainability motivations	Political consumerism (sustainability)	*Signalling sharing as sustainable*

The temporality of access is discussed by Echeverri et al (2021) and Sankari (2019) in the extremes of one-off transactions in drop-in spaces and longitudinal transactions such as memberships and leases. Echeverri et al. (2021) also highlight the temporality in duration, specifically flexible and short leases versus long leases. A space can be used simultaneously, which enables community and collaboration (Kyrö et al. 2016; Jakonen et al. 2017; Sankari 2019), or through serial usage which is often anonymous as the sharing occurs at different times (Brinkø et al. 2015; Echeverri et al. 2021). In the spatial context the spatial anonymity extremes which could be found were those of satellite (Capdevila 2013; Berbegal-Mirabent 2021) versus central locations (Kyrö et al. 2016; Weijs-Perrée et al. 2019), with the latter being less intimate.

The market mediation dimension pertains whether the organisation is for profit or non-profit. Similarly, the consumer involvement and type of accessed object (material and function), have the same extremes as those presented by Bardhi and Eckhardt (2012), only relating to the space instead of the organisation. Political consumerism in shared spaces is non-political commercial space (Curtis and Lehner 2019; Sankari 2019) on one end, and decommercialized space which signals sharing as sustainable and antimarket (Mei-Hui Yang 2004) on the other.

The existing framework included temporal dimensions related to access and duration. However, the temporality of the organisation emerged as a new dimension from the case study data. Shared spaces were found to be inherently fluid, in a constant changing state, and was thought to be enabled by a strong virtual presence, e.g., online and hybrid solutions. Further, the political consumerism dimension is split into two dimensions, namely, antimarket and sustainability. The findings suggest these dimensions drive the intent of the other dimensions as they are closely linked to ideologies and values. The market mediation on the other hand did not seem to impact the other dimensions as initially thought.

4.2. Paper II: Your vibe attracts your tribe – the adaptive reuse of buildings delivering aesthetic experience and social inclusion

Paper II aims to explore the potential of adaptive reuse and shared spaces in delivering social CE and focus is on characterising the social dimension and social CE in the built environment. The research approach is a qualitative case study of two adaptive reuse cases with shared spaces in Sweden and Finland. The data was collected through interviews, document reviews and observations. The cases are extreme cases and were chosen due to their unique characteristics for maximum variation. Despite being similar in many aspects they also differ significantly in terms of organisation, budget, and location. The location context differed through one case being located in an old industrial town with declining industries and the other in an affluent neighbourhood in a city.

The core values of the New Bauhaus initiative are environmental sustainability, aesthetic experiences, and social inclusion (European Union 2021). The sustainability values relate to ecological sustainability, whilst the aesthetics and inclusion values have a closer social sustainability connection. The New Bauhaus social values emerged from the data and the initiative was thus used to further categorise the data, with focus on the social aspects of aesthetic experience and social inclusion to conceptualise social CE in built environment projects.

The main finding of Paper II, as it relates to this dissertation, is the positive social impact on both end-users and the local community which is delivered through a positive aesthetic experience and social inclusion. The aesthetic experience, referred to as the 'vibe' by some respondents, is delivered though the adaptive reuse of existing buildings and their site surroundings, as well as creative content. Social inclusion, referred to as the 'tribe' by some respondents, on the other hand is delivered through engagement activities and accessibility of spaces. Thus, the paper concludes the 'vibe' and the 'tribe' are key elements of social CE in the built environment. The social CE characteristics are presented in Figure 4.

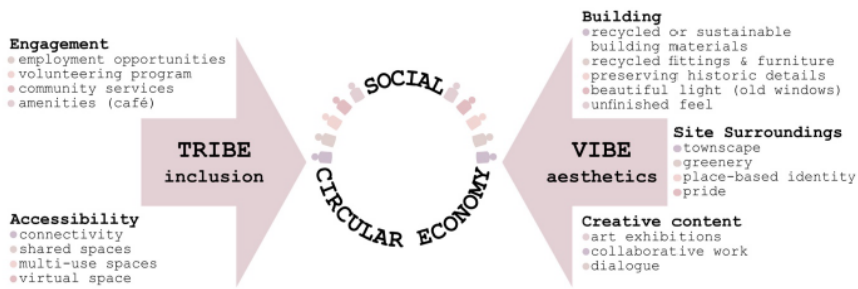

Figure 4. Characteristics of social CE in the built environment.

4.3. Paper III: Adapting for shared use – evaluating the life cycle carbon impact

The main focus of the third paper is the environmental impact assessment process for an adaptive reuse case with shared spaces. Additionally, conclusions could be drawn about material consumption and the related impact which can be utilised to optimise future construction works. The study is a quantitative single-case study which employs two assessments, namely, manual LCA and an online LCA tool, of which the first was undertaken twice utilising typical and conservative values from a public Swedish database (Boverkets klimatdatabas). The data was collected from document review and observations during two separate site visits. The analysis consisted of a comparison between the assessment methods, as well as hot-spot analysis both for life cycle stages and material consumption.

The assessments differ in results, although in reasonable proximity of one another. Notably however, the online tool which was supposed to favour conservative values had a lower total emissions value than both the conservative and typical value manual assessment. There was an inability to clearly define what caused this discrepancy due to the lack of drilling down ability in the online tool module.

Steel was the largest contributor to CO_2e emissions due to difficulties in assessing the structural integrity of the building possibly causing an increased requirement for structural steel compared to if the structural integrity was known. This could be a potential issue for other adaptive reuse cases. On the other hand, concrete and brick which normally make up a significant part of the overall construction emissions, were in this case negligible, confirming findings from previous research (e.g., Itard and Klunder 2007; Ness and Xing 2017) that adaptive reuse significantly saves emissions in these material groups as the structure of the building is kept.

When conducting a hot-spot analysis of the life cycle stages it became evident that the timeframe of the use phase was significantly impacting the results. If a timeframe of the first replacement of an energy efficiency measure (20 years) was used, as was the case in the project LCA documentation, the product stage was the most significant. If the timeframe for the use phase was extended beyond the 20 years, the inverted was true. The savings in embodied carbon through retaining the structure puts emphasis back on the use-phase, however, as can be seen from the significance of the employed timeframe, both the product and the use stage deserves attention in future adaptive reuse cases. As the product phase was significant there should be a continued focus on decreasing use of virgin materials. These findings lead to the conclusion of emphasis being required for both the product and the use stage simultaneously to weigh up any trade-off effects.

4.4. Paper IV: A social sustainability life cycle approach to adaptive reuse

Paper IV aims to establish the social impact of adaptive reuse and shared spaces. Additionally, a general S-LCA framework by UNEP (2020) is tested and adapted to fit in the built environment context. The research design is a qualitative single-case study, however there are some quantitative elements. The S-LCA framework was first supplemented with indicators found in existing social sustainability studies in the built environment context. The adapted framework was used to assess the social sustainability of the case. As per UNEP's S-LCA guidelines a generic assessment was first carried out using generic country and industry level data to identify hot-spots. In the case assessment only those indicators believed to be very unlikely to be significant were disregarded. The case specific data was then collected for the remaining indicators through interviews, document review, and observations at two separate site visits, one during construction and one post completion.

The S-LCA evaluation showed a significant positive social impact, especially to the local community and the end-users. Many of the social sustainability indicators related to the local community had strong links to economic sustainability, such as the indicators for economic development and those related to employment. Most of the overall positive social impact concerns the adaptive reuse of existing building and shared spaces. A minor refurbishment without the added shared spaces would likely lose much of the social impact related to the space itself, such as the positive impact from shared public spaces. Additionally to the impact resulting from adaptive reuse and shared spaces, the owner/developer organisation also has several local community initiatives to increase social sustainability in the area which affects several of the owner/developer's buildings, including those without shared spaces. These initiatives are often carried out in collaboration with local non-profit organisations which have a strong connection to the community. The respondents believe this collaboration enhances the positive impact on the community.

The S-LCA framework, supplemented with indicators specific for the built environment, was found to be a useful tool to assess the social impact of development projects. A list of indicators to supplement the framework is provided in the paper. In the site-specific assessment impact was revealed where the generic assessment discovered no issues. For instance, the generic assessment results of the sub-category 'education for children' suggested the sub-category could be disregarded as the education level in Sweden is at a high standard, however, in the site-specific assessment positive impact was found in this category which would have been disregarded if the sub-category had been removed in the generic assessment step. It is therefore recommended that future assessments do

not disregard indicators that might be lacking significance in the generic assessment and thus risk overlooking site-specific significant issues. This would also avoid a selection bias by organisations.

4.5. Paper V: The life cycle impact and value capture of circular business models in the built environment

The final paper aims to contribute to new knowledge on value capture of CE business models within the built environment, specifically in the context of real estate development. It is a mixed method single-case study where the value capture of two refurbishment options is compared. The main difference between the two options is that the major intervention includes a larger refurbishment scope, as well as adaptation to increase space utilisation, both through smaller but more functional spaces for individual tenants as well as shared spaces.

An existing framework for the evaluation of CE business models is employed together with existing knowledge of life cycle assessments. The following value propositions from the perspective of the real estate developer are established: extending the useful life of the building, stimulating circular activities, creating an industry benchmark, optimising space use, building a community, and climate conscious profit. The environmental, economic, and social value capture is then assessed based on a variety of indicators including vacancy rate, space efficiency, circular activities, waste generation, energy, greenhouse gas emissions, and net present value (NPV).

The study finds that the employed business model assessment framework is useful for assessments in the built environment, if extended to include economic and social impact. The main finding of Paper V in relation to this dissertation, however, is the evaluation of the two refurbishment options which shows that the major scope captures more of the intended value propositions than the minor scope, which lacked space efficiency measures, shared spaces, and engagement activities. This suggests that the addition of shared spaces and other space efficiency measures to adaptive reuse business models enhances the value capture for the organisation. It is however an important consideration that the value capture for optimising space use and climate conscious profit would not be as evident if the functional unit was emissions per m^2 as opposed to emissions per person, therefore capturing not only the traditional functional unit of the building's lettable area, but also the space efficiency in terms of users.

Further, trade-offs were found which need to be considered when refurbishing existing buildings. Increased adaptation also leads to increased environmental impact. The trade-offs are between the total energy use and emissions, and between operational and embodied energy and carbon. In practice, this means that more circular activities do not necessarily equal better environmental performance. Still, adaptive reuse projects save much of the embodied energy and carbon by keeping the brick or concrete construction intact. This does however increase the relative impact of the in-use phase, making operational emissions relevant again. The energy decarbonisation currently underway might on the other hand make the impact from the in-use phase less significant.

The study concludes that adaptive reuse projects should seek to achieve energy reduction and space optimisation in the new operational phase and that several functional units can with favour be used in combination, such as emissions per m^2 and per person, to better understand the potential trade-offs.

5.Discussion

This dissertation sought to provide insights of how CE business models in the built environment can be further developed to consider all three sustainability dimensions and optimise value proposition. The findings are discussed in sub-sections relating to each research question.

5.1. Characteristics of shared spaces and adaptive reuse

Paper I suggests that access-based consumption in the spatial context, namely, shared spaces, would typically include the following dimensions: (1) temporality (access); (2) temporality (duration); (3) temporality (organisation); (4) anonymity (interpersonal); (5) anonymity (spatial); (6) market mediation; (7) consumer involvement; (8) type of accessed space; (9) function of accessed space; (10) political consumerism (antimarket); (11) political consumerism (sustainability).

Paper I further suggest that the political consumerism dimension, particularly the environmental ideals, drive both the intent and outcome of the other dimensions. When selecting the cases for the study it was believed that whether the organisation was for profit or non-profit would impact some of the other dimensions and cases were selected which represented both extremes. However, nothing in the data suggested that the market mediation dimension impacted the other dimensions. This implies that it is the core values and ideology of an organisation which impacts the other dimensions, as opposed to economic factor which Kirchherr et al. (2017) found CE to be focusing on. Additionally, the core values and ideology of an organisation may cause the value proposition as described by Bocken et al. (2014) to include more than the economic dimension.

Further, Paper I found that the CE business model of shared spaces can be enhanced by the inclusion of digitalisation, which supports the findings of Ness and Xing (2017) and Agrawal et al. (2022). In the study hybrid and online solutions were seen to enable shared space organisations to be fluid and thus in constant change, to enable them to deliver the services sought after by the users

despite these preferences changing, as well as adapting to external changes such as the Covid-19 situation. Additionally, the content and collaboration enabled by a facilitator in several of the cases in Papers I and II can be considered as one way of servitizing space, thus supporting the findings of Kojo and Nenonen (2016) that the built environment can be considered a service rather than simply a place, and that the physical space is only one part of the service provision.

Paper II suggests that the use of an existing building, its surroundings, and e.g., artistic content onsite create a positive aesthetic experience, or a 'vibe', Furthermore, engagement activities, such as both online and physical events, and accessibility contribute to social inclusion, referred to as a 'tribe'. The 'vibe' and 'tribe' also emerged as important factors in the social impact assessment in Paper IV. This dissertation therefore suggests that the combination of both the 'vibe' and the 'tribe' is achieved through adaptive reuse and shared spaces together, which can enable the delivery of a social CE.

5.2. Life cycle impact assessment of sharing and adaptive reuse

In order to further develop CE, measuring its impact is crucial (Malabi Eberhardt et al. 2022). Papers III-V all consider how these assessments can be undertaken in the built environment and what factors need to be considered. Findings suggest both the tool and functional unit used affect the results of environmental assessments. This supports the findings by Peuportier et al. (2004), Bueno and Fabricio (2018), and Azevedo et al. (2011) of inconsistencies between LCA tools, and Munarim and Ghisi (2016) who found that the most common functional unit of m^2 did not show the full impact. In Paper III discrepancies were found between the use of an online tool and manual assessments, although the differences were not large it does raise concerns, especially considering the online tool results were lower than the typical values despite the utilised module in the online tool being one that is supposed to favour conservative values, which are higher than the typical values.

When assessing the social impact in the building context the S-LCA framework was shown to be a useful tool in Paper IV. There was however significant impact that would have been overlooked if the framework had not been supplemented with indicators from the built environment context. There will be a trade-off between capturing all significant impact and the resource requirements of collecting all relevant data for the indicators. The framework has over 200 indicators and a further 50 was found to be relevant in the built environment context. The uptake of the framework in the context of CE has been slow (Padilla-Rivera et al. 2020) and for it to be used more actively in industry and research

perhaps a condensed version specific for each sector needs to be produced. Meanwhile, this will limit the ability to compare results across sectors.

In Paper IV it was highlighted by the main tenant that one of the main reasons for locating their offices in that building was the 'vibe' and the 'tribe' which was enabled there. The 'tribe' was, as in the cases in Paper II, closely linked to the shared spaces. Thus, shared spaces might be one of the reasons for a higher value capture, e.g., revenue, as tenants were attracted to the building and the vacancy rate was projected much lower than in the minor refurbishment option in Paper V. Further, findings in Papers I, II and IV related to the 'vibe' was strongly connected to the building being an existing building with a history in the place, despite not necessarily being a listed heritage building.

The social impact assessment carried out in Paper IV showed significant positive impact from an adaptive reuse case with shared spaces. The most significant impact related to the end-users and the local community. Some of the positive impact on the local community found in Paper IV has strong links to economic sustainability, such as the economic development indicator and indicators related to employment. Additionally, in this paper as well as in Paper II the 'vibe and tribe' were considered important to respondents and is therefore suggested to be included as an indicator in S-LCAs undertaken in the context of the built environment. The positive impact was not only seen to impact on the end-users, but also the local community in both studies. For example, the 'vibe' being created through the feeling of the reused building which not only impacted the end-users positively, but also the local community as seen by indicators such as sense of place and cultural heritage related to that stakeholder group in the S-LCA. This was also found by Yung and Chan (2012a) in their study to identify critical factors in building conservation projects for enhancing social sustainability. Another example is the 'tribe' which is enabled largely through shared spaces, of which some are public and thus inviting in those in the local community to be part of the 'tribe'.

Findings from the LCA in Paper III showed a significant saving in the use of concrete and brick in the product phase. Typically, these material groups make up the largest proportion of materials, however in the studied project it was negligible. There was however still a significant amount of steel being used due to the inability to determine the structural integrity of the existing building and was thus likely over dimensioned. Trade-offs in the emissions between the life cycle stages could be seen, where installations which reduced the in-use emissions caused the product stage emissions to rise, such as the installation of solar panels. Therefore, emphasis is required for both the product and the use stage simultaneously to weigh up any trade-off effects.

More significantly, the use of the standard functional unit of emissions per m^2 did not measure the impact of the small loop business model of decreasing space use

through space efficiency measures such as sharing, where more people can use the same area. This supports the findings of Munarim and Ghisi (2016) that the functional unit of emissions per m^2 does not provide a view of the full impact. It is therefore suggested that the functional unit of emissions m^2 is supplemented with emissions per person, and that the two need to be considered in conjunction. With space efficiency being one of the most effective environmental measures according to the hierarchy presented by Reike et al. (2018) it is imperative that this is included in future environmental impact assessments. The occupancy rate is however much more dynamic than the area of the building and can thus cause problems when conducting comparisons. The occupancy rate might change over time, and a building designed for a certain occupancy rate does not necessarily mean the building is utilised to that level. In Papers III and V the occupancy rate was limited to the design occupancy rate at any one time, i.e., the physical capacity of the building as it relates to rules and regulations such as fire safety and ventilation requirements. The occupancy rate capacity employed also neglects to consider time vacancies, i.e., the number of hours that the building is not being used. The actual occupancy rate and person hours was not available as the project was recently completed.

An issue for further consideration is the timeframe employed in life cycle assessments. Paper III highlighted the significance of the in-use stage timeframe, where the project used a 20-year timeframe which was based on when the first energy reduction measure would need to be replaced. When this timeframe was used the product stage had the highest relative impact, however if the timeframe was extended beyond 20-years, the in-use phase was instead the largest. A 50-year in-use stage was therefore employed in Paper V, which is the most typically employed timeframe for built environment life cycle assessments (Pomponi and Moncaster 2016). However, as the climate crisis requires action that reduces emissions now, considering we are on route to reach the 1.5°C within 10 to 15 years (Diffenbaugh and Barnes 2023), it would be prudent to emphasise product stage impacts which are happening here and now (Zimmermann et al. 2023). One way would be to shorten the timeframe used in building life cycle assessments, as seen in Paper III where a shorter timeframe resulted in the product phase weighting higher in terms of total life cycle emissions.

5.3. Optimising value capture from adaptive reuse projects with shared spaces

Despite the findings in Paper I, which suggest the ideology of an organisation impacts the other dimensions of the access-based framework, for profit organisations will still be concerned with profits, and all types of organisations

will need to consider economic sustainability to endure. Findings in Paper V suggest that incorporating space efficiency in adaptive reuse enhances the value capture for the organisation more than a minor refurbishment without the tenant improvements enabling more efficient space utilisation. The value capture for the studied case organisation did not only relate to revenue and included environmental and social aspects alongside, as suggested by Boons and Lüdeke-Freund (2013) signifies a sustainable business model.

In the studied case the space efficiency measures included both smaller but more functional spaces for individual tenants and shared spaces. It might therefore be considered possible that more efficient space without the shared spaces could also capture the value proposition of space optimisation. For example, Francart et al. (2018) suggest both shared spaces and space optimisation to lessen the negative environmental impact of buildings by decreasing the demand for space. However, as seen in Paper IV, as well as in the value proposition building a community in Paper V, without the shared spaces creating the 'tribe' the tenants may not be as willing to lease a space in the building, as well as some of the positive social effects on the local community might be lost.

Nonetheless, trade-offs were found to exist between space efficiency and emissions, where both the total product stage and in-use stage increased due to the measures put in place to increase the efficiency. However, when the emissions were considered on a per person basis as opposed to m^2, the negative environmental impact was reduced for the space efficiency measures in comparison to the refurbishment only. This supports the findings of Munarim and Ghisi (2016) that the emissions per m^2 functional unit does not take into consideration space efficiency and thus does not include a full view of the impact.

5.4. Contribution of the dissertation

Previous research has highlighted the fragmentation between the sustainability dimensions in CE (Kirchherr et al. 2017). Research on adaptive reuse and shared spaces has been focused on separately and usually within one or perhaps two, sustainability dimensions. For example, Itard and Klunder (2007) comparing environmental impact of renovation with new construction, Yung and Chan (2012b) exploring adaptive reuse in relation to sustainable development, Waters-Lynch and Potts (2017) studying coworking spaces from a social perspective, and Durante and Turvani (2018) also studying coworking spaces, however, from an economic perspective. This dissertation has contributed with advancing the characterisation of both shared spaces and adaptive reuse within the built environment context, specifically workplaces such as offices, including coworking spaces, and cultural sector studios. Further, this dissertation found the combination

of adaptive reuse and shared spaces in workplaces to contribute positively to all three sustainability dimensions. By enabling the creation of the 'vibe' and the 'tribe' social sustainability is created not only for the end-users, but also the local community.

Environmental sustainability is mainly enabled through the reduction of embodied energy and carbon in the construction phase. Adding space efficiency measures such as shared spaces the environmental impact per person is further reduced. Further, the addition of space optimisation and shared spaces also contributes positively to economic sustainability, in part through the economic development impact on the local community level as a result of e.g., increased business in the area, but furthermore as it was more profitable than a minor refurbishment without space sharing in terms of NPV. Additionally, more value was captured for the developer in terms of the value propositions, outside of the profit value.

No specific life cycle assessment exists for the evaluation of CE business models in the built environment (Hossain et al. 2020), however LCAs are commonly used for the evaluation of environmental impact of CE in the built environment (e.g., Nasir et al. 2017; Deschamps et al. 2018; Eberhardt et al. 2019a; Minunno et al. 2020; Fufa et al. 2021). Similarly, in this dissertation life cycle assessments were utilised, however across all three sustainability dimensions, and considered valuable in assessing sustainability impacts in the built environment context. Two main considerations have however been put forward in this dissertation in order to improve life cycle assessments in the built environment.

Whilst the LCA is often used in the evaluation of environmental impact for buildings (Ghisellini et al. 2018), focusing solely on emissions per m^2 neglects the positive impact of space optimisation, a short loop CE business model. When conducting the S-LCA indicators had to be supplemented specific for the built environment context in order for significant impact not to be lost. This dissertation therefore suggests that emissions per m^2 is used in combination with emissions per person and that S-LCAs are supplemented with building specific indicators, as presented in Paper IV. Further, it was found that an economic life cycle assessment, through an NPV calculation, can be used in combination with an LCA which has the same system boundaries and life cycle stages. Findings from an S-LCA could additionally be used to compliment the standard LCA results for a holistic perspective on the sustainability impact of a CE business model, as was done in this dissertation.

Thus, the insights from this dissertation advance a holistic CE concept in the built environment. Finding key characteristics of shared spaces and adaptive reuse has furthered the understanding of these CE business models. Findings from life cycle assessments have also highlighted measures which have high impact on a wide range of stakeholders relating to the two CE business models of adaptive reuse and sharing in the context of workplaces. Further, improvement suggestions relating to

the assessment of CE in the built environment are presented as well as ways to optimise development projects, specifically of adaptive reuse and shared spaces. Combining the CE business models of adaptive reuse and shared spaces create the 'vibe' and the 'tribe', which together can enable the delivery of a social CE. Further, the combination of adaptive reuse and shared spaces deliver more of the value propositions from an owner/developer perspective than a minor refurbishment.

Findings are of interest to researchers as well as industry practitioners who aspire to improve sustainability in all three dimensions in projects in the built environment in general, and workplaces specifically. The characterisation of shared spaces can be employed both in research and for industry professionals wishing to better understand the characteristics of shared spaces. The characterisation of shared spaces and adaptive reuse together can be used to frame future research in social CE as well as provide insights to industry professionals of how social CE can be enhanced by adaptive reuse and shared spaces and which related aspects contribute. These aspects can then be taken into consideration in future projects to enhance the delivery of social CE.

Findings from the assessment evaluations are useful for anyone wishing to conduct a life cycle assessment in the built environment as the findings suggest improvement potential, adapts the frameworks to fit the built environment context, and provide insights of possible issues which need to be taken into consideration. For the practitioners, the findings from the assessments provide awareness of how different CE business models, CE measures, and social initiatives impact the different sustainability dimensions. This awareness can assist in optimising the effectiveness of future projects.

5.5. Evaluation of the dissertation

Papers I-IV, appended to this dissertation, have been peer-reviewed and published in scientific journals and conference proceedings. Paper V is currently in a review process. The papers have each outlined the limitations associated with the individual studies. An evaluation of the dissertation research is presented in this section.

The dissertation with its related studies were carried out from a perspective of postmodern research philosophy, which is value-constituted, and thus it is important to reflect on ones underlying values when undertaking research (Heron 1996). The author's reflection is provided in detail in Section 3.1. A postmodern philosophy shaped the research process in some ways, however, these are considered as positive inputs. For example, in postmodernism the researcher should be open to many types of data sources, both of a qualitative and a

quantitative nature which was one of the reasons mixed methods were employed. Case studies were chosen as a strategy partly due to postmodernism favouring in-depth investigations of phenomena (Saunders et al. 2009), which suggest case studies are appropriate (Yin 2009).

High construct validity was provided through the multiple methods and data sources employed, both within and across the individual papers. The methods and data sources were chosen for their potential to answer the research questions. For example, life cycle assessments were chosen as they are commonly used in evaluation of both CE and in the built environment. Thus, the life cycle assessments were deemed appropriate to be able to analyse and conclude part of the optimal adaptive reuse option in paper V, whilst simultaneously being evaluated as methods to further the life cycle assessments in the built environment. However, further insights were required to answer the research question and qualitative data therefore supplemented the dataset. To enable analysis of both quantitative and qualitative data the value propositions of the organisation were first established. These could then be evaluated with either quantitative or qualitative data. Conclusions were then drawn for each value proposition individually and a final optimal solution could be suggested based on which option met the most value propositions. However, in order to further the analysis between quantitative and qualitative data and the related value propositions an analytic hierarchy process (AHP) could have been employed. However, the focus in paper V was to provide an initial view of value propositions in adaptive reuse and for each proposition suggest which refurbishment option is the optimal. Further research could include an AHP in order to provide a framework for decision making, which was not the aim of paper V.

In terms of life cycle assessments, the S-LCA is a less established method than the LCA and it was therefore supplemented with indicators from the built environment and further improvement suggestions were made in the conclusions of Paper IV. Employing a less established method creates uncertainties of the findings. As Paper IV concludes, more work is required to increase the uptake of the S-LCA framework and to ensure it captures the intended impact.

Internal validity relates to how the existing conditions impacted on the outcome (Yin 2009), and if the results were affected by a variable which was not considered (Saunders et al. 2009), i.e., if the results are what they appear to be. In the studies related to this dissertation, national and industry data was at times used where case specific data was lacking. This might have affected the outcome of the results, for instance in the LCA, where non-case specific data could have provided results which would not have been the same if case specific data was utilised. In Paper III however, the same case was assessed through two tools and three data sets, and showed a variation which was not considered significant. The different methods and datasets were however only possible in the products stage, as the online tool only allowed for this stage to be inputted. This means that any discrepancies in the

other stages were not considered in the comparison and data issues could therefore have been neglected. Additionally, in Paper V where the emissions from maintenance were included, an input-output model was used, based on costs which are translated into emissions through national and international input-output matrices, instead of calculating emissions by material type and weight. Input-output based LCAs are typically less accurate than process-based LCAs, but their benefit lies in widening the system boundaries. The majority of the LCA was carried out employing a process-based strategy. However, for the purpose of the study it was however deemed important to include the emissions from maintenance into the assessment to get a comprehensive view of the in-use emissions.

Meanwhile, in the S-LCA it is recommended in the guidelines to use national and industry data to first conduct a general assessment and find hot-spots to look further into (UNEP 2020). Thus, in that instance the use of non-site-specific data was not considered to impact the results, especially considering only those indicators deemed very unlikely to be significant were removed through the generic assessment. The S-LCA did however assess the intended impact, as opposed to the actual impact. This is a recommendation in the guidelines (UNEP 2020), however consideration must be given to a possible gap between intended and actual impact.

External validity relates to whether the findings from the study can be generalised (Robson 2002). Statistical generalisation is not possible from case study research, and this was not the intent of the dissertation. Instead, the aim of the dissertation was analytic generalisation, where theories are expanded and generalised without probabilities, and characteristics are identified which may be transferable to other cases (Yin 2009). Through characterisation and life cycle assessments in triangulated studies characteristics were identified which may be transferable to other cases. However, due to the tendency of built environment project to differ from one another, especially in the case of adaptive reuse, it could be difficult to establish benchmarks.

Reliability of this dissertation is further enhanced by clearly outlining the case selection criteria for each study, enabling similar cases to be selected in future studies. The data and data sources have been summarised and presented in each individual paper with the context described in detail. However, the data is contextual and thus difficult to replicate.

Further, the combination of the different data collection approaches enabled method triangulation. Each method included several data sources, which in turn enabled data triangulation as well as a richer data set. Triangulation increases the reliability (Robson 2002), i.e., the repeatability (Yin 2009), of research. Additionally to method and data triangulation, researcher triangulation, where more than one researcher was involved in data collection and analysis, was applied

to Papers I-III and V. As Paper IV was produced with the author of this dissertation as the sole author, this was not the case in that study. The study did however employ a mixed methods approach and several data sources.

6.Conclusions

This dissertation focused on the combination of adaptive reuse and shared spaces in workplaces which was shown to have positive sustainability impact on end-users and local community. Negative environmental impact in terms of CO_2e emissions is reduced by saving much of the building structure, which is known to have the largest impact in relation to other building elements. Using space more efficiently also has positive implications on environmental sustainability by reducing the emissions per person. In addition to positive social impact on end-users of adaptive reuse buildings with shared spaces, significant positive impact was also found on the local community. Some social sustainability indicators affecting the local community also have strong ties to the economic dimension, such as economic development and employment. Adaptive reuse in combination with shared spaces thus has a positive impact on all sustainability dimensions.

Existing frameworks and concepts can with favour be used to analyse and evaluate CE business models in the built environment. In this dissertation one existing theoretical framework, namely access-based consumption, and one policy initiative, namely the New European Bauhaus, were used and the former was also adapted to better suit the built environment context. Existing assessment frameworks were also employed, namely LCA, LCP and S-LCA. Whilst the LCA and LCP were already fit for purpose and the LCA frequently used in built environment evaluations, the S-LCA was adapted to better suit the built environment context and can be used in future evaluations in the context. Two main considerations have been put forward in this dissertation in order to improve life cycle assessments of CE business models in the built environment, namely additional functional units capturing space efficiency and social indicators specific to the built environment context.

A framework for evaluating the environmental value proposition of CE business models was also employed to frame one of the studies and assisted in broadening the analysis. The framework focused on environmental value propositions and suggested evaluation methods to include an LCA. In order to broaden the value proposition of CE business models the economic dimension was added and was evaluated by employing an LCP. The LCP showed an increase in revenue which made the space optimisation refurbishment option the most profitable, which would have been missed if a traditional LCC was carried out.

Assessment results showed that in order to optimise the environmental sustainability impact of adaptive reuse, consideration need to be taken regarding the trade-offs between product and use phase emissions which have a complex relationship. Additionally, although adaptive reuse was shown to be superior to a minor refurbishment in terms of value capture, the investment had a larger absolute and per m^2 environmental impact than the minor option. When considering per person emissions the inverted was true. This further highlights the need to consider complexity and trade-offs in environmental impact assessments.

In order to optimise adaptive reuse with workplaces holistically across all sustainability dimensions shared spaces can with benefit be included, to create the 'vibe' and 'tribe'. Shared spaces in combination with adaptive reuse deliver the 'vibe' and the 'tribe' through social inclusion enabled by such features as shared public spaces, and through the building aesthetics and site surroundings, together with content within the space. Organisations delivering shared spaces were found to be inherently fluid which was enabled by a strong virtual or hybrid presence, delivering content both in the physical and virtual space.

Combining adaptive reuse and shared spaces in workplaces could present the opportunity to significantly contribute to sustainable development. Adaptive reuse saves a large amount of material, energy, and consequent carbon emissions compared to new construction. Adaptive reuse already contributes to a positive social impact, however when including shared spaces this is further increased. The addition of shared spaces also allowed more value to be captured by the developer. Thus, adaptive reuse and shared spaces is a way of combining two CE business models in the built environment context to deliver sustainability across all three dimensions.

6.1. Future research needs and final remarks

Previous research found tension between the three sustainability dimensions (Bañon Gomis et al. 2011; Fischer et al. 2020), where some environmental sustainability measures are accused of negatively affecting one or both other dimensions, and vice versa. Further, Malabi Eberhardt et al. (2022) suggests a lack of knowledge of environmental impacts and benefits is the reason for the slow uptake of CE business models. Finding solutions which can have a positive impact across the dimensions can lead to a higher uptake as the tension between the sustainability dimensions can be weakened. Further research is required which assesses additional CE business models in the built environment on a holistic level, including all sustainability dimensions. Additionally, currently the CE hierarchy solely relate to value retention, in the way of saving natural resources (Reike et al. 2018). Hierarchies could instead be based on all three dimensions.

This would require a definition of social value retention as well as weighting the impacts of each dimension in order to form a hierarchy based on all three dimensions.

In the measuring of social sustainability further research is needed to determine which indicators should be included in assessments in order for them to both capture significant impact, positive and negative, whilst not being too complex as to increase uptake. Current S-LCA framework is extensive and resource intensive which could limit its uptake, however reducing the scope might lead to significant impact being neglected.

Another important factor to increase uptake is to accurately show the sustainability impact of investments through measuring the right things (Malabi Eberhardt et al. 2022). Further research is needed regarding the functional units employed in environmental assessments. For example, in Paper V the functional unit of m^2 and per person was suggested, however per person was measured in terms of the number of people using the facility at any one time. This measure excludes the time vacancy factor, meaning that any measures which increases the times which a building can be used is not included. Future studies may wish to explore the per person measure so that it captures time vacancies.

References

Abowitz, D.A. and Toole, T.M. 2019. Mixed Method Research: Fundamental Issues of Design, Validity, and Reliability in Construction Research. *J. Constr. Eng. Manage.* 136(1), pp. 108–116. doi: 10.1061/ASCECO.1943-7862.0000026.

Agrawal, R., Wankhede, V.A., Kumar, A., Upadhyay, A. and Garza-Reyes, J.A. 2022. Nexus of circular economy and sustainable business performance in the era of digitalization. *International Journal of Productivity and Performance Management* 71(3), pp. 748–774. doi: 10.1108/IJPPM-12-2020-0676.

Akhimien, N.G., Latif, E. and Hou, S.S. 2021. Application of circular economy principles in buildings: A systematic review. *Journal of Building Engineering* 38. doi: 10.1016/j.jobe.2020.102041.

Amaratunga, D., Baldry, D., Sarshar, M. and Newton, R. 2002. Quantitative and qualitative research in the built environment: application of "mixed" research approach. *Work Study* 51(1), pp. 17–31. doi: 10.1108/00438020210415488.

Andersen, S.C., Birgisdottir, H. and Birkved, M. 2022. Life Cycle Assessments of Circular Economy in the Built Environment—A Scoping Review. *Sustainability (Switzerland)* 14(11). doi: 10.3390/su14116887.

Antikainen, M., Uusitalo, T. and Kivikytö-Reponen, P. 2018. Digitalisation as an Enabler of Circular Economy. In: *Procedia CIRP*. Elsevier B.V., pp. 45–49. doi: 10.1016/j.procir.2018.04.027.

Armstrong, G., Wilkinson, S. and Cilliers, E.J. 2023. A framework for sustainable adaptive reuse: understanding vacancy and underuse in existing urban buildings. *Frontiers in Sustainable Cities* 5. doi: 10.3389/frsc.2023.985656.

Arup. 2016. *Circular Economy in the Built Environment - Arup*. Available at: https://www.arup.com/perspectives/publications/research/section/circular-economy-in-the-built-environment [Accessed: 11 March 2019].

Assefa, G. and Ambler, C. 2017. To demolish or not to demolish: Life cycle consideration of repurposing buildings. *Sustainable Cities and Society* 28, pp. 146–153. doi: 10.1016/j.scs.2016.09.011.

Azevedo, M., Oliveira, M., Pereira, J.P. and Reis, A. 2011. Comparison of two LCA methodologies in the machine-tools environmental performance

improvement process. In: *Glocalized Solutions for Sustainability in Manufacturing - Proceedings of the 18th CIRP International Conference on Life Cycle Engineering*. Springer Science and Business Media, LLC, pp. 575–580. doi: 10.1007/978-3-642-19692-8_100.

Baden, D., Peattie, K. and Oke, A. 2020. Access over ownership: Case studies of libraries of things. *Sustainability (Switzerland)* 12(17). doi: 10.3390/su12177180.

Baker, H., Moncaster, A., Remøy, H. and Wilkinson, S. 2021. Retention not demolition: how heritage thinking can inform carbon reduction. *Journal of Architectural Conservation* 27(3), pp. 176–194. Available at: https://www.tandfonline.com/doi/full/10.1080/13556207.2021.1948239.

Bañon Gomis, A.J., Guillén Parra, M., Hoffman, W.M. and Mcnulty, R.E. 2011. Rethinking the Concept of Sustainability. *Business and Society Review* 116(2), pp. 171–191. doi: 10.1111/j.1467-8594.2011.00381.x.

Bardhi, F. and Eckhardt, G.M. 2012. Access-Based Consumption: The Case of Car Sharing. *Journal of Consumer Research* 39(4), pp. 881–898. Available at: https://www.journals.uchicago.edu/doi/10.1086/663766.

Bejrum, H. 1991. *Livscykelekonomiska kalkyler för byggnader och fastigheter*.

Belk, R. 2014a. Sharing versus pseudo-sharing in web 2.0. *Anthropologist* 18(1), pp. 7–23. doi: 10.1080/09720073.2014.11891518.

Belk, R. 2014b. You are what you can access: Sharing and collaborative consumption online. *Journal of Business Research* 67(8), pp. 1595–1600. doi: 10.1016/j.jbusres.2013.10.001.

Berbegal-Mirabent, J. 2021. What do we know about co-working spaces? Trends and challenges ahead. *Sustainability (Switzerland)* 13(3), pp. 1–30. doi: 10.3390/su13031416.

Berglund, D., Kharazmi, P., Miliutenko, S., Björk, F. and Malmqvist, T. 2018. Comparative life-cycle assessment for renovation methods of waste water sewerage systems for apartment buildings. *Journal of Building Engineering* 19, pp. 98–108. doi: 10.1016/j.jobe.2018.04.019.

Bocken, N.M.P., Short, S.W., Rana, P. and Evans, S. 2014. A literature and practice review to develop sustainable business model archetypes. *Journal of Cleaner Production*. doi: 10.1016/j.jclepro.2013.11.039.

Böcker, L. and Meelen, T. 2017. Sharing for people, planet or profit? Analysing motivations for intended sharing economy participation. *Environmental Innovation and Societal Transitions* 23, pp. 28–39. doi: 10.1016/j.eist.2016.09.004.

Boons, F. and Lüdeke-Freund, F. 2013. *Business models for sustainable innovation: State-of-the-art and steps towards a research agenda*. doi: 10.1016/j.jclepro.2012.07.007.

Bragança, L., Mateus, R. and Koukkari, H. 2010. Building sustainability assessment. *Sustainability* 2(7), pp. 2010–2023. doi: 10.3390/su2072010.

Brinkø, R., van Meel, J. and Nielsen, S. 2014. The shared building portfolio: An exploration and typology. In: *CIB Facilities Management Conference 21-23 May 2014*. Available at: https://www.researchgate.net/publication/264868394.

Brinkø, R. and Nielsen, S.B. 2017. The characteristics to consider in municipal shared spaces. *Journal of Facilities Management*. doi: 10.1108/JFM-11-2016-0051.

Brinkø, R. and Nielsen, S.B. 2018. Multiplying the use of space and what it implies in practice: a cross-case analysis. *Journal of Facilities Management* 16(2), pp. 197–216. doi: 10.1108/JFM-09-2017-0045.

Brinkø, R., Nielsen, S.B. and Meel, J. Van. 2015. Access over ownership – a typology of shared space. *Facilities* 33(11–12), pp. 736–751. doi: 10.1108/F-11-2014-0094.

Brown, J. 2017. Curating the "Third Place"? Coworking and the mediation of creativity. *Geoforum* 82, pp. 112–126. doi: 10.1016/j.geoforum.2017.04.006.

Bueno, C. and Fabricio, M.M. 2018. Comparative analysis between a complete LCA study and results from a BIM-LCA plug-in. *Automation in Construction* 90, pp. 188–200. doi: 10.1016/j.autcon.2018.02.028.

Bullen, P. and Love, P. 2011. A new future for the past: A model for adaptive reuse decision-making. *Built Environment Project and Asset Management* 1(1), pp. 32–44. doi: 10.1108/20441241111143768.

Bullen, P.A. 2007. Adaptive reuse and sustainability of commercial buildings. *Facilities* 25(1–2), pp. 20–31. doi: 10.1108/02632770710716911.

Bullen, P.A. and Love, P.E.D. 2010. The rhetoric of adaptive reuse or reality of demolition: Views from the field. *Cities* 27(4), pp. 215–224. doi: 10.1016/j.cities.2009.12.005.

Capdevila, I. 2013. Knowledge dynamics in localized communities: coworking spaces as microclusters. *SSRN*.

Çimen, Ö. 2021. Construction and built environment in circular economy: A comprehensive literature review. *Journal of Cleaner Production* 305. doi: 10.1016/j.jclepro.2021.127180.

Conejos, S., Langston, C. and Smith, J. 2015. Enhancing sustainability through designing for adaptive reuse from the outset: A comparison of adaptstar and adaptive reuse potential (ARP) models. *Facilities* 33(9–10), pp. 531–552. doi: 10.1108/F-02-2013-0011.

Crawford, R. 2013. *Life Cycle Assessment in the Built Environment*. New York: Routledge.

Cruz Rios, F., Grau, D. and Bilec, M. 2021. Barriers and Enablers to Circular Building Design in the US: An Empirical Study. *Journal of Construction Engineering and Management* 147(10), p. 04021117. doi: 10.1061/(asce)co.1943-7862.0002109.

Curtis, S.K. and Lehner, M. 2019. Defining the sharing economy for sustainability. *Sustainability (Switzerland)* 11(3). doi: 10.3390/su11030567.

Curtis, S.K. and Mont, O. 2020. Sharing economy business models for sustainability. *Journal of Cleaner Production* 266. doi: 10.1016/j.jclepro.2020.121519.

Dabaieh, M., Heinonen, J., El-Mahdy, D. and Hassan, D.M. 2020. A comparative study of life cycle carbon emissions and embodied energy between sun-dried bricks and fired clay bricks. *Journal of Cleaner Production* 275. doi: 10.1016/j.jclepro.2020.122998.

Daunorienė, A., Drakšaitė, A., Snieška, V. and Valodkienė, G. 2015. Evaluating Sustainability of Sharing Economy Business Models. *Procedia - Social and Behavioral Sciences* 213, pp. 836–841. doi: 10.1016/j.sbspro.2015.11.486.

Deschamps, J., Simon, B., Tagnit-Hamou, A. and Amor, B. 2018. Is open-loop recycling the lowest preference in a circular economy? Answering through LCA of glass powder in concrete. *Journal of Cleaner Production* 185, pp. 14–22. doi: 10.1016/j.jclepro.2018.03.021.

Diffenbaugh, N.S. and Barnes, E.A. 2023. Data-driven predictions of the time remaining until critical global warming thresholds are reached. *Proceedings of the National Academy of Sciences of the United States of America* 120(6). doi: 10.1073/pnas.2207183120.

Domenech, T. and Bahn-Walkowiak, B. 2019. Transition Towards a Resource Efficient Circular Economy in Europe: Policy Lessons From the EU and the Member States. *Ecological Economics* 155, pp. 7–19. doi: 10.1016/j.ecolecon.2017.11.001.

Durante, G. and Turvani, M. 2018. Coworking, the Sharing Economy, and the City: Which Role for the 'Coworking Entrepreneur'? *Urban Science* 2(3), p. 83. doi: 10.3390/urbansci2030083.

Dytianquin, N., Gregersen-Hermans, J., Kalogeras, N., Van Oorschot, J. and Ritzen, M. 2021. Circularity in Selected EU Countries: The Case of Construction and Demolition Industry. In: *IOP Conference Series: Earth and Environmental Science*. IOP Publishing Ltd. doi: 10.1088/1755-1315/855/1/012017.

Eberhardt, L., Birgisdottir, H. and Birkved, M. 2019a. Comparing life cycle assessment modelling of linear vs. circular building components. In: *IOP Conference Series: Earth and Environmental Science*. Institute of Physics Publishing. doi: 10.1088/1755-1315/225/1/012039.

Eberhardt, L., Birgisdóttir, H. and Birkved, M. 2019b. Life cycle assessment of a Danish office building designed for disassembly. *Building Research and Information* 47(6), pp. 666–680. doi: 10.1080/09613218.2018.1517458.

Echeverri, N., Jylhä, T. and Koppels, P. 2021. Searching for flexibility in corporate real estate portfolio: Six co-working strategies for user corporations. *Buildings* 11(3). doi: 10.3390/buildings11030115.

Eckhardt, G. and Bardhi, F. 2015. The Sharing Economy Isn't About Sharing at All. *Harvard Business Review*.

Ellen MacArthur Foundation. 2013. *Towards the Circular Economy, Opportunities for the consumer goods sector 2 Pre-print version*.

Ellen MacArthur Foundation. 2015a. *Circularity indicators: an approach to measuring circularity*. Available at: http://www.ellenmacarthurfoundation.org/circularity-indicators/.

Ellen MacArthur Foundation. 2015b. *Delivering the circular economy. A toolkit for policymakers.*

European Commission. 2011. *Roadmap to a Resource Efficient Europe*. Brussels.

European Commission. 2014. *EU Resource Efficiency Scoreboard*. Available at: http://europa.eu.

European Commission. 2015. *Closing the loop - An EU action plan for the Circular Economy*. Brussels.

European Commission. 2020. *A new Circular Economy Action Plan*. Available at: https://www.un.org/sustainabledevelopment/sustainable-consumption-production/.

European Union. 2021. *New European Bauhaus*. Available at: https://new-european-bauhaus.europa.eu/about/about-initiative_en [Accessed: 10 May 2023].

Ferreira, J., Duarte Pinheiro, M. and De Brito, J. 2015. Economic and environmental savings of structural buildings refurbishment with demolition and reconstruction - A Portuguese benchmarking. *Journal of Building Engineering* 3, pp. 114–126. doi: 10.1016/j.jobe.2015.07.001.

Filho, W.L., Azul, A.M., Brandli, L., Özuyar, P.G. and Wall, T. 2020. *Encyclopedia of the UN Sustainable Development Goals Series Editor*. Available at: https://www.springer.com/series/15893.

Fischer, D., Brettel, M. and Mauer, R. 2020. The Three Dimensions of Sustainability: A Delicate Balancing Act for Entrepreneurs Made More Complex by Stakeholder Expectations. *Journal of Business Ethics* 163(1), pp. 87–106. doi: 10.1007/s10551-018-4012-1.

Flyvbjerg, B. 2006. Five misunderstandings about case-study research. *Qualitative Inquiry* 12(2), pp. 219–245. doi: 10.1177/1077800405284363.

Folger, R. and Stein, C. 2017. Abduction 101: Reasoning processes to aid discovery. *Human Resource Management Review* 27(2), pp. 306–315. doi: 10.1016/j.hrmr.2016.08.007.

Foster, G. 2020. Circular economy strategies for adaptive reuse of cultural heritage buildings to reduce environmental impacts. *Resources, Conservation and Recycling* 152. doi: 10.1016/j.resconrec.2019.104507.

Francart, N., Höjer, M., Mjörnell, K., Orahim, A.S., von Platten, J. and Malmqvist, T. 2020. Sharing indoor space: stakeholders' perspectives and energy metrics. *Buildings and Cities* 1(1), pp. 70–85. doi: 10.5334/bc.34.

Francart, N., Malmqvist, T. and Hagbert, P. 2018. Climate target fulfilment in scenarios for a sustainable Swedish built environment beyond growth. *Futures* 98, pp. 1–18. doi: 10.1016/j.futures.2017.12.001.

Fufa, S.M., Flyen, C. and Flyen, A.C. 2021. How can existing buildings with historic values contribute to achieving emission reduction ambitions? *Applied Sciences (Switzerland)* 11(13). doi: 10.3390/app11135978.

Geissdoerfer, M., Pieroni, M.P.P., Pigosso, D.C.A. and Soufani, K. 2020. Circular business models: A review. *Journal of Cleaner Production* 277. doi: 10.1016/j.jclepro.2020.123741.

Geissdoerfer, M., Savaget, P., Bocken, N.M.P. and Hultink, E.J. 2017. The Circular Economy – A new sustainability paradigm? *Journal of Cleaner Production* 143, pp. 757–768. doi: 10.1016/j.jclepro.2016.12.048.

Ghisellini, P., Cialani, C. and Ulgiati, S. 2016. A review on circular economy: The expected transition to a balanced interplay of environmental and economic systems. *Journal of Cleaner Production* 114, pp. 11–32. doi: 10.1016/j.jclepro.2015.09.007.

Ghisellini, P., Ripa, M. and Ulgiati, S. 2018. Exploring environmental and economic costs and benefits of a circular economy approach to the construction

and demolition sector. A literature review. *Journal of Cleaner Production* 178, pp. 618–643. doi: 10.1016/j.jclepro.2017.11.207.

Giorgi, S., Lavagna, M. and Campioli, A. 2019. Circular economy and regeneration of building stock in the Italian context: Policies, partnership and tools. In: *IOP Conference Series: Earth and Environmental Science*. Institute of Physics Publishing. doi: 10.1088/1755-1315/225/1/012065.

Goel, A., Ganesh, L.S. and Kaur, A. 2020. Social sustainability considerations in construction project feasibility study: a stakeholder salience perspective. *Engineering, Construction and Architectural Management* 27(7), pp. 1429–1459. doi: 10.1108/ECAM-06-2019-0319.

Gressgård, L.J. 2011. Virtual team collaboration and innovation in organizations. *Team Performance Management* 17(1), pp. 102–119. doi: 10.1108/13527591111114738.

Hauschild, M.Z., Rosenbaum, R.K. and Olsen, S.I. 2018. *Life Cycle Assessment*. Cham: Springer International Publishing.

Henry, M., Schraven, D., Bocken, N., Frenken, K., Hekkert, M. and Kirchherr, J. 2021. The battle of the buzzwords: A comparative review of the circular economy and the sharing economy concepts. *Environmental Innovation and Societal Transitions* 38(November 2020), pp. 1–21. Available at: https://doi.org/10.1016/j.eist.2020.10.008.

Heron, J. 1996. *Co-operative Inquiry: Research into the Human Condition*. London: Sage.

Hossain, M.U., Ng, S.T., Antwi-Afari, P. and Amor, B. 2020. Circular economy and the construction industry: Existing trends, challenges and prospective framework for sustainable construction. *Renewable and Sustainable Energy Reviews* 130. doi: 10.1016/j.rser.2020.109948.

Huuhka, S. and Vestergaard, I. 2020. Building conservation and the circular economy: a theoretical consideration. *Journal of Cultural Heritage Management and Sustainable Development* 10(1), pp. 29–40. doi: 10.1108/JCHMSD-06-2019-0081.

Ibn-Mohammed, T., Greenough, R., Taylor, S., Ozawa-Meida, L. and Acquaye, A. 2013. Operational vs. embodied emissions in buildings - A review of current trends. *Energy and Buildings* 66, pp. 232–245. doi: 10.1016/j.enbuild.2013.07.026.

IPCC. 2023. *Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel*

on Climate Change. Arias, P. et al. eds. Available at: https://www.ipcc.ch/report/ar6/syr/.

ISO14044. 2006. *Environmental management - Life cycle assessment - Requirements and guidelines*.

Itard, L. and Klunder, G. 2007. Comparing environmental impacts of renovated housing stock with new construction. *Building Research and Information* 35(3), pp. 252–267. doi: 10.1080/09613210601068161.

IVL Svenska Miljöinstitutet. 2019. *The sharing potential*.

Jakonen, M., Kivinen, N., Salovaara, P. and Hirkman, P. 2017. Towards an Economy of Encounters? A critical study of affectual assemblages in coworking. *Scandinavian Journal of Management* 33(4), pp. 235–242. doi: 10.1016/j.scaman.2017.10.003.

Kirchherr, J., Reike, D. and Hekkert, M. 2017. Conceptualizing the Circular Economy: An Analysis of 114 Definitions. *SSRN Electronic Journal*. doi: 10.2139/ssrn.3037579.

Kojo, I. and Nenonen, S. 2016. Typologies for co-working spaces in Finland – What and how? *Facilities* 34(5–6), pp. 302–313. doi: 10.1108/F-08-2014-0066.

Korhonen, J., Honkasalo, A. and Seppälä, J. 2018. Circular Economy: The Concept and its Limitations. *Ecological Economics* 143, pp. 37–46. Available at: https://doi.org/10.1016/j.ecolecon.2017.06.041.

Krausmann, F. et al. 2017. Global socioeconomic material stocks rise 23-fold over the 20th century and require half of annual resource use. *Proceedings of the National Academy of Sciences of the United States of America* 114(8), pp. 1880–1885. doi: 10.1073/pnas.1613773114.

Kyrö, R. 2020. Share, preserve, adapt, rethink - A focused framework for circular economy. *IOP Conference Series: Earth and Environmental Science* 588(4). doi: 10.1088/1755-1315/588/4/042034.

Kyrö, R., Jylhä, T. and Peltokorpi, A. 2019. Embodying circularity through usable relocatable modular buildings. *Facilities* 37(1–2), pp. 75–90. doi: 10.1108/F-12-2017-0129.

Kyrö, R., Peltokorpi, A. and Artto, K. 2016. Connectivity, cost-efficiency, community and collaboration. *Facilities* 34(13/14), pp. 873–890. Available at: http://www.emeraldinsight.com/doi/10.1108/F-05-2015-0032 [Accessed: 7 March 2019].

Lange, L. 2022. Business Models, Including Higher Value Products for the New Circular, Resource-Efficient Biobased Industry. *Frontiers in Sustainability* 3. doi: 10.3389/frsus.2022.789435.

Langston, C. 2008. The sustainability implications of building adaptive reuse. In: *Chinese Research Institute of Construction Management (CRIOCM) International Symposium, Beijing , China*. Available at: http://epublications.bond.edu.au/sustainable_development/4.

Langston, C., Wong, F.K.W., Hui, E.C.M. and Shen, L.Y. 2008. Strategic assessment of building adaptive reuse opportunities in Hong Kong. *Building and Environment* 43(10), pp. 1709–1718. doi: 10.1016/j.buildenv.2007.10.017.

Larsen, V.G., Tollin, N., Sattrup, P.A., Birkved, M. and Holmboe, T. 2022. What are the challenges in assessing circular economy for the built environment? A literature review on integrating LCA, LCC and S-LCA in life cycle sustainability assessment, LCSA. *Journal of Building Engineering* 50. doi: 10.1016/j.jobe.2022.104203.

Lawson, S.J., Gleim, M.R. and Hartline, M.D. 2021. Decisions, decisions: variations in decision-making for access-based consumption. *Journal of Marketing Theory and Practice* 29(3), pp. 358–374. doi: 10.1080/10696679.2020.1855990.

Leising, E., Quist, J. and Bocken, N. 2018. Circular Economy in the building sector: Three cases and a collaboration tool. *Journal of Cleaner Production* 176, pp. 976–989. doi: 10.1016/j.jclepro.2017.12.010.

Lentini, L. and Decortis, F. 2010. Space and places: When interacting with and in physical space becomes a meaningful experience. *Personal and Ubiquitous Computing* 14(5), pp. 407–415. doi: 10.1007/s00779-009-0267-y.

Liu, S. and Qian, S. 2019. Evaluation of social life-cycle performance of buildings: Theoretical framework and impact assessment approach. *Journal of Cleaner Production* 213, pp. 792–807. doi: 10.1016/j.jclepro.2018.12.200.

Lundgren, R., Kyrö, R. and Olander, S. 2023. Circular Economy in the Nordic Real Estate and Construction Industry: A Policy Review. In: *Nordic Conference on Construction Economics and Organization CREON 2022: SDGs in Construction Economics and Organization*. Springer, pp. 297–310.

Malabi Eberhardt, L., Birkved, M. and Birgisdottir, H. 2022. Building design and construction strategies for a circular economy. *Architectural Engineering and Design Management* 18(2), pp. 93–113. doi: 10.1080/17452007.2020.1781588.

Manninen, K., Koskela, S., Antikainen, R., Bocken, N., Dahlbo, H. and Aminoff, A. 2018. Do circular economy business models capture intended environmental

value propositions? *Journal of Cleaner Production* 171, pp. 413–422. Available at: https://doi.org/10.1016/j.jclepro.2017.10.003.

Di Marino, M. and Lapintie, K. 2017. Emerging Workplaces in Post-Functionalist Cities. *Journal of Urban Technology* 24(3), pp. 5–25. doi: 10.1080/10630732.2017.1297520.

Mei-Hui Yang, M. 2004. Spatial Struggles: Postcolonial Complex, State Disenchantment, and Popular Reappropriation of Space in Rural Southeast China. *Journal of Asian Studies* 63(3), pp. 719–755. doi: 10.1017/S002191180400169X.

Mies, A. and Gold, S. 2021. Mapping the social dimension of the circular economy. *Journal of Cleaner Production* 321. doi: 10.1016/j.jclepro.2021.128960.

Minunno, R., O'Grady, T., Morrison, G.M. and Gruner, R.L. 2020. Exploring environmental benefits of reuse and recycle practices: A circular economy case study of a modular building. *Resources, Conservation and Recycling* 160. doi: 10.1016/j.resconrec.2020.104855.

Munarim, U. and Ghisi, E. 2016. Environmental feasibility of heritage buildings rehabilitation. *Renewable and Sustainable Energy Reviews* 58, pp. 235–249. doi: 10.1016/j.rser.2015.12.334.

Munaro, M.R., Tavares, S.F. and Bragança, L. 2020. Towards circular and more sustainable buildings: A systematic literature review on the circular economy in the built environment. *Journal of Cleaner Production* 260. doi: 10.1016/j.jclepro.2020.121134.

Murray, A., Skene, K. and Haynes, K. 2017. The Circular Economy: An Interdisciplinary Exploration of the Concept and Application in a Global Context. *Journal of Business Ethics* 140(3), pp. 369–380. doi: 10.1007/s10551-015-2693-2.

Nasir, M.H.A., Genovese, A., Acquaye, A.A., Koh, S.C.L. and Yamoah, F. 2017. Comparing linear and circular supply chains: A case study from the construction industry. *International Journal of Production Economics* 183, pp. 443–457. doi: 10.1016/j.ijpe.2016.06.008.

Ness, D.A. and Xing, K. 2017. Toward a Resource-Efficient Built Environment: A Literature Review and Conceptual Model. *Journal of Industrial Ecology* 21(3), pp. 572–592. doi: 10.1111/jiec.12586.

Nußholz, J., Çetin, S., Eberhardt, L., De Wolf, C. and Bocken, N. 2023. From circular strategies to actions: 65 European circular building cases and their decarbonisation potential. *Resources, Conservation and Recycling Advances* 17. doi: 10.1016/j.rcradv.2023.200130.

Orel, M. and Alonso Almeida, M. del M. 2019. The ambience of collaboration in coworking environments. *Journal of Corporate Real Estate* 21(4), pp. 273–289. doi: 10.1108/JCRE-12-2018-0050.

Osterwalder, A., Pigneur, Y. and Tucci, C.L. 2005. Clarifying Business Models: Origins, Present, and Future of the Concept. *Communications of the Association for Information Systems* 16. doi: 10.17705/1cais.01601.

Padilla-Rivera, A., do Carmo, B.B.T., Arcese, G. and Merveille, N. 2021. Social circular economy indicators: Selection through fuzzy delphi method. *Sustainable Production and Consumption* 26, pp. 101–110. doi: 10.1016/j.spc.2020.09.015.

Padilla-Rivera, A., Russo-Garrido, S. and Merveille, N. 2020. Addressing the social aspects of a circular economy: A systematic literature review. *Sustainability (Switzerland)* 12(19). doi: 10.3390/SU12197912.

Patton, M.Q. 2015. *Qualitative research and evaluation methods*. 4th ed. Thousand Oaks, CA: Sage.

Persson, J. and Sahlin, N.E. 2013. *Vetenskapsteori för sanningssökare*. Stockholm: Fri tanke.

Persson, M., Hedenus, F. and Sprei, F. 2018. *Sustainable Development - Nuances and Perspectives*. 1st ed. Lund: Studentlitteratur.

Petrulaitiene, V., Korba, P., Nenonen, S., Jylhä, T. and Junnila, S. 2018. From walls to experience – servitization of workplaces. *Facilities* 36(9–10), pp. 525–544. doi: 10.1108/F-07-2017-0072.

Peuportier, B. et al. 2004. Inter-comparison and benchmarking of LCA-based environmental assessment and design tools. In: *SB04 Warsaw: Regional Central and Eastern European Conference on Sustainable Building, 27-29 Oct 2004, Warsaw, Poland*.

Pitkänen, K. et al. 2023. How to measure the social sustainability of the circular economy? Developing and piloting social circular economy indicators in Finland. *Journal of Cleaner Production* 392. doi: 10.1016/j.jclepro.2023.136238.

Plevoets, B. and Van Cleempoel, K. 2011. Adaptive reuse as a strategy towards conservation of cultural heritage: a literature review. Available at: www.witpress.com,.

Pomponi, F. and Moncaster, A. 2016. Embodied carbon mitigation and reduction in the built environment – What does the evidence say? *Journal of Environmental Management* 181, pp. 687–700. doi: 10.1016/j.jenvman.2016.08.036.

Pomponi, F. and Moncaster, A. 2017. Circular economy for the built environment: A research framework. *Journal of Cleaner Production* 143, pp. 710–718. doi: 10.1016/j.jclepro.2016.12.055.

Porter, M.E. and Kramer, M.R. 2011. Creating shared value. *Harv. Bus. Rev.* 89(1/2).

Power, A. 2008. Does demolition or refurbishment of old and inefficient homes help to increase our environmental, social and economic viability? *Energy Policy* 36(12), pp. 4487–4501. doi: 10.1016/j.enpol.2008.09.022.

Ranjbari, M., Morales-Alonso, G. and Carrasco-Gallego, R. 2018. Conceptualizing the sharing economy through presenting a comprehensive framework. *Sustainability (Switzerland)*. doi: 10.3390/su10072336.

Ranta, V., Aarikka-Stenroos, L., Ritala, P. and Mäkinen, S.J. 2018. Exploring institutional drivers and barriers of the circular economy: A cross-regional comparison of China, the US, and Europe. *Resources, Conservation and Recycling* 135, pp. 70–82. doi: 10.1016/j.resconrec.2017.08.017.

Reike, D., Vermeulen, W.J.V. and Witjes, S. 2018. The circular economy: New or Refurbished as CE 3.0? — Exploring Controversies in the Conceptualization of the Circular Economy through a Focus on History and Resource Value Retention Options. *Resources, Conservation and Recycling* 135, pp. 246–264. doi: 10.1016/j.resconrec.2017.08.027.

Ritala, P., Huotari, P., Bocken, N., Albareda, L. and Puumalainen, K. 2018. Sustainable business model adoption among S&P 500 firms: A longitudinal content analysis study. *Journal of Cleaner Production* 170, pp. 216–226. doi: 10.1016/j.jclepro.2017.09.159.

Robson, C. 2002. *Real World Research: A Resource for Social Scientist and Practitioner-Researchers*. Blackwell Publishers.

Röck, M. et al. 2020. Embodied GHG emissions of buildings – The hidden challenge for effective climate change mitigation. *Applied Energy* 258. doi: 10.1016/j.apenergy.2019.114107.

Sanchez, B., Esnaashary Esfahani, M. and Haas, C. 2019. A methodology to analyze the net environmental impacts and building's cost performance of an adaptive reuse project: a case study of the Waterloo County Courthouse renovations. *Environment Systems and Decisions* 39(4), pp. 419–438. doi: 10.1007/s10669-019-09734-2.

Sanchez, B. and Haas, C. 2018. A novel selective disassembly sequence planning method for adaptive reuse of buildings. *Journal of Cleaner Production* 183, pp. 998–1010. doi: 10.1016/j.jclepro.2018.02.201.

Sankari, I. 2019. *Co-working space as workplace*. Doctoral dissertation, Aalto University.

Saunders, M., Lewis, P., Thornhill, A., Lewis, S.• and Thornhill, •. 2009. *Research methods for business students fi fth edition*. Available at: www.pearsoned.co.uk.

Schröder, P., Lemille, A. and Desmond, P. 2020. Making the circular economy work for human development. *Resources, Conservation and Recycling* 156. doi: 10.1016/j.resconrec.2020.104686.

Spinuzzi, C. 2012. Working Alone Together: Coworking as Emergent Collaborative Activity. *Journal of Business and Technical Communication* 26(4), pp. 399–441. doi: 10.1177/1050651912444070.

Sundling, R. 2019. *Factors influencing the outcome of renovation projects*. Lund: Lund University.

The World Commission on Environment and Development. 1987. *Report of the World Commission on Environment and Development: Our Common Future Towards Sustainable Development 2. Part II. Common Challenges Population and Human Resources 4*.

UNEP. 2020. *Guidelines for SOCIAL LIFE CYCLE ASSESSMENT OF PRODUCTS AND ORGANIZATIONS*.

UNEP. 2021. *Methodological Sheets for Subcategories in Social life cycle assessment (S-LCA)*.

United Nations General Assembly. 2015. *70/1. Transforming our world: the 2030 Agenda for Sustainable Development Transforming our world: the 2030 Agenda for Sustainable Development Preamble*.

Walker, A.M., Opferkuch, K., Roos Lindgreen, E., Simboli, A., Vermeulen, W.J.V. and Raggi, A. 2021. Assessing the social sustainability of circular economy practices: Industry perspectives from Italy and the Netherlands. *Sustainable Production and Consumption* 27, pp. 831–844. doi: 10.1016/j.spc.2021.01.030.

Waters-Lynch, J. and Potts, J. 2017. The social economy of coworking spaces: a focal point model of coordination. *Review of Social Economy* 75(4), pp. 417–433. doi: 10.1080/00346764.2016.1269938.

Weijs-Perrée, M., van de Koevering, J., Appel-Meulenbroek, R. and Arentze, T. 2019. Analysing user preferences for co-working space characteristics. *Building Research and Information* 47(5), pp. 534–548. doi: 10.1080/09613218.2018.1463750.

De Wolf, C., Pomponi, F. and Moncaster, A. 2017. Measuring embodied carbon dioxide equivalent of buildings: A review and critique of current industry practice. *Energy and Buildings* 140, pp. 68–80. doi: 10.1016/j.enbuild.2017.01.075.

World Economic Forum. 2016. *Industry Agenda Shaping the Future of Construction A Breakthrough in Mindset and Technology Prepared in collaboration with The Boston Consulting Group*.

Wu, X. and Zhi, Q. 2016. Impact of Shared Economy on Urban Sustainability: From the Perspective of Social, Economic, and Environmental Sustainability. In: *Energy Procedia*. Elsevier Ltd, pp. 191–196. doi: 10.1016/j.egypro.2016.12.033.

Yin, R. 2009. *Case Study Research Design and Methods*. Fourth. Bickman, L. and Rog, D. eds. Thousand Oaks, California: SAGE Publications, Inc.

Yung, H.K.E. and Chan, H.W.E. 2012a. Critical social sustainability factors in urban conservation: The case of the central police station compound in Hong Kong. *Facilities* 30(9), pp. 396–416. doi: 10.1108/02632771211235224.

Yung, H.K.E. and Chan, H.W.E. 2012b. Implementation challenges to the adaptive reuse of heritage buildings: Towards the goals of sustainable, low carbon cities. *Habitat International* 36(3), pp. 352–361. doi: 10.1016/j.habitatint.2011.11.001.

Zimmermann, R.K., Barjot, Z., Rasmussen, F.N., Malmqvist, T., Kuittinen, M. and Birgisdottir, H. 2023. GHG emissions from building renovation versus new-build: incentives from assessment methods. *Buildings and Cities* 4(1). doi: 10.5334/bc.325.

Zuo, J., Jin, X.H. and Flynn, L. 2012. Social sustainability in construction - An explorative study. *International Journal of Construction Management* 12(2), pp. 51–63. doi: 10.1080/15623599.2012.10773190.

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Adaptive reuse and shared spaces as circular business models

Climate change, primarily through greenhouse gas emissions, is causing increasing weather and climate extremes all around the world. The emissions continue to rise, and it is likely that global warming will exceed the target of 1.5°C during this century. The real estate and construction sector is a major contributor to climate change, however, there is a substantial reduction potential. Circular economy has strong links to sustainable development, although focus has been on economic and environmental dimensions, neglecting the social dimension. Additionally, the uptake of circular economy business models is slow and fragmented in the built environment industries which could be caused by a lack of knowledge of impacts and benefits. Combining the circular business models of adaptive reuse and shared spaces could present the opportunity to significantly contribute to sustainable development. Adaptive reuse saves a large amount of material, energy, and consequent carbon emissions. Adaptive reuse already contributes to a positive social impact, however when including shared spaces this is further increased. The addition of shared spaces also allows more value to be captured by the developer. Thus, adaptive reuse and shared spaces is a way of combining two circular economy business models in the built environment context to deliver sustainability across all three dimensions. Further, existing frameworks can be employed to characterise and conceptualise circular economy business models, and life cycle assessments can with favour be carried out to assess the environmental, economic, and social impact to increase the knowledge of impacts and benefits.

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