Beyond blueprints: The crucial role of stakeholder engagement in sustaining R-strategies of circular economy in housing projects

A study of stakeholder engagement in the conceptualisation phase of a project life cycle for lasting r-strategies in housing projects.

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ABSTRACT | This study looks into the variables of stakeholder engagement and the implementation of R-strategies in new housing developments with the goal of identifying motives, difficulties, and opportunities. The study promotes sustainable urbanisation by providing stakeholders with ways to improve circular innovation in housing development and fill knowledge gaps regarding stakeholder engagement in the research field of circular economy. This study employs qualitative analytical techniques, including thematic analysis and software coding, to extract structured insights from interviews with stakeholders in new social housing developments. The methodology centred on identifying common themes and trends in the data and ensuring thorough coverage of all stakeholder views. This study investigates stakeholder interaction during the conceptualization stage of a project, with an emphasis on the application of R-ladder principles. It highlights constructors as critical in enabling collaboration among varied stakeholders, including project developers, environmental consultants, architects, contractors, and municipalities, in order to achieve sustainability goals and manage regulatory difficulties. Social Network Analysis (SNA) gives useful insights into stakeholder interactions, despite limits in capturing human relationships and subjectivity in data collection. Efforts to mitigate biases, such as using the snowball sampling method, address issues like potential sampling bias and limited generalizability. Moving forward, this study proposes stronger stakeholder engagement frameworks and governance structures to increase the adoption of circular economy principles in the built environment while addressing issues like financial limits and regulatory ambiguity.

KEYWORDS | Engagement **|** Circularity **|** R-strategies **|** Social housing projects **|** Stakeholder networks **|** conceptualisation stage **|** Social Network Analysis

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1. Introduction

At a time when there are serious problems with the environment and a pressing need for sustainable urban development. The conversation about circular economies has become very important. With the implementation of circular economy (CE) policies in the field of sustainable development (SD), interest in the concept has grown significantly in recent years (European Commission, 2015). Schöggl et al. (2020) assert that CE and SD inherently connect and intertwine, addressing numerous environmental aspects. Nevertheless, the concept of circular development, like the R-ladders framework, which includes strategies like reduce, reuse, repair, remanufacture, recycle, and recover, manages resources in a practical and organised way (Van Stijn & Gruis, 2020) and has emerged as one of the most important ways to address the environmental impact of housing projects (Joensuu et al., 2020).

These circular social housing projects involve a diverse group of stakeholders, each with their own unique perspective and set of expectations for the project. This creates a complex network of interconnected interests. The diverse range of interests and conflicting objectives can be a bottleneck for a project. This dilemma frequently manifests as a conflict between profit maximisation and long-term societal sustainability (Hagbert & Malmqvist, 2019; Hamdan et al., 2021). This results in the practice of r-strategies being adjusted because they are too expensive or because stakeholders find them too difficult to implement in housing projects (Ionașcu et al., 2020). J. Yang and Yang (2014) and Salvioni and Almici (2020) emphasise the significance of clear communication, innovative collaboration, and strategic planning among stakeholders for projects.

Yet, many new social housing projects still struggle to effectively implement these circular r-strategies. Figure 1 (Senaratne et al., 2023) shows that many studies primarily concentrate on circular economy (CE) in construction and the built environment, rather than on stakeholder involvement in circular projects. The current ratio indicates that there are 7.5 times more studies published on circular economy (CE) in construction and the built environment compared to stakeholder involvement studies in 2023 alone. There is also little research on overcoming these obstacles. And how new players in the stakeholder web, like environmental consultants, can contribute to finding solutions. Additionally, it is crucial to explore how engagement between different stakeholders can foster innovative approaches to overcome these barriers and challenges during a new housing project.

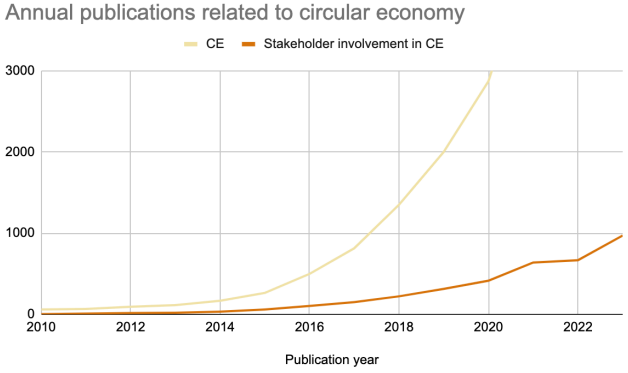


Figure 1 Annual publications related to circular economy (own work)

However, as studies show the importance and benefits of circular housing projects, applying the R-ladder framework to new social housing projects is not an easy undertaking. It necessitates a thorough understanding of the extensive network of stakeholders and entities involved in a project. In the last decade, there has been a significant increase in interest in this research field, emphasising the importance of studying stakeholder engagement in the context of the circular economy, as can be seen in Figure 1.

Therefore, this study looks into the engagement between different stakeholders that are involved in new social housing projects. Furthermore, this study focuses on how the R-ladder framework can be used and maintained during the conceptualisation phase of a project. The prime research question is:

"*What variables influence stakeholder engagement in new circular housing projects, and how can R-strategies be sustained during the conceptualisation phase?"*

Three sub questions were constructed to provide a complete answer to this research question. This ensures that the various subjects related the core research question are taken into account:

RQ1: Which stakeholders from various backgrounds actively engage and contribute to the design conceptualisation phase of a circular housing project?

RQ2: What are the fundamental motivations and objectives that encourage the active involvement and contributions of various stakeholders throughout the conceptualisation phase of a circular housing project?

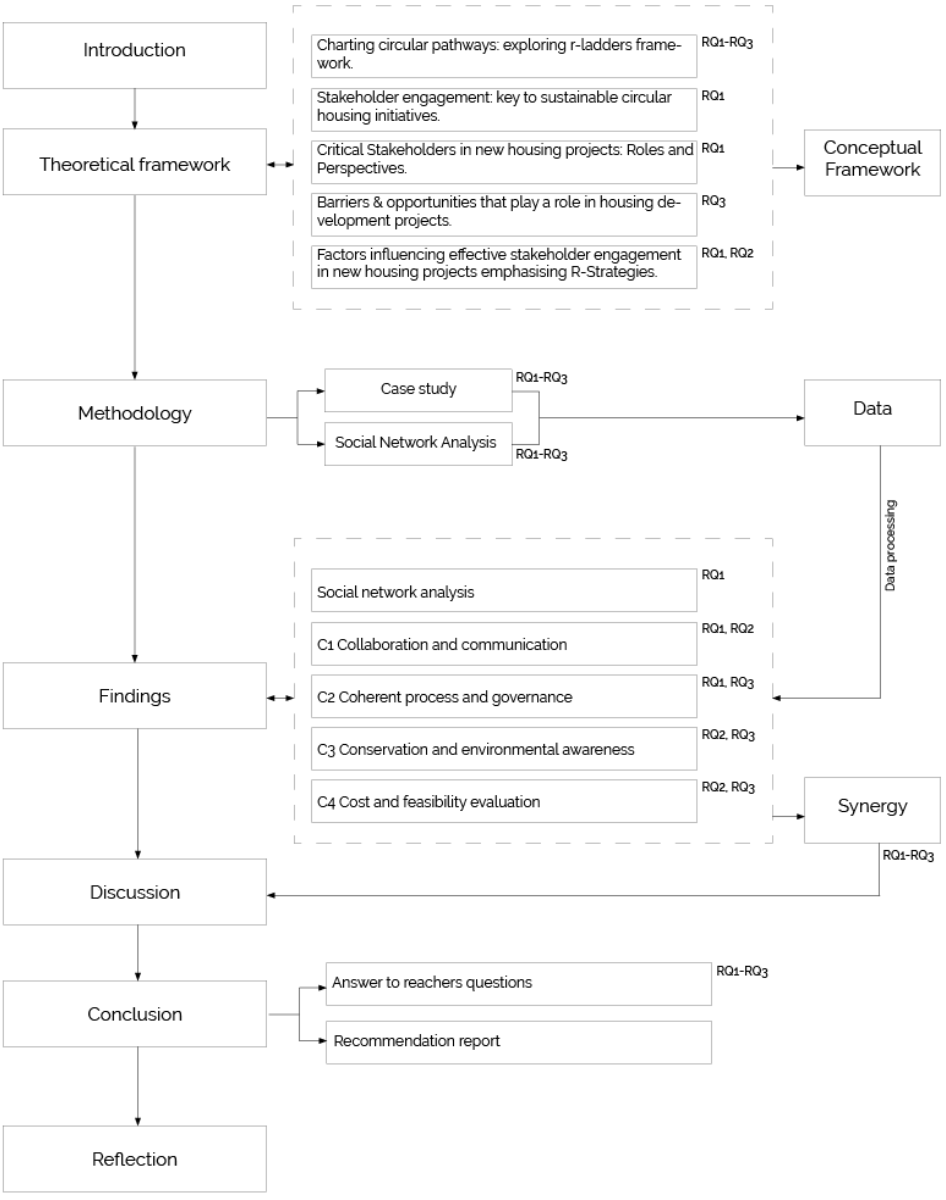
RQ3: What are the key challenges and opportunities stakeholders encounter in implementing the R-ladder principles, in housing projects?

The ultimate goal of this study is to contribute to the emerging discourse on sustainable urbanisation by investigating the intricate dynamics of stakeholder networks in the context of circular housing development. This research tries to identify factors and establish a plan to recommend to stakeholders involved in housing projects through a thorough examination of the function and influence of varied stakeholders. In order to actualize housing projects that will serve as beacons of circular innovation in tomorrow's cities.

2. Structure of Thesis

The following chapter provides a clear roadmap to guide the reader through the progression of the research. Each chapter builds on the previous one, ensuring that the ideas are systematically organised while providing practical analysis. This structure connects the research questions, methods, and findings cohesively to ensure that the research objectives posed at the beginning are addressed throughout the thesis.

Flowchart one illustrates the relationships between the chapters, research questions, and key components such as the conceptual framework, methodology, and findings, ensuring clarity and coherence throughout the thesis.



Flowchart 1 Structure of master thesis

The thesis starts with an Introduction, where the context of the study is laid out, including the problem statement and the main research question and sub-questions. Following this, the theoretical framework delves into the literature and core concepts that form the basis of this study. It looks specifically at stakeholder engagement and R-ladders in circular housing initiatives. This sets the stage for understanding how these strategies are used in practice.

The methodology chapter outlines the research approach, including the selection of case studies and data collection methods like interviews and Social Network Analysis (SNA). It also explains the process used to analyse the gathered data. The Findings chapter presents the results of these methods, focusing on the network variables and collaboration between stakeholders. This chapter ties directly to the research questions, offering insights on collaboration, cost feasibility, governance, and environmental awareness.

The discussion chapter then interprets the findings, comparing them with existing literature and highlighting the implications for future circular housing projects. Finally, the conclusion chapter synthesises the insights from the research, addressing the research questions directly and offering recommendations.

3. Theoretical framework

In this chapter, a thorough study of the available literature on collaborative housing projects and the R-ladder framework is presented. The study investigates the complex variables and effect of collaboration among many parties involved in housing projects. As the global paradigm evolves towards circular practices, the inquiry focuses on understanding the varied ways in which r-strategies might endure throughout the conceptualisation phase of a new housing project.

3.1 Charting circular pathways: exploring R-ladders framework

The R-ladders framework, which includes strategies like Reduce, Reuse, Repair, Remanufacture, Recycle, and Recover, manages resources in a practical and organised way (Van Stijn & Gruis, 2020). It creates real chances for circular growth and gets rid of obstacles to circularity. Furthermore, it is more measurable to the extent that it is used in projects. Figure 2 gives a general overview of the R-ladder framework and its concept.

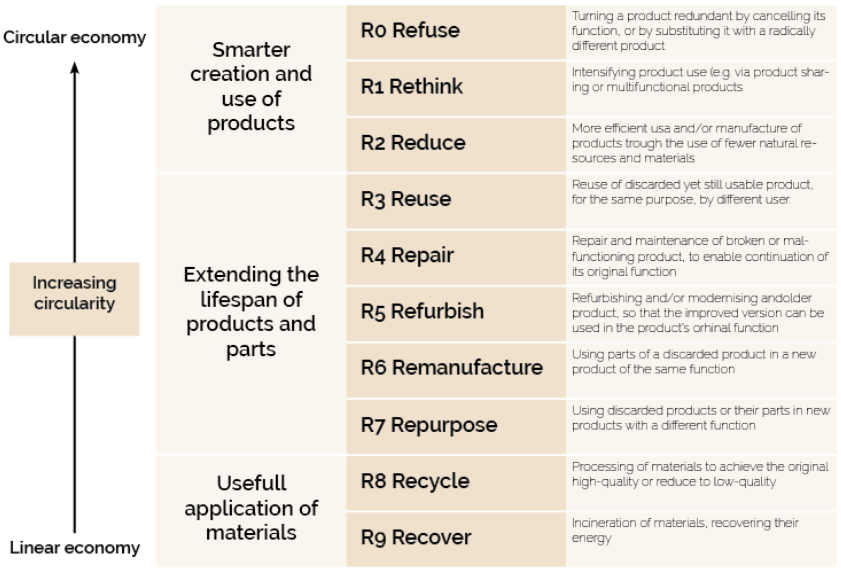


Figure 2 R-ladder framework (Kirchherr et al., 2017)

The R-ladders framework can be used to see how to apply circular economy ideas to real-life situations. These strategies strive to optimise resource utilisation, extend product life cycles, and reduce waste by implementing initiatives such as modular construction techniques, reusable packaging systems, and building component refurbishment, all of which are consistent with sustainability and waste reduction concepts (Van Buren et al., 2016).

Van Buren et al. (2016) emphasise the significant gap between a linear and circular economy. While the linear economy model is based on continual inputs of raw materials and generates waste as a byproduct of production and consumption, the circular economy aims to reduce waste by closing material and energy cycles (Van Stijn & Gruis, 2020). In a linear economy, energy consumption is primarily related with the extraction and use of finite

resources, such as oil and gas, whereas the circular economy model relies on renewable energy sources to support circular practices (Kirchherr et al., 2017). Social housing developments that move to a circular economy can help to make the economy more robust and ecologically friendly.

3.2 Stakeholder engagement: key to sustainable circular housing initiatives

The adoption of a circular economy and the establishment of the r-ladder framework in housing initiatives have emerged as effective solutions to address the worldwide issues of limited resources and environmental sustainability. Effective stakeholder engagement is crucial to guaranteeing the success and long-term sustainability of these projects (J. Yang & Yang, 2014; Salvioni & Almici, 2020). This chapter examines the importance of stakeholder engagement in circular housing initiatives.

Salvioni and Almici (2020) emphasise the significant impact of involving stakeholders in promoting a culture of sustainability. Santos et al. (2019) and Häkkinen en Belloni (2011) recognise this notion, stating that this could be of substantial utility, particularly early in the process. The development of a sustainability culture within circular housing projects is closely linked to the effectiveness of stakeholder engagement. Salvioni and Almici (2020) identify four key points that define this effectiveness starting with awareness and education. Stakeholder engagement initiatives should give top priority to increasing awareness and providing education to stakeholders regarding the advantages and consequences of implementing circular practices in housing projects (Salvioni & Almici, 2020).

Secondly, collaborative decision-making studies done by Santos et al. (2019) and Salvioni and Almici (2020) show that the active involvement of stakeholders in the decision-making process guarantees the incorporation of their viewpoints and concerns into the planning and implementation of circular housing projects. J. Yang and Yang (2014) support this by saying that innovative collaboration should explicate and communicate the mutual benefits for multiple stakeholders from engaging in the development of sustainable housing. Collaborative decision-making leads to projects that are better attuned to the values and needs of the community. In addition, Williams (2022) states that involving a wide range of stakeholders, like governments, real estate developers, local communities, and residents, can enhance the project's holistic approach. Salvioni and Almici (2020) also discuss the need for policy and regulatory assistance. Chapter 2.4.1 will provide further details and explanations on this particular sociocultural element.

Lastly, they talk about behavioural changes. Involving stakeholders in circular housing initiatives can promote a shift in behaviour among stakeholders and communities (Salvioni & Almici, 2020). Stakeholders who actively engage in the development of the project are more inclined to adopt and actively participate in circular practices within their living environments. Ionașcu et al. (2020b) and Williams (2022) mention that overall, transparent communication between stakeholders is crucial for realising ambitions. Figure 3 gives an overview of the findings described in the text.

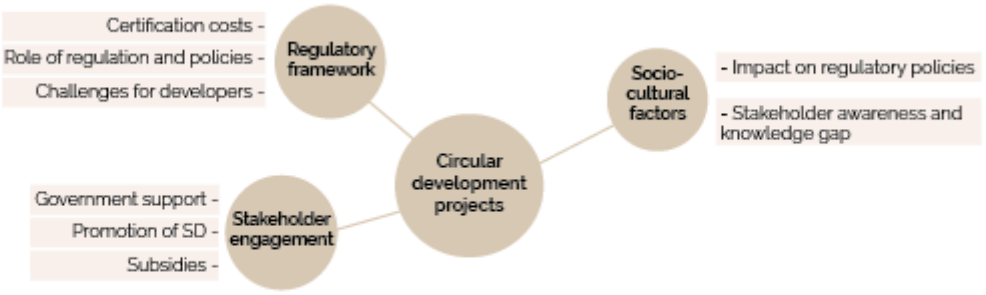


Figure 3 Visualisation of stakeholder engagement and regulatory impact (own work)

In conclusion, this chapter has examined the crucial role of stakeholder engagement in the success and long-term viability of circular housing initiatives. Drawing on the work of J. Yang and Yang (2014), Salvioni and Almici (2020), Santos et al. (2019), Häkkinen and Belloni (2011), Williams (2022), Ionaşcu et al. (2020), and others, it is clear that involving stakeholders is essential for instilling a culture of sustainability within circular housing projects.

Salvioni and Almici (2020) emphasise the importance of awareness and education, collaborative decision-making, policy and regulatory assistance, and behavioural changes. Governments, real estate developers, local communities, and residents are all involved in creating a holistic approach to circular housing development. Projects that actively engage stakeholders not only integrate multiple perspectives but also benefit from informed decision-making, supportive legislation, and behavioural modifications that all contribute to the realisation of circular housing practices. Transparent communication emerges as a recurring theme, emphasising its critical role in realising the goals of circular housing programmes.

3.3 Critical Stakeholders in new housing projects: Roles and Perspectives

Stakeholders in new housing projects include a wide range of individuals and entities who have a vested interest in the initiative's successful development and outcome. These may include a diverse group of people, but various studies show that there are seven key stakeholders who play critical roles in the housing supply chain (Z. Yang & Yang, 2009).

Stakeholder 1, *the government department,* in charge of overseeing one of the project's major funding grants, expertly navigated legal minefields to ensure regulatory compliance.

Stakeholder 2, *the project's architect*, who is actively involved in submitting bids and meticulously planning the project's launch.

Stakeholder 3, *a project manager*, who expertly managed the project's numerous moving parts. At the centre of it all.

Stakeholder 4, *consultant,* promoted critical relationships, highlighting the importance of networking in project development.

Stakeholder 5, *real estate developers*, infuse the project with their grand vision and objectives, providing critical guidance for the project's trajectory.

Stakeholder 6, *the contractor*, who is in charge of building and carrying out the project's blueprint.

Stakeholder 7, *Investor,* by providing the necessary funds, taking on risks, sharing market knowledge, using networks, and making sure the project is successful and can go forward. (Z. Yang & Yang, 2009; Gu et al., 2023).

Each stakeholder adds a distinct point of view and set of expectations to the project, resulting in a complicated web of interwoven interests. Conflicting priorities, varied expectations, legal impediments, and financial limits are all common causes of challenges (Mok et al., 2018). Because a contractor in charge of building a project will approach the financial aspects of the project differently than an architect who designs it. Balancing the requirements of homeowners seeking inexpensive and desirable housing, developers seeking profit, and government agencies guaranteeing regulatory compliance can be difficult. To overcome these hurdles and build a unified approach that balances the interests of all stakeholders, effective communication, innovative collaboration, and strategic planning are required (Yang & Yang, 2014).

Contractors frequently play an important role in the decision-making process for circular housing projects. According to Gerding et al. (2021), this is especially true during the conceptualisation stage of a project. Their influence is typically demonstrated through contractual obligations. In a case study conducted by Gerding et al. (2021), findings from a social network analysis revealed that the contractor held a central position within the network. Contractors play a significant role in decisions related to material use and construction methods. This is especially true when it comes to implementing circular-strategies within the project. For instance, they are often involved in decisions about reusing secondary materials and applying circular construction techniques (Gerding et al., 2021).

Various stages of a project's life cycle will occur. Each stage has its own set of development activities and stakeholders. During these stages, stakeholder values and perspectives may shift (Hamdan et al., 2021). Studies in the past looked at the relationships between a project's lifecycle and the collaborative activities that came with each stage. They divided a project's life cycle into four different kinds of stages namely; conceptualisation, preparation, implementation and closure (Pinto & Prescott, 1988). For this study, the focus will be on the conceptualisation phase of new housing projects because it plays a significant role in shaping the trajectory of the r-ladder framework in housing projects. During this phase, critical decisions about the adoption of circular practices are frequently made, setting the tone for the entire project lifecycle as can be seen in Table 1.

Table 1 Collaboration activitites among project stakeholders throughout a project's life cycle (own work)

Conceptualization	Preperation	Implementation	Closure
- Identification of stake-holders and resources - Legitimacy and interde-pendence of stakeholders - Common definition of the problem	- Ground rules and agenda setting - Joint information search and exchange - Exploring options and trade-offs Reaching agreements and closing th deal	- Carrying out the actual work - Monitoring and ensuring compliance - Renegotiation and settle-ment	- Demobilization of stake-holders and resources - Hand over to owners or users

For example, in this phase, a programme of requirements is often made. Furthermore, the conceptualisation phase provides a one-of-a-kind opportunity for all project stakeholders to meet for the first time, marking a critical point in the project timeline. This initial engagement provides an excellent opportunity to foster engagement, align goals, and incorporate circular economy principles like the r-ladder framework into the project's overall vision.

In conclusion, the engagement of seven key stakeholders in housing projects reveals a complex mixture of interests and challenges. Conflicting priorities, legal obstacles, and financial limits form the complicated web of project dynamics. Balancing the requirements of homeowners, developers, and regulators requires strategic communication, innovative teamwork, and thorough planning (Yang & Yang, 2014). As projects proceed through the ideation, planning, execution, and closing stages, stakeholder roles and viewpoints shift, adding layers of complexity (Pinto & Prescott, 1988; Hamdan et al., 2021). Table 1 presents a reflecting picture of collaborative actions across the project life cycle (Z. Yang & Yang, 2009; Gu et al., 2023). Navigating through this path requires a comprehensive approach that recognises and adjusts to stakeholders' different responsibilities and expectations during each project phase.

3.4 Barriers & opportunities that play a role in housing development projects

In the following subchapter, a thorough look at the barriers and opportunities that stakeholders face when working on circular housing projects will be done. The analysis is organised around three overarching themes: sociocultural factors, which describe the impact of societal dynamics on stakeholders; economic barriers and factors, which include financial challenges and economic incentives; and environmental factors, which investigate the impact of environmental considerations on project stakeholders. Through a comprehensive examination of these issues, a better understanding of the intricate web of obstacles and opportunities in the field of circular housing will be gained, providing useful insights for circular and resilient urban development.

3.4.1 Sociocultural factors

Exploring circular development projects, this chapter seeks to clarify the influence of sociocultural factors. For example like the impact of regulatory policies and address critical issues such as stakeholder awareness and knowledge gaps. Understanding how sociocultural dynamics shape perceptions and community engagement is critical. Simultaneously, the chapter will examine the role of regulatory policies, with a focus on potential roadblocks resulting from a lack of awareness and knowledge about stakeholders.

Existing research highlights the difficulties associated with regulatory frameworks that lack support or incentives for circular development. Despite rising market demand for sustainable products, developers face challenges such as high certification fees, which are frequently viewed as barriers (Maqbool et al., 2023). The complexities of regulations, identified by Shen et al. (2010) as tools for addressing societal concerns, exacerbate the challenges faced by developers. Nonetheless, literature indicates that policy tools, such as regulations, can have a significant impact on circular building practices (Enker & Morrison, 2020). Salvioni and Almici (2020) highlight the importance of policy and regulatory support in shaping sustainable development. Stakeholders must actively participate in the development and implementation of policies that promote circular housing practices (Salvioni & Almici, 2020). Such policies not only increase the likelihood of adopting circular-strategies but also help to foster a culture of sustainability in the construction industry.

Ionașcu et al. (2020) advocate for public institutions to actively promote sustainability in the real estate sector, emphasising the importance of government and local government support. Government bodies and local governments, as key stakeholders, have the potential to improve the attractiveness of the business environment for developers through mechanisms such as subsidies (Hoppe, 2012) and streamlining of bureaucratic processes (Nielsen et al., 2019).

Building on the critical role of government bodies and local governments as key stakeholders in creating a favourable business environment for developers, it is critical to address the current gaps in awareness and knowledge about circular development projects. As the Annual publications related to circular economy shows us, there are not many publications on stakeholder involvement in the circular economy. While studies are scarce, they highlight a persistent barrier in the form of a lack of awareness and education. Häkkinen and Belloni (2011) suggest that developers may avoid incorporating circular features due to a lack of understanding about demand and implementation. Munaro et al. (2020) emphasise the importance of professionals adopting an environmentally conscious mindset, proposing proactive strategies such as mapping and developing training plans to provide stakeholders with the skills required for environmentally friendly practices. This integrated approach seeks to close knowledge gaps and encourage the use of circular practices in the design and construction of adaptable projects and materials.

Furthermore, knowledge exchange and shared experiences throughout a project's life cycle are critical in closing the knowledge gap between involved stakeholders (Hamdan et al., 2021; Andersen et al., 2004). Kellogg and Keating (2011) also emphasise the importance of knowledge transfer between designers and contractors in maintaining the r-strategies. Stakeholders also play an important role in sustaining relevant sustainability-related

knowledge exchange by acting as intermediaries between different actors and importing new knowledge from external environments (Li et al. 2018).

In conclusion, this chapter examined the complex dynamics of circular development projects, highlighting the importance of sociocultural variables, regulatory frameworks, and stakeholder engagement. Sociocultural factors influence attitudes and community engagement, while regulatory rules, such as expensive certification costs, present possible barriers. Key players, such as government bodies and municipal governments, can promote circular development through methods such as subsidies. Addressing present awareness and knowledge gaps about circular development projects is critical, as seen in Figure 1. Scarce publications on stakeholder involvement highlight continuing hurdles caused by a lack of awareness and education. Munaro et al. (2020) provide strategies to provide stakeholders with the skills required for circular practices, promote a sustainable culture, and close knowledge gaps.

The chapter emphasises the importance of knowledge exchange and shared experiences across stakeholders in successful circular development implementation (Hamdan et al., 2021; Andersen et al., 2004; Kellogg & Keating, 2011; Li et al., 2018). In essence, while problems are acknowledged, the chapter highlights the potential for informed policy, proactive stakeholder involvement, and ongoing information exchange to achieve the transformative impact of circular development in the construction industry.

3.4.2 Economic barriers and factors

During the last decade, investors have demanded improved sustainable operational performance and capital governance from the managers of their real estate assets. Enhanced regulatory requirements in Europe are now acting as a stimulus for this transition (Vanags & Butāne, 2013; European Commission, 2015).

The increasing focus on sustainability in the real estate sector extends beyond investors alone. Policymakers, tenants, and homebuyers have shown a strong interest in sustainable housing. So, it is crucial to include sustainability while doing property valuation and financial analysis. Because it is necessary to value and analyse a property in order to increase its long-term value through lower operating costs and increased market demand, it lowers the risks that come with changes in the environment and keeps up with changing rules and regulations. Jotjensen et al. (1986) demonstrate that economic risk variables include the increase in the term structure, anticipated and unanticipated inflation, industrial output, and the disparity between high-quality and low-quality bonds.

A study conducted by Vanags en Butāne (2013) shows that the financial realities of sustainable growth, such as the upfront costs, how to allocate capital, get a return on investment, and the operation costs, have become very important. Especially the high upfront costs sometimes lead to an adjustment on the r-strategies (Abidin et al., 2013). Operating costs in the real estate environment refer to the ongoing expenses associated with maintaining and managing a property. These costs are incurred beyond the initial acquisition or development of the property and are essential for keeping the property functional, attractive, and in compliance with regulatory requirements. Dwaikat en Ali (2016) mentions that these economic factors play a role in sustainable and circular housing

projects, and Ionașcu et al. (2020) indicate that developers often do not participate in building in a circular manner because it is too expensive. Figure 4 shows a breakdown of the economic factors described in the text.

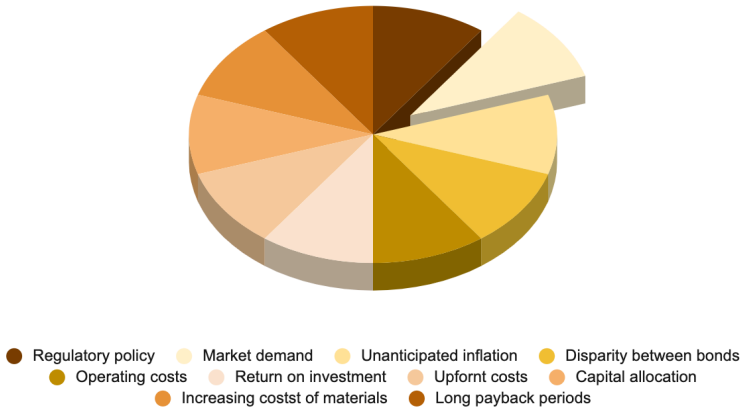


Figure 4 Economic obstacles that influence circular housing initiatives (own work)

Diversification of funding could also be used to balance the needs of various groups (Zhan, de Jong, & de Bruijn, 2018). Using a variety of funding methods could help to spread power and reduce the likelihood of conflict. Diverse stakeholder groups result in a broader range of funding sources. Diversifying funding sources can help a project's finances by bringing different stakeholders together, but it can also lead to fragmentation (Kyvelou & Papadopoulos, 2011) if some funding parties demand specific technical solutions or procedures without considering what others want from the project.

Another thing is that developers or investors may be concerned about their return on investment (ROI) because circular projects take longer to pay for themselves than traditional ones, so a good feasibility study is necessary (Shen et al., 2010). According to Shen et al. (2010), people frequently consult with sustainability compliance professionals because it is difficult to keep up with the complicated and constantly changing sustainability laws and building standards. It may be difficult to find environmentally friendly building materials in some areas, resulting in increased costs and a shortage.

In conclusion, increased demands from investors, policymakers, tenants, and homebuyers are driving a profound shift in the real estate sector toward sustainability. Increased regulatory requirements in Europe further encourage this shift. The focus on sustainability extends beyond mere financial considerations, becoming an integral aspect of property valuation and financial analysis. Jotjensen et al. (1986) highlighted economic risk variables, which emphasise the numerous difficulties developers face, particularly in terms of upfront costs, capital allocation, return on investment, and ongoing operational costs. The necessity to maintain functionality, attractiveness, and compliance with regulations adds another layer of complexity. Dwaikat en Ali (2016) and Ionașcu et al. (2020) emphasise the role of economic factors in sustainable and circular housing projects, citing cost concerns as a significant impediment to widespread adoption. Diversifying funding sources emerges as a potential strategy to balance stakeholder needs, although it comes with the challenge of potential fragmentation (Zhan, de Jong, & de Bruijn, 2018; Kyvelou & Papadopoulos, 2011).

Moreover, the extended payback periods for circular projects raise concerns about return on investment, necessitating thorough feasibility studies and consultation with sustainability compliance professionals. The scarcity of environmentally friendly building materials in certain areas adds to the financial and logistical challenges. In navigating these complexities, it is imperative for developers and investors to strategically align economic considerations with sustainability goals, fostering a harmonious integration of circular practices into real estate development.

3.4.3 Environmental factors

Numerous sources have discussed how a variety of environmental factors affect circular housing projects, showing both opportunities and obstacles that must be carefully considered.

Developers of circular housing frequently face concerns regarding the integration of new environmentally friendly technologies (Häkkinen & Belloni, 2011; Shen et al., 2010). These uncertainties may impede its implementation and require changes to construction methods and materials, thereby increasing and complicating the building process. Häkkinen and Belloni (2011), as well as Shen et al. (2010), stress the difficult balance between innovation and practical application. Additionally, Maqbool et al. (2023) and Gansmo (2012) mention that a significant barrier is a lack of knowledge about circular characteristics among potential buyers or renters. Despite rising market demand for sustainable housing, developers may be cautious to implement circular processes without strong market support. Bridging this awareness gap is viewed as a critical step towards promoting circular housing practices (Hamdan et al., 2021; Andersen et al., 2004).

Sustainability certifications, like LEED or BREEAM, can also create extra hurdles (Häkkinen and Belloni, 2011). The expenses and time required to achieve these certifications can serve as barriers, influencing developers' decisions. Finding a balance between certification standards and project practicality is critical, as noted in studies by Häkkinen and Belloni (2011) and Shen et al. (2010). Shen et al. (2010) and Gansmo (2012) highlight the difficulty of sustainability regulations and building standards. Developers frequently contact sustainable compliance professionals due to the difficulty of keeping up with continually changing requirements. Shen et al. (2010) and Gansmo (2012) advocate for a comprehensive approach to feasibility studies that also considers environmental factors.

The availability of ecologically friendly building materials is a key concern, resulting in rising costs and shortages, according to studies by Shen et al. (2010) and Maqbool et al. (2023). This highlights the significance of creating a circular supply chain for such commodities in order to increase price and accessibility. Hamdan et al. (2021) and Shen et al. (2010) highlight neighbourhood sustainability assessment (NSA) technologies, such as BREEAM-C, as facilitators of stakeholder communication. These tools act as catalysts for discussions and collaborative activities, creating a common understanding of sustainability goals among project participants.

In conclusion, a thorough investigation of diverse sources reveals the complexity and opportunities inherent in circular housing projects. Developers face uncertainty while integrating environmentally beneficial technologies, as emphasised by Häkkinen and Belloni (2011) and Shen et al. (2010). The complexities of sustainability certifications, as emphasised by Häkkinen and Belloni (2011) and Shen et al. (2010), and the need to bridge awareness gaps among potential purchasers or renters, as highlighted by Maqbool et al. (2023) and Gansmo (2012), further influence the landscape. Sustainability requirements and building standards add another degree of complexity, prompting developers to seek advice from compliance experts (Shen et al., 2010; Gansmo, 2012). The scarcity of environmentally friendly building materials, as outlined in research by Shen et al. (2010) and Maqbool et al. (2023), leads to growing costs and highlights the critical need for circular supply chains.

The incorporation of technologies such as neighbourhood sustainability assessments, as advocated by Hamdan et al. (2021) and Shen et al. (2010), appears to be a potential path for increasing stakeholder communication and collaboration. To navigate these difficulties and opportunities, a comprehensive and collaborative approach is required, with an emphasis on education, stakeholder participation, and the establishment of circular supply chains. These strategic factors, based on findings from the aforementioned studies, collectively accelerate the trajectory of successful circular housing initiatives.

3.5 Factors influencing effective stakeholder engagement in new housing projects emphasising R-Strategies

This chapter methodically organises and analyses the various aspects impacting stakeholder engagement. The goal, based on a thorough literature study, is to shed light on the intricate factors that create successful stakeholder engagement in the field of circular development. To improve clarity and assist comprehension, this report offers these findings in an organised table. Each row represents a key feature, while columns go into the details of awareness, decision-making, policy support, behavioural changes, communication, and more as can be seen in Table 2. Importantly, this list will be used in the qualitative portion of our next research, where interviews will provide further insights and viewpoints.

Initially, broad coding themes were developed from existing literature, encompassing concepts such as "Awareness and Education," "Collaborative Decision-making," "Policy and Regulatory Assistance," "Behavioral Changes," "Transparent Communication," "Economic Barriers," "Diversification and Funding," "Knowledge Exchange," "Guidance on Sustainability," "Collaborative Approach," and "Innovation," as shown in Table 2.

However, these themes are overly broad. Therefore, they were refined into the four C’s: Collaboration and Communication, Cost and Feasibility Evaluation, Conservation and Environmental Awareness, and Coherent Process and Governance. These refined themes will guide us through the complexities of stakeholder collaboration.

Table 2 list of factors that have influence on circular housing projects (own work)

Factor categories	Stakeholder group	Explanation	Source
Awareness and Education	All Stakeholders	Increase awareness and provide education on circular practices and development goals (CDGs).	J. Yang & Yang, 2014; Salvioni & Almici, 2020
Collaborative Decision-Making	All Stakeholder	Actively involve stakeholders in decision-making processes for circular housing projects. Emphasize collaborative decision-making in a comprehensive approach.	Santos et al., 2019; Salvioni & Almici, 2020; J. Yang & Yang, 2014; Williams, 2022
Policy and Regulatory Assistance	Government Department	Advocate for supportive policy and regulatory frameworks for sustainable development in circular housing projects.	Salvioni & Almici, 2020
Behavioral Changes	All Stakeholders	Recognize the role of stakeholders in promoting behavioral shifts towards sustainability in living environments.	Salvioni & Almici, 2020; Ionescu et al., 2020b; Williams, 2022
Transparent Communication	All Stakeholders	Emphasize transparent communication between stakeholders to realize ambitions and ensure the success of circular housing programs.	Ionescu et al., 2020; Williams, 2022
Economic Barriers	Real Estate Developers	Address economic factors such as upfront costs, ROI concerns, and the need for feasibility studies to overcome barriers to circular development.	Vanagas et al., 2013; Maqbool et al., 2023; Dwaikat et al., 2018; Shen et al., 2010; Ionescu et al., 2020
Diversification of Funding	Real Estate Developers	Consider diversifying funding sources to balance the needs of various stakeholder groups while being mindful of potential fragmentation.	Zhan, de Jong, & de Bruijn, 2018; Kyvelou & Papadopoulos, 2011
Knowledge Exchange	Project Managers	Promote knowledge exchange and shared experiences throughout a project's life cycle to close knowledge gaps between stakeholders.	Hamdan et al., 2021; Andersén et al., 2004; Kalkgg & Kiesling, 2011; Li et al., 2018 2011
Guidance on Sustainability	Consultants	Emphasize the role of sustainability compliance professionals in navigating complex and constantly changing sustainability laws, building standards, and technologies.	Shen et al., 2010; Munaro et al., 2020
Collaborative Approach	All Stakeholders	Stress the importance of a comprehensive and collaborative approach that includes education, stakeholder participation, and the establishment of sustainable supply chains.	Salvioni & Almici, 2020; Hamdan et al., 2021; Andersen et al., 2004
Innovation	All Stakeholders	Acknowledge the need to balance innovation with practical application when integrating environmentally friendly technologies in circular housing projects.	Häkkinen & Belloni, 2011; Shen et al., 2010; Maqbool et al., 2023; Gansmo, 2012

3.6 Conceptual framework

The conceptual framework depicted in Figure 5 will be used as a theoretical lens to look at the complicated ways that stakeholders work together on circular housing projects. As circular R-strategies gain prominence, understanding how stakeholders engage in the conceptualisation phase of a new housing project. This chapter explains the ideas that will guide the research. Aligned with the overarching research goal, this conceptual framework addresses how engagement among diverse stakeholders influences the lasting impact of R-strategies in housing projects. The framework guides this investigation into the multifaceted interactions among stakeholders and their roles in shaping circular and resilient urban development.

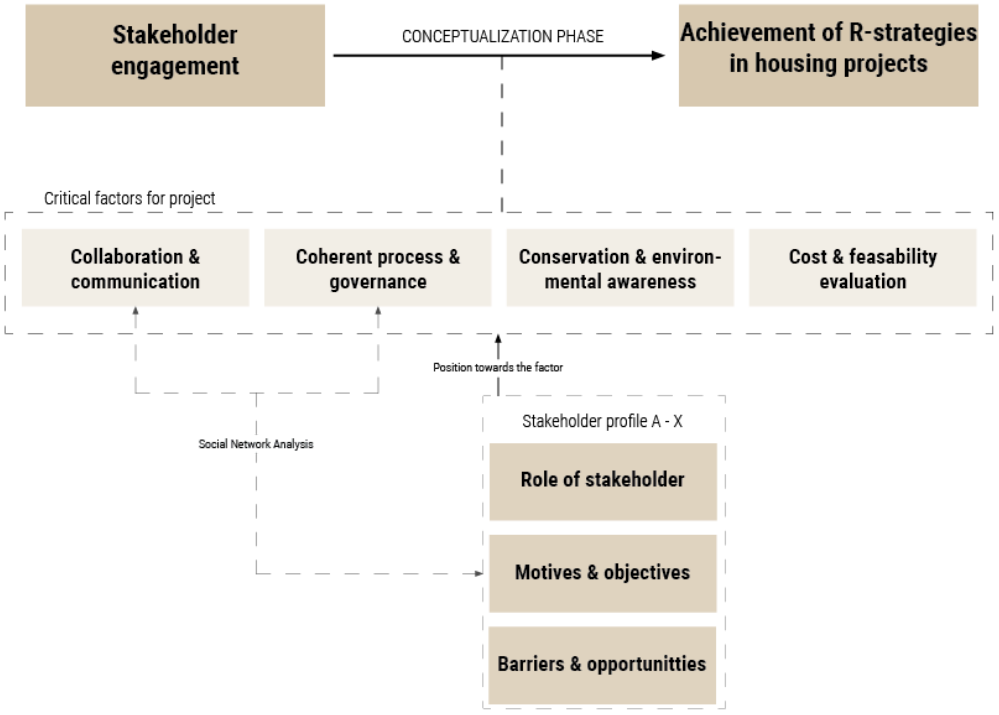


Figure 5 Conceptual framework (own work)

In this study, the two key concepts include stakeholder engagement and the achievement of R-strategies in housing projects. Stakeholder engagement embodies the diverse perspectives brought by stakeholders, while the R-strategies represent the overarching circular objectives. The project conceptualisation phase sets the time frame for how key stakeholders engage with the project. This relationship is supported by four overarching themes: Collaboration & communication, Cost & feasibility evaluation, Conservation & environmental awareness and Coherent process & governance. Within these overarching themes, a more in-depth examination at the stakeholders' profiles will be conducted. This provides a deeper knowledge of the stakeholder's role, motivations and objectives regarding the themes, as well as the barriers and opportunities they encounter. Given the complexity of stakeholder engagement, this study posits that effective engagement correlates positively with the achievement and endurance of R-strategies in housing projects. This study will argue that stakeholder engagement, innovation are critical components for navigating challenges and increasing circularity in housing projects.

This concept was chosen for its usefulness in understanding the collaborative complexities of circular housing projects. By merging stakeholder theory and circular development concepts, the framework provides a complete lens through which to examine stakeholders' responsibilities, motivations, objectives and difficulties. The conceptual framework is based on an extensive body of research on collaborative housing projects, circular development, and stakeholder participation. By applying these principles, this study has the potential to make a valuable contribution to the ongoing discourse surrounding the attainment of maximum circularity within the housing sector.

4. Methodology

This chapter describes the methodology used in this study, which is the foundation of the study's exploratory approach. The methodology includes a multidimensional structure intended to thoroughly investigate the research questions at hand. This methodology relies on a variety of data collection methods, including literature research, case study analysis, observations, and qualitative interviews. These techniques combine to create a thorough and comprehensive grasp of the subject.

The case study serves as a focus point for in-depth investigation, allowing for a thorough examination of real-world circumstances within the context of the research objectives. Valuable insights will be gained from project analysis, observation, and qualitative interviews done inside the selected case study, contributing to a better understanding of the research issue.

Furthermore, a new feature of this methodology is the use of Social Network Analysis (SNA), which will be based on qualitative interviews and bespoke Python code created expressly for this purpose. This approach will allow for the visualisation and analysis of relational data acquired from interviews, providing fresh perspectives on stakeholder interactions and network dynamics.

4.1 Research Framework

This part of the paper presents a comprehensive overview of the mixed method research design where literature research is combined with a case study. On how the collaboration between different stakeholders is in circular housing projects. This study focuses on how the R-ladder framework can be used and maintained during the conceptualisation phase of a project. Figure 6 depicts the research process, which is divided into four steps.

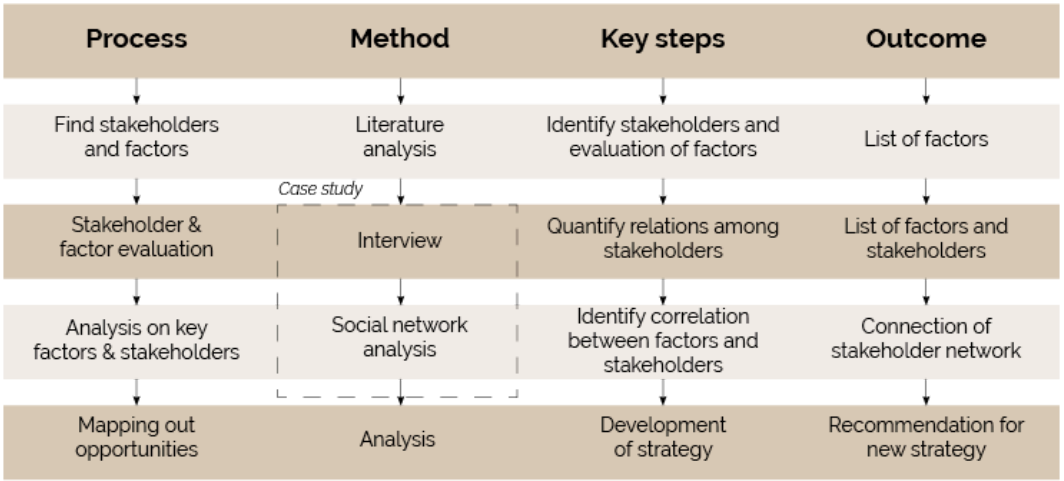


Figure 6 Research framework (own work)

It starts with a literature review aimed at identifying important factors relevant to the study's goals. In this step, rigorous data collection and analysis procedures are used to get

quantitative insights into the specified factors. A full understanding is sought through semi-in-depth interviews, and the obtained material is quantified to lay the groundwork for later analysis.

After the qualitative research phase, we use a social network analysis (SNA) to explore the intricate web of stakeholder interactions. This analytical technique goes beyond simple quantification by investigating the qualitative features of network interactions. Stakeholder network analysis (SNA) is a strong method for revealing patterns, structures, and dynamics inherent in the stakeholder network, shining light on the complexities of relationships, influence, and cooperation (Van Der Hulst, 2008).

The study attempts to provide a complete perspective on the issue by integrating empirical research and qualitative insights from interviews with the methodical investigation provided by social network analysis. This comprehensive method not only quantifies important indicators but also reveals the underlying social structures, connections, and behavioural elements within the stakeholder network, increasing the overall understanding of the phenomena under investigation.

4.2 Data Collection

4.2.1 Literature- based research

It is critical to begin with a well-defined research plan, a literature analysis, and a methodology. This is to guarantee that research complies with scientific standards and retains its credibility. According to Bryman (2016), a systematic assessment is a transparent procedure that, unlike narrative reviews, follows specific processes and relies on clear reporting, which offers several advantages that contribute to the overall improvement of a literature study. To ensure the research's validity and dependability, factors for data collection and analysis will be prioritised. Additionally, a time constraint was given to the literature review, focusing on publications from the last 25 years and incorporating the most recent breakthroughs in the field of circular development projects. Figure 7 shows the literature distribution used for this study.

Furthermore, a high reliance was placed on literature studies provided by Scopus or Google Scholar, with a thorough validation procedure that included an assessment of the number of citations for each reference. When establishing assumptions based on sources, efforts were made to substantiate them with further references or to give multiple perspectives from disparate sources. This method seeks to maintain objectivity throughout the study process. According to studies, CE is still a relatively new concept in the world of sustainable development (European Commission, 2015). Furthermore, studies suggest an inextricable link between CE and SD (Schöggl et al., 2020). The term "sustainable development" will also serve as a search term in this study, given the extensive literature on SD and the evidence of CE's subcomponent status within it. This approach creates a broader field of view to address the research questions of the study.

This study uses the terms “housing projects” and “neighbourhood projects” to avoid an overwhelming number of irrelevant research results. The terms “stakeholder collaboration”

and “stakeholder networks” were also used. These terms were used in tandem with "circular built environment" or “circular economy” to enhance knowledge of the situation.

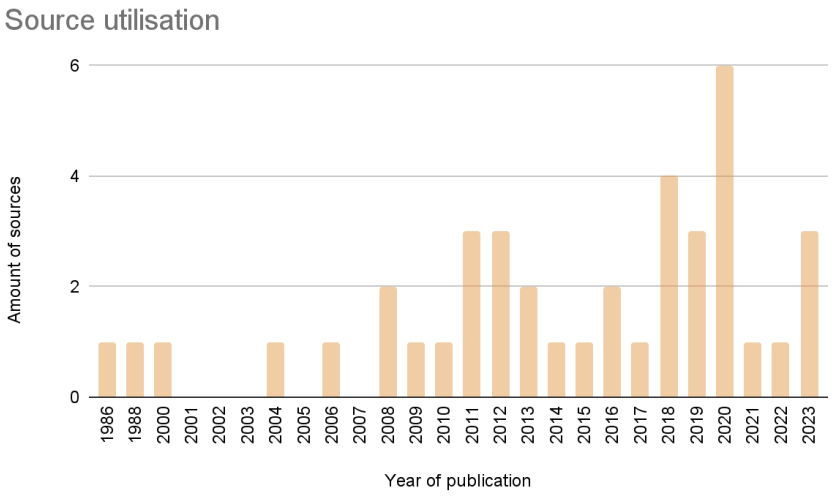


Figure 7 Source utilisation and year of publications (own work)

4.2.2 Case study

Project Analyse

This section looks into the selection process and rationale for using the case study for this study. As previously stated, the study's focus will be on new housing projects, particularly those aimed at the urban social middle-rent category. To add clarity and specificity to the study focus, this chapter describes the criteria used to identify acceptable studies.

For this research, the aim is to use a case study named “Matchbox (Veld K)," which is from the company TRUDO, a housing corporation based in Eindhoven. The project consists of 36 apartments in the social middle-rent segment and a plinth where small business owners can set up shop. Trudo's visionary commitment to innovation aligns with the principles of the Circular Economy R-Ladders framework as we delve into how the TRUDO Plan "Matchbox" embodies various stages (*Trudo | Onze Visie*, n.d.). For example, the Refuse Ladder rejects traditional approaches to housing construction in favour of transformative change (Suda, 2023). By pushing the boundaries of sustainability and architectural creativity, Trudo demonstrates a Rethink mindset, challenging conventional notions of urban development.

The Trudo Plan "Matchbox," located in Strijp S, exemplifies reuse and recycling ladders by incorporating reclaimed materials and embracing circular design principles. Through its dedication to eco-friendly construction practices, Trudo showcases a commitment to reducing waste and minimising environmental impact. Additionally, the project's ambition to become CO2-negative aligns with the recovery ladder, as it aims to mitigate carbon emissions and contribute positively to the environment (Suda, 2023). By creating adaptable spaces that cater to diverse lifestyles and work arrangements, TRUDO fosters a circular economy mindset, where resources are optimised and utilised efficiently. This approach not only minimises waste but also promotes social inclusivity and community resilience, as can be seen in Figure 8.

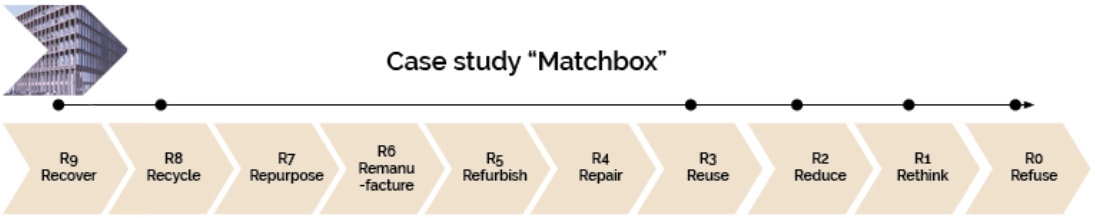


Figure 8 Overview of circular economy integration in "Matchbox" project.

Incorporating a case study into the qualitative research framework increases the investigation's depth and relevance, especially in light of my research on new housing projects. This case study provides a tangible example of the theoretical underpinnings investigated in qualitative interviews by immersing them in real-world circumstances. This technique enables a detailed examination of the complexity inherent in sustainable urban development programmes like Matchbox, offering light on actual obstacles and novel solutions observed in the field. My research combines case study analysis with qualitative interviews to reveal the deep variables and multiple perspectives that shape contemporary housing construction paradigms.

This study attempts to reconcile theory and practice by investigating the synergies between the TRUDO Plan "Matchbox" and the Circular Economy R-Ladders framework, providing insights into novel methods for sustainable urban development. Through thorough research and discussion, this project hopes to contribute to the advancement of more resilient, socially inclusive, and environmentally circular urban futures.

Observation

On March 21st, I attended the start of the building phase of Project Matchbox, which was a detour from my major concentration on the conceptualisation portion of my research. Despite this transition, my observations during the implementation phase revealed vital insights into stakeholders' dedication to the project's success.

The participation of all stakeholders at this critical moment demonstrated a deep commitment to achieving the project's goals. While my research focused mostly on the conceptualisation phase, watching the joint efforts and enthusiasm during implementation revealed the depth of dedication propelling Project Matchbox forward.

This surprising insight highlighted the significance of studying projects holistically, acknowledging that each phase contributes uniquely to the project's overall success. By attending the start of the implementation phase, I developed a greater understanding of the collaborative dynamics and stakeholder participation that are critical to project success.

Thus, while my research initially focused on the ideation phase, this direct observation throughout execution gave essential context and expanded my understanding of the

project's lifecycle. It acts as a reminder of the interdependence of project phases and the long-term commitment necessary to turn conceptual ideas into actual results.

Qualitative interviews

For the qualitative part of this case study, interviews will be held. Interviews give a deeper look into the wide range of human experiences and points of view that can help understand the complexities of the research questions. This qualitative phase not only helps to understand the topic more deeply, but it also gives people who are very close to the subject a chance to share their thoughts. Personal stories and points of view will be shared, making interviews an important tool for peeling back the layers of our research question.

The Snowball Sampling Method (SSM) will be used for the interviews because SSM is crucial for its capacity to quickly approach and engage diverse and difficult-to-reach stakeholder populations, facilitating trust-building and allowing for complete data gathering in complicated research contexts such as circular housing initiatives (Cohen & Arieli, 2011). Furthermore, this study aims to learn more about how different stakeholders interact with one another in the network. As a result, employing SSM already provides insight into the network of stakeholders involved in this project.

In addition, due to the complexities of stakeholder networks in circular housing projects, discovering and contacting all essential parties can be time-consuming and resource-intensive. Cohen and Arieli (2011) argue that SSM accelerates this process by beginning with a few important informants and subsequently growing the sample through referrals, saving time and effort. Especially when researching complex and specific topics like circular development goals and the intricate web of stakeholder collaboration. Overall, through these interviews, a better understanding of real estate world experiences, objectives, and problems can be gained, which can provide a more nuanced picture (Bryman, 2016).

In this study, the focus will be on the conceptualisation phase of a project. As mentioned earlier, there are seven key stakeholders who play a critical role in the housing supply chain (Z. Yang & Yang, 2009). Therefore, the selected focus group for this research will be partially based on these key stakeholders. Consisting of a project manager from the company TRUDO who is in charge of coordinating the work on a project and talking to people who have an interest in it. They have valuable insights about how to run projects and get people to work together. The second one is an environmental consultant from ALBA concepts. This person should have specific knowledge that can help with environmental issues and making strategic decisions throughout the whole project lifecycle. Furthermore, a constructor from ABT who designs and builds structures out of wood, focussing on the technical details and structural integrity of wood as the load-bearing structure. Additionally, a wood supplier from the company Derix is chosen. This is because this person is well-versed in how to properly work with a timber structure, as well as the challenges that come with it. Furthermore, the contractor from VolkerWessels is in charge of overseeing and managing the whole building project. And who ensures the project's timely completion by coordinating various tasks and managing on-site activities effectively.The developer from TRUDO ensures that the project meets financial, regulatory, and market requirements while achieving the overall vision.

Lastly, the architect from KAAN Architecten is responsible for creating both functional and aesthetically pleasing structures. Figure 9 gives an overview of the selected target group for the in-depth, semi-structured interviews.

Figure 9 Selected stakeholders for in-depth, semi-structured interviews

The average number of participants in a qualitative study, according to Bolderston (2012), is between five and ten. As a result, the goal of this research is to conduct seven interviews with a diverse group of stakeholders with experience in housing project development. The interviews will take place at a venue of the contestants' choosing. The interview will last approximately 45 minutes. The reason for this is to make participation in this research as simple as possible for the candidate. As a result, by making things as simple as feasible for them, a better response rate can be achieved.

First, the contestants who will take part in the interview will be given a brief introduction. As illustrated in Appendix 1, The purpose of this introduction is to quickly explain the topic of the question. Which will be about the engagement between different stakeholders involved in housing projects. With a focus on how r-strategies can last through the conceptualisation phase of a project's life cycle. Furthermore, the introduction aims to put the participant at ease, assure them of the confidentiality of any information they provide, and emphasise their right to withdraw from the study at any time. Finally, Appendix 3 provides a consent form for them to complete. As a result, the participant will know what to expect during the interview.

Each interview is set up in order to emphasise the interactions of various stakeholders, such as the government, project architects, project managers, consultants, and property developers. The interview style is deliberately crafted to help participants comprehend the complex networks of stakeholders in the conceptualisation phase of a project's life cycle. The introduction emphasises the rising relevance of the circular economy and sustainable urban development, which are backed by global regulations. After the introduction, the interview begins with an examination of the level of participation of various stakeholders, noting that individuals frequently speak strongly about subjects important to their hearts, as

can be seen in Appendix 2. This allows stakeholders to offer particular instances of how they are excited about collaborating and contributing to circular housing initiatives.

It then dives deeper into these stakeholders' motives and ambitions, focusing on what drives them to actively participate in these initiatives. The third part discusses the problems and possibilities that stakeholders confront during the conceptualisation phase of a project, as well as how these elements impact their decision-making, involvement, and project outcomes. Finally, it discusses techniques for overcoming hurdles and how stakeholder participation could promote unique alternatives. The interview is carefully planned to get a thorough knowledge of many stakeholders' experiences and recommendations, with the ultimate goal of contributing to the expanding debate on sustainable urban development in the context of circular housing developments.

In addition an interview protocol will be developed to ensure consistent, rigorous, and high-quality interviews. This protocol, as shown in Appendix 1, will assist me by outlining the exact steps, questions, and most important things to remember during the interview. The protocol will be directly related to the research questions. This will allow for a more in-depth examination of the topic. This strategy will assist me in making the interview data more valid and reliable as a whole, providing a stronger foundation for further analysis and interpretation.

4.2.3 Social Network Analysis

Following the qualitative interviews gathered for this study, a Social Network Analysis (SNA) will be used to provide a more organised assessment of stakeholder networks within circular housing projects. This chapter describes the process for doing SNA and incorporating qualitative findings into the analysis. The case study "Matchbox" will serve as a guideline for this SNA.

According to Van Der Hulst (2008), combining SNA with qualitative research improves our understanding of stakeholder dynamics in complex systems like circular housing projects. The qualitative interviews conducted for this study yielded valuable insights into stakeholder interactions, motives, and obstacles. SNA will supplement these findings by providing quantitative measurements for examining the structure and dynamics of stakeholder networks.

The SNA will focus on two key metrics: density and centrality. Density measures the interconnectedness of stakeholders within the network, revealing the breadth of interactions and relationships. Density is a quantity that ranges from 0 when a network has no edges to 1 when the network is perfectly connected. As a result, dense networks have high density values, whereas sparse networks have low density values (Tabassum et al., 2018). To compute this, first calculate the maximum number of potential edges. Using the following formula, where N is the number of nodes:

*Maximum Possible Edges = (N * (N-1))*

Following that, the maximum number of conceivable edges will be divided by the number of existing edges (Tabassum et al., 2018). As seen in the formula below:

Network Density = (Number of Edges/Maximum Possible Edges).

This estimated figure indicates how intertwined the stakeholders are in the network of circular housing projects. Wasserman and Faust (1994) divide social network density into three categories. A network with low density has fewer connections than the maximum possible connections, indicating that nodes are not firmly coupled. A density rating of less than 0.1 (10%) is normally considered low. Medium density networks feature an intermediate amount of connections in comparison to the maximum feasible connections, showing moderate node interconnectivity. This category has density levels ranging from 0.1 (10%) to 0.5 (50%). High density networks, on the other hand, have a large number of connections in comparison to the maximum number of connections. Indicating that nodes are densely coupled. Density numbers more than 0.5 (50%) may be deemed high (Wasserman & Faust, 1994). It also identifies regions where the network may be fractured or where particular stakeholders may be isolated from others. Highlighting areas that require more analysis or action to improve network cohesion and efficacy.

Centrality, as proposed by Kim et al. (2010), highlights the significance and influence of specific stakeholders within the network. The degree of centrality can be obtained by dividing the degree of node v (the number of edges incident to node v) by N minus one, which is the total number of nodes in the network. As seen in the formula below.

Centrality degree = Degree of node v / (N-1)

High centrality suggests increased visibility and importance, identifying key decision-makers and collaborators.

To ensure the robustness of the Social Network Analysis (SNA) procedure, data will be prepared using a methodical approach. This entails providing unique identifiers to stakeholders identified through qualitative interviews, who will be categorised based on their positions and affiliations. These identifiers will serve as nodes in the network. In addition, the qualitative data will be transcribed and organised into a specific Nodes sheet, where stakeholders will be assigned their individual IDs. This sheet will then be used with an Edge sheet to map out the relationships between stakeholders as derived from interview results. This will be done through the VLOOKUP function in Excel that seeks and retrieves data from a table based on certain criteria. It accepts four arguments:

lookup_value, table_array, col_index_num, and [range_lookup].

For example, take the formula lookup_value in cell B1 of the "Data" worksheet and table_array in the "Nodes" worksheet, which ranges from B2 to C18. The function retrieves values from the table array's second column (col_index_num = 2), ensuring an exact match

(range_lookup = FALSE). This formula looks for a value in B1 of "Data" that falls within the defined range in "Nodes" and returns the value from the second column of the matched row.

The prepared data will be processed with Python code created specifically for SNA, which can be found in Appendix 13. Network analysis libraries like NetworkX will be used to calculate centrality, identify clusters, and visualise the stakeholder network. The Python code will generate a SNA summary, offering information about stakeholder density and centrality.

In conclusion, combining SNA with qualitative research provides a comprehensive method to studying stakeholder dynamics in circular housing initiatives. This study uses centrality and density measurements to identify important influencers within the network.

4.3 Data Processing

This section will detail the methods used to analyse qualitative data collected through interviews and then analysed using coding techniques backed by software such as Atlas.ti. The purpose was to extract structured insights from the considerable qualitative data gathered from stakeholders involved in new social housing construction projects.

To adequately manage the vast amount of data generated, it was determined to only employ codes generated by the coding process with a frequency of five or greater. Furthermore, each code was referred to by at least three different stakeholders. This decision was made to ensure that each code reflected the broad perspectives provided by the stakeholders.

Thematic analysis methods were utilised to rigorously examine and code the qualitative data gathered during the interviews. Each interview transcript was carefully reviewed to identify common themes and trends. Individual codes were then assigned to certain text segments to capture the core of each topic or concept. This technique allowed for a thorough review of the data, resulting in the discovery of critical insights and results.

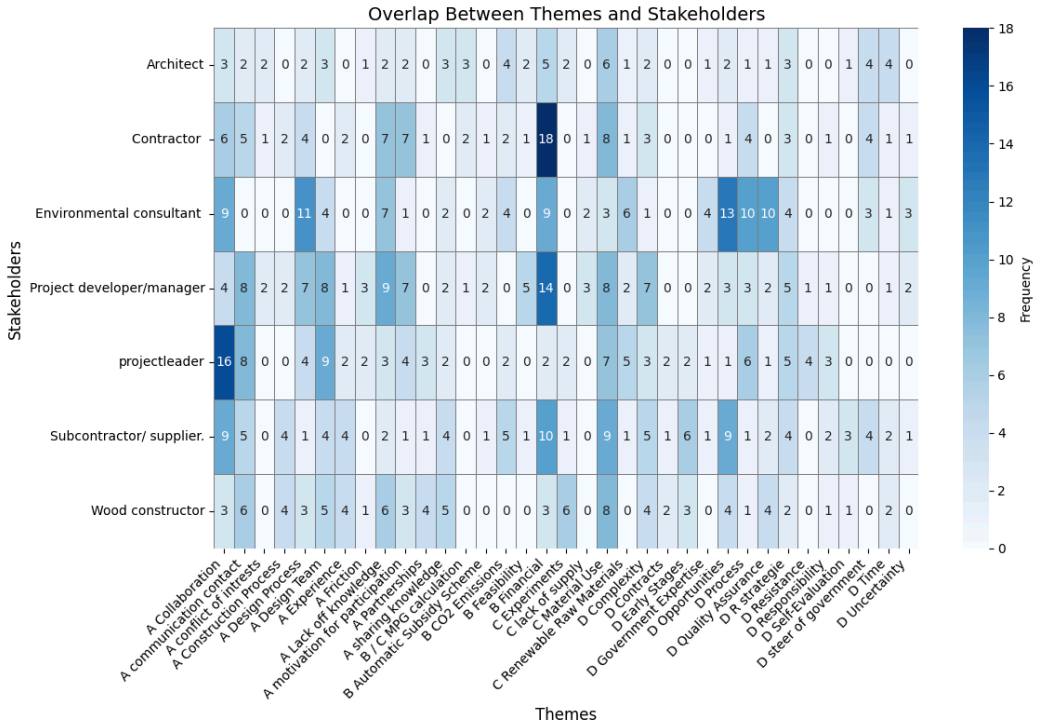
The generated codes were then methodically organised into themes that corresponded to the initial code configuration. Table 3 depicts a segment of how the raw data was assigned to specific codes. Then they were categorised into themes. Appendix 7 provides a complete overview of this process.

Table 3 coding processes raw data from qualitative research.

Raw Data	1ste order concepts	Aggregate dimension
"design team was formed with parties who have experience in timber construction, so to speak."	Collaboration	Collaboration & Communication
"you first have to involve the advisor who has experience in it. So not a consultant that's been around for 100 years. And not an advisor anymore they think sustainability is nonsense."	Experience	
"But there is a fair amount of emailing back and forth. But it also becomes very structural. In the design team. In the preparation phase just like that."	Communication of contact	
"we think in a lot of people the intrinsic motivation to do something with it. And the realization of, uh, if we don't do anything, it stops."	Motivation to participation	
"You do see that at this stage there are still a lot of parties that are not so familiar with it. And who also raise questions in all kinds of areas."	Lack off knowledge	
"Ultimately, those discussions are always between the contractor. And architect and client. That's where the main discussions end up. Architect wants something more in terms of architecture. Or in terms of perception."	Complexity	

This repeated procedure enabled a more nuanced and extensive analysis, ensuring that the themes appropriately represented the data's complexity while remaining consistent with the initial coding structure. By fine-tuning the coding process, the analysis acquired depth and specificity, improving overall comprehension of the research setting and contributing to stronger conclusions as can be seen in Table 4.

Table 4 Code distribution derived from qualitative data for housing development project themes.



This categorising method resulted in the development of four overarching themes, which I refer to as the "Four C's" that guide the conclusions of this study. These themes encompass critical components of housing development projects, including collaboration and communication, capital and feasibility evaluation, conservation and environmental awareness, and coherent process and governance. Each of these themes sheds light on the intricacies and challenges inherent in circular housing programmes, providing a complete framework for understanding and tackling significant concerns in the sector. Appendix 4, providing detailed documentation of the coding process and the emergence of thematic categories. The results obtained from this data analysis will be elaborated upon in the following section of this report.

5. Findings

In this chapter of the study, the findings from qualitative research will be explained, which shed light on several critical factors of the project's effectiveness. The findings have been organised into four separate themes, affectionately referred to as "the four C's," each representing key pillars integral to the project's development trajectory. These themes as mentioned earlier encompass Collaboration and Communication, Coherent Process and Governance, Conservation and Environmental Awareness and Cost and Feasibility Evaluation. Through the investigation of these issues, this study provides complete insights into the complex dynamics and considerations required for informed decision-making and effective project management in the social housing industry. Furthermore, the findings of the Social Network Analysis (SNA) will be presented in the part. In order to get a better understanding on how the network works.

5.1 Social network analysis

The next section delves into the findings of the Social Network Analysis (SNA). This analysis provides useful insights into the complex web of relationships among stakeholders in circular housing projects by examining network topology, centrality measurements, and relationship dynamics. By investigating important variables such as density, centrality, and cohesion, we hope to identify patterns, trends, and influential actors within the stakeholder network. These findings provide a thorough understanding of stakeholder interactions and shedding light on the intricacies that surround circular housing programmes.

5.1.1 Centrality

Understanding the dynamics of stakeholder networks in social housing development is essential for successful project management and long-term community development. One important aspect of this study is the centrality of stakeholders in the network, which reveals their relative importance and impact. While performing the Social Network Analysis (SNA), I assigned unique identifiers to stakeholders using qualitative interview data as described in Chapter 4.2.3. This information was then organised into a Nodes sheet and connected to an Edge sheet to illustrate stakeholder relationships. I utilised Python along with the NetworkX library to find centrality, pinpoint clusters and visualise the network.

stakeholder	Node	Centrality	stakeholder	Node	Centrality
Project developer	1	0.5	Municipality	11	0.166666
Environmental consultant	2	0.666666	Cost experts	12	0.055555
Contractor	3	0.722222	Consultants	13	0.222222
Home owners	4	0.055555	Engineers	14	0.222222
Architect	5	0.666666	Suppliers	15	0.611111
Instalation specialist	6	0.222222	Colleagues	16	0.111111
Constructor	7	0.777777	University	17	0.166666
Landscape Architect	8	0.055555	Concrete supplier	18	0.055555
Client	9	0.277777	fire department	19	0.055555
Project leader	10	0.5			

Table 5 centrality analysis of stakeholders

The centrality analysis shown in Table 5 sheds light on the importance of various stakeholders in new social housing developments. In this context, centrality refers to the degree to which a stakeholder is interconnected and significant within the network. The stakeholder's centrality rating indicates their importance in promoting communication, cooperation, and decision-making within the network.

The Constructor (Node 7) has the highest centrality score of 0.777777, indicating that it is an important component of the stakeholder network. As the main character, the Constructor connects various stakeholders such as Project Developers, Contractors, Environmental Consultants, and Architects. This emphasises the Constructor's critical role in overseeing the development of social housing projects from beginning to end.

Stakeholders such as the Contractor (Node 3) and the Architect (Node 5) are close behind, with centrality values of 0.722222 and 0.666666 respectively. These stakeholders play critical roles in determining the design, construction, and environmental aspects of social housing projects, demonstrating their importance to the network.

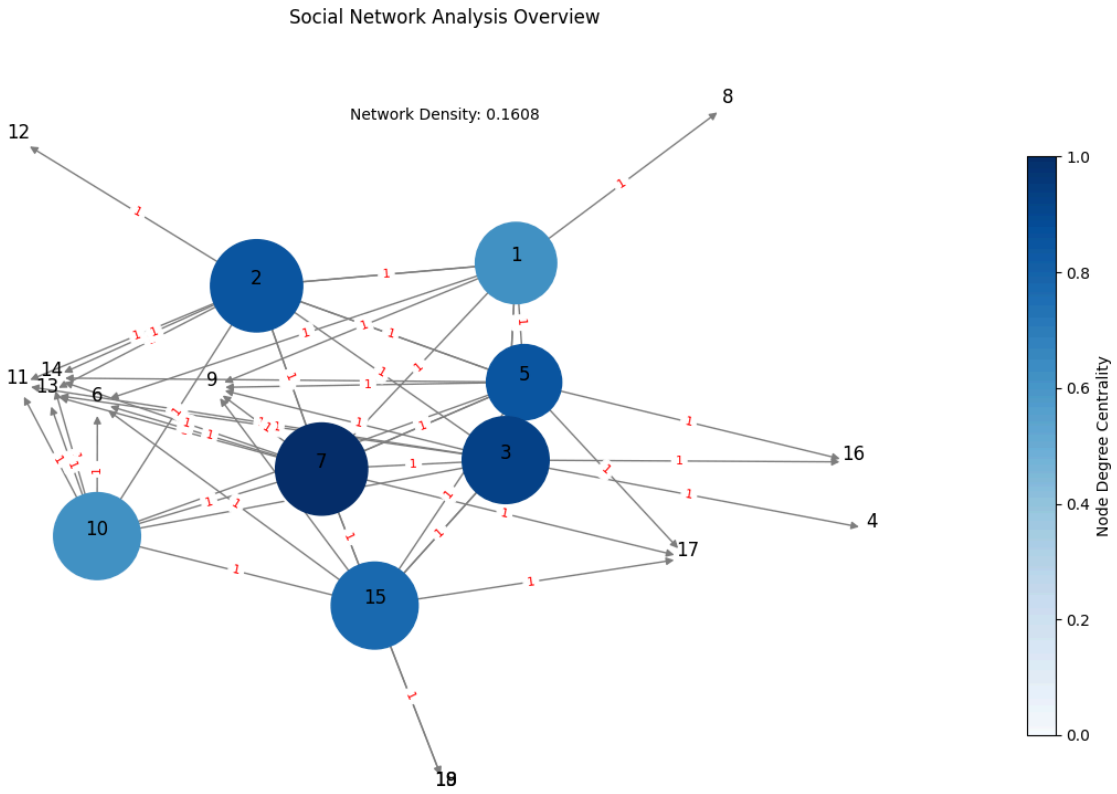


Figure 10 Social network analysis Overview (own work)

Figure 10 depicts the network's collaborative subgroup, which consists of a municipality, consultant, engineer, and suppliers. This cluster represents common interests, goals, or dependencies, indicating a collaborative effort in project-related activities. Analysing the relationships within this cluster provides insight into collaborative dynamics, information exchange, and resource sharing among key actors. Understanding the cluster's structure and influence can help to guide stakeholder engagement and collaboration management strategies.

Furthermore, University ID 17 plays an important role in the illustrated network. Both qualitative research and a comprehensive literature review reveal a significant gap in knowledge transmission and acquisition within the specified field. Notably, a lack of fundamental knowledge persists. In this context, universities that prioritise rigorous research and experimentation, such as University ID 17, are poised to play a critical role in closing this gap. As shown in Figure 10, the University communicates directly with both constructors, subcontractors/suppliers, and architects, resulting in a quadrilateral collaborative system. This collaboration provides opportunities for future refinement and expansion. This collaboration, which brings together the University's experience and resources with the practical insights and talents of constructors and architects, has the potential to significantly contribute to information sharing and innovation in the field.

Finally, the centrality analysis illuminates the intricate web of relationships that exist among stakeholders in new social housing developments. Identifying key influencers and connectors in the network enables project managers and policymakers to better allocate

resources, encourage collaboration, and increase stakeholder engagement, ultimately contributing to the effective and long-term development of social housing communities.

The comparison of stakeholders identified through centrality analysis to those defined by their roles and contributions provides valuable insights into the complexity and dynamics of stakeholder networks in new housing projects. While centrality analysis reveals the interconnectedness and relative importance of various stakeholders in the network, examining specific roles and contributions provides a more nuanced understanding of the key players in project management, design, funding, and consultancy. For example, studies by Yang & Yang (2009) and Gu et al. (2023) highlight the critical roles of stakeholders such as government departments, architects, project managers, consultants, real estate developers, contractors, and investors in ensuring the success of housing projects.

However, investors do not play an important part in a project's ideation phase. The social network research conducted at this stage also supports this, as not a single participant mentions this stakeholder. By comparing these perspectives, it is clear that stakeholders include a wide range of entities, each with their own distinct but interconnected role in shaping project outcomes. This comparative approach enables a thorough examination of collaborative dynamics, role distribution, and stakeholder influence within the housing project ecosystem, resulting in a more holistic understanding of stakeholder engagement and network dynamics.

5.1.2 Density

Network density is a measure of how connected the nodes are in a network. Specifically, it represents the proportion of potential connections that are actually present in the network. As previously stated, the project "Matchbox" will be used as a case study for this research. According to the data generated from the qualitative part of this research the following numbers rollout:

- Number of Nodes: 19
- Number of Edges: 55

This can then be used in the equations described below, generating the following summation:

*Maximum Possible Edges (N * (N - 1)): 19 * (19- 1) = 342*

Network Density (Number of Edges / Maximum Possible Edges): 55 / 342 = 0.1608

A network density of 0.161 indicates that around 16.1% of all possible connections between nodes in the network are really active. In other terms, it means that the network is moderately connected, with some nodes having more connections than others but not completely interconnected as can be seen in Figure 10.

A density of zero indicates that there are no connections in the network. Whereas a density of one indicates that every conceivable connection between nodes occurs will result in a fully connected network. The social network analysis produced a density value of 0.1608, indicating a medium-density network. Wasserman and Faust (1994) define medium density networks as having an intermediate number of connections compared to the maximum feasible connections. With this they imply a moderate node interconnectivity. This density value ranges from 0.1 (10%) to 0.5 (50%), which is considered medium. A given amount of interconnection reveals details about the network's structure and relationships. Highlighting the moderate level of interaction and interconnection between nodes.

5.2 Collaboration and communication

In the following part, a deeper look at the intricate dynamics of collaboration and communication inside the project will be done. Effective collaboration among stakeholders and open lines of communication are essential for navigating hurdles, promoting creativity, and, ultimately, achieving project goals (Yang & Yang, 2009; Gu et al., 2023). These insights, gleaned from qualitative research, particularly interviews with important stakeholders, form a complex tapestry of experiences and opinions. Furthermore, these findings will be intricately linked to existing literature in the field as well as the overarching themes explored in this report, providing a comprehensive understanding of the interplay between theory and practice in the realm of collaboration and communication in social housing project management.

5.2.1 The design team and the process

"The collaboration in the conceptualisation phase is multifaceted and deeply integrated into the project's lifecycle," as highlighted by the project leader from Trudo, a housing association, who describes their role as overseeing projects from conception to delivery. He states, "Mostly I am just project manager for projects, whether renovation, redevelopment or new construction. And in doing so, I often do the guidance or pulling role from vision development to delivery."

The circular development project's conception phase promotes sustainability and resource efficiency through a collaborative design approach. According to the project head, "at Matchbox, we said from the very beginning, we are going to make an effort to build as much biobased there as possible." This commitment demonstrates the project's proactive effort to incorporate R-strategies. For example, the use of timber instead of concrete or steel aligns with the Refuse (R0) strategy by opting for renewable, bio-based materials, reducing reliance on non-renewable resources. Additionally, recycled materials in the window framing support both the Reduce (R2) and Recycle (R8) strategies by minimising new material consumption and repurposing waste materials. These insights align closely with the research findings conducted by Salvioni and Almici (2020), reinforcing the role of bio-based materials in advancing circular construction.

From that vision, the project team prioritises selecting partners who are aligned with the project's goals. The project leader emphasises this, stating, "we actually looked from the

beginning at which architect we should have who is willing and able to do that. Which structural engineer fits in with those who are willing and able." This proactive approach ensures that all stakeholders are committed to the project's vision. Maqbool et al. (2023) support this claim. Especially when the vision is to create a circular building out of timber, certain stakeholders, such as the wood constructor, are critical to the project's successful completion. And the relationship between this wood constructor, who can be considered a subcontractor, and the main contractor, in this case VolkerWessels and the company ABT.

This is well aligned with stakeholders' eagerness to embrace biobased materials and their dedication to circularity and innovation. Just as the project leader emphasises the need of finding architects and engineers who are eager and able to contribute to the project's vision, stakeholders choose to engage because they share a commitment to circularity.In the case of the Matchbox projects, the involvement of ALBA concepts, which fulfilled the position of environmental consultant, as well as the project leader, was critical in synchronising these R strategies.

Furthermore, the culture of experimentation and collaboration within project teams reflects the project leader's responsibility in directing the project's progress. As Kaan architecten, VolkerWessels, ABT and Alba concepts demonstrate a desire to try new techniques and collaborate, the project leader's role in giving leadership and direction from vision to delivery becomes increasingly important.

The intrinsic motivations driving stakeholder involvement in the project, such as the desire to make a positive environmental impact, are closely aligned with the project leader's commitment to creating programmes that contribute to a livable earth. However, balancing sustainability goals with financial constraints remains a challenge. As the project developer notes, "You have to make a lot of choices during such a process, and those choices cost money." For instance, the option to use dry construction methods, such as gravel ballast for sound insulation, was ultimately not pursued due to its higher costs. This decision reflects the reality that striving for perfection in every aspect is not always feasible within budgetary limits: "If you score a 10 for everything, then there just won't be a building."

Similarly, VolkerWessels, the contractor, highlighted the impact of aesthetic choices on the project’s budget, pointing out that KAAN architecten insisted on the inclusion of aesthetic columns, which came at a significant financial cost. For the same investment, they could have opted for more sustainable choices, such as constructing the inner walls with bio-based materials. This trade-off illustrates the constant negotiation between design preferences, sustainability ambitions, and financial feasibility in the development process.

The perspectives expressed in this interview are supported by the findings of Yang and Yang (2009) and Gu et al. (2023), who emphasise that in collaborative decision-making processes, stakeholders weigh circularity issues against financial concerns. This reflects the project leader's responsibility for aligning all stakeholders with the project's goals. In the case of the "Matchbox" project, the design team, which included the contractor, wood constructor,

architect, environmental consultant, and municipality, was formed to address both sustainability and feasibility issues. However, while Yang and Yang (2009) and Gu et al. (2023) do not emphasise the role of the wood constructor as a key player, my research shows that the wood constructor is critical in circular building projects. Particularly in ensuring the structural integrity and sustainability of timber-based designs. Notably, the investor, Stakeholder 7, did not play a central role in this phase, despite providing critical funding, accepting financial risks, and contributing market knowledge and networks to the overall project.

5.2.2 Early stakeholder involvement

The conscious selection of a design team with competence in timber building reflects the project's commitment to circular materials. According to the project leader, for the Matchbox project, "the design team was formed with parties who have experience in timber construction, so to speak." Furthermore, the project leader stated, "The strategic assembly of professionals reflects our commitment to aligning skill sets with project requirements." This careful selection of partners reflects a dedication to collaboration and sharing expertise.

The projectleader emphasises the pivotal role of collaborative dynamics and organisational structure within the design team in ensuring the success of construction projects. A common topic emerging from the transcripts is the importance of early involvement throughout the project lifecycle, particularly during the conceptualisation phase. "Being engaged from the project's inception ensures that fundamental decisions are informed by a comprehensive understanding of project objectives and constraints," highlights the environmental consultant from ALBA concepts

Central to the collaborative process is the intensity and frequency of interactions among team members. "We have active engagements among architects, structural engineers, builders, and consultants, contributing to a rich exchange of ideas," says one of the project managers. This dynamic involvement promotes agile decision-making, ensuring that project development adapts to changing requirements. Research conducted by Yang and Yang (2009) and Gu et al. (2023) support this claim.

These key decision-makers have a major impact over project direction. "Our involvement highlights the importance of aligning strategic priorities," a developer states, underlining the need for collaborative decision-making to promote project success.

However, within this collaborative framework, distinct roles emerge as a critical component of good teamwork. "Defining responsibilities and expectations cultivates a sense of accountability and cohesion," says the project manager, emphasising the importance of role clarity in driving group efforts towards project goals.

Furthermore, the project team prioritises early inclusion of key stakeholders, such as contractors, constructors and consultants, to ensure that their feedback is incorporated into the conceptualisation phase from the start. The constructor from ABT in the case of the project "Matchbox" emphasises this by saying: "actually, we always want... to be involved in

the project as early as possible, so that you can also simply direct on efficient overstretch or solutions that lend themselves well for in this case wooden constructions." The project leader supports this, saying, "And then you collaborate with a regular contractor to incorporate them very early in the project as well. Actually, from the draft design onward." He emphasises the significance of proactive participation in the early phases of conceptualisation to address difficulties.

5.2.3 Communication

Regardless of the challenges that may develop, such as decision-making delays and unforeseen technical concerns, the project leader recognises the necessity of regular communication within the design team to address these issues. Yang and Yang (2014) support this claim in their research, where they emphasise the importance of effective communication, innovative collaboration, and strategic planning to balance the interests of various stakeholders. Research has indicated that there are primarily four forms of interacting between stakeholders: emailing, face-to-face meetings, online meetings and phone calls.

The communication dynamics among stakeholders in the circular development project are distinguished by a mix of digital and in-person encounters, highlighting the necessity of collaboration and problem-solving. The insights align closely with the research findings conducted by Yang and Yang (2014). According to one project leader, "there is a fair amount of emailing back and forth," demonstrating the structural nature of email exchanges within the design team. However, the intensity of contacts has increased, necessitating more frequent and intensive participation from KAAN architecten, structural engineers from ABT, VolkerWessels, and environmental experts from ALBA ideas. The leader of the project enquiries, "Is it still just a bit more intensive, also with the architect, with structural engineer, with the contractor, with all the consultants that you have a bit more frequent." This is also supported by the SNA, which shows that these stakeholders have high node degree centrality. This means that they work closely together.

This enhanced degree of participation needs a thorough examination of design features, which frequently necessitates multiple rounds of discussions to resolve potential points of dispute. As one project manager explains, "There is just so much on the agenda; we just sit down and go over all 40 elements again. We look for a solution, and then there are five more, after which you sit down again." Financial restrictions influencing material choices, such as avoiding dry construction methods due to high costs, resulted in concessions on circular materials, such as the use of attractive columns. Furthermore, difficulties occurred about the feasibility of bio-based materials, particularly the moisture resistance and long-term durability of timber, resulting in disagreements between contractors and project managers. To solve these issues, meetings are occasionally arranged in a hybrid format, with some stakeholders engaging online and others attending in person.

In this context, feedback mechanisms are critical for reinforcing agreements and clarifying expectations as digital and in-person players interact. However, stakeholders believe that this method of communication is not the best approach to conduct meetings." And if people are willing to hold disciplined meetings as well. And if it's good, that's also a fantastic option," says a project manager, emphasising the significance of structured communication. Still,

physical meetings are preferred by all stakeholders, as they make it easier to address certain problems and reach a solution. As the project manager explains, “Then you don't have all of the connection issues, which may be rather problematic at times”. This highlights the challenges posed by virtual meetings, reinforcing the value of in-person collaboration to ensure smoother communication and decision-making. So, with correct conduct and consultation, the hybrid meeting style can be useful for collaboration, but it is not the greatest option. They prefer physical design team meetings, which allow for real-time discussion and decision-making. "By convening stakeholders in live sessions, we foster dynamic exchanges," says the project developer, emphasising the need of responding quickly to emerging challenges and possibilities.

Furthermore, Face-to-face meetings are being held that are critical because they allow for nuanced discussions and effective issue solving. To maximise the efficacy of digital interactions, stakeholders emphasise the significance of consistent internet connectivity and disciplined meeting behaviour. Another way of communicating is through phone calls that are especially crucial since they give a direct channel for discussing difficulties and ensuring clarity in the face of complicated project requirements. The emphasis on verbal communication highlights the significance of proactive engagement and prompt settlement of difficulties. As the project manager put it, "Furthermore, phone calls I think are very essential that people don't throw everything on the mail, but if they have a problem with something that they call."

Throughout the "Matchbox" project, one significant tension emerged from ineffective communication between stakeholders, particularly regarding the placement of a concrete collision protection for the building. During an interview with the project leader he mentions an occasion in which all parties, including the architect and municipality, initially agreed on an external collision protection option, such as bicycle racks or a concrete band. However, the communication breakdown became apparent when multiple stakeholders began forwarding emails and contradicting earlier agreements. The municipality, after having approved the initial design, later raised concerns that the protection should be located within the property rather than externally, as initially planned.

This misalignment in communication created confusion among the involved parties, leading to a prolonged decision-making process. The constant forwarding of emails exacerbated the issue, as different interpretations and conflicting positions emerged. The project leader emphasised that the unstructured email communication led to the problem escalating unnecessarily. This occurred despite the fact that the environmental permit had already been approved. This shows how important it is to have clear, centralised communication during projects with many stakeholders. This is very important when making decisions that will have an impact on the development's structure and rules.

5.2.4 Knowledge exchange

Moving away from the emphasis on successful communication methods, it becomes clear that, in addition to addressing urgent difficulties, realising r-strategies has a broader imperative: information exchange.

In the quest of circular construction techniques, teamwork and knowledge exchange emerge as critical strategies for innovation and efficiency. According to an environmental consultant, teamwork means seeking knowledge outside the customary boundaries: "Where together they actually set up details of how you should build with wood in projects like Matchbox." The architect of the project supports this claim by saying: “We let our architects understand enough so they can ask the right questions to the experts, so they can understand their problem”. This perspective emphasises the importance of sharing expertise in developing circular building approaches. The insights align closely with the research findings conducted by Yang and Yang (2009).

Interview transcripts with diverse players in the building sector highlight the importance of collaboration in promoting sustainable construction. According to the environmental consultant this can be done in different ways. He emphasises the shift away from traditional practices, urging for collaboration to investigate biobased alternatives: "In consultation, we started looking together, can we also convert this concept house to a 100% biobased variant." This collaborative approach not only promotes innovation, but it also accelerates the use of ecologically friendly construction materials. In addition, teamwork makes it easier to learn from experts and apply their knowledge to improve building designs. As another environmental consultant admits, "They also build a lot with wood." They also have extensive experience in that area." Such collaborations allow project developers to include innovative techniques, such as dry joints, into their designs, thereby improving circularity and efficiency.

The drive for standardisation and centralised knowledge resources emerges as a major subject in the interviews. A project developer emphasises the importance of complete criteria, saying, "What you actually need is some guidelines only for wood construction." This appeal for standardisation emphasises the necessity of clear, understandable information frameworks in guiding circular construction practices efficiently. This interview's revelations find validation in the comprehensive studies undertaken by Hamdan et al. (2021) and Andersen et al. (2004).

Furthermore, there is a call for leadership and research activities to accelerate advances in circular construction. According to a project creator, "I think it would be good if a TNO or university would take the lead in this." Such leadership is required to synthesise existing information, identify gaps, and devise concrete plans to move the industry ahead. In addition, collaborative knowledge sharing is critical in the journey towards circular construction (Yang & Yang, 2009). The design team may advance the adoption of circular building practices and optimise designs for efficiency and effectiveness by forming partnerships, learning from professionals, standardisation initiatives, and providing research leadership.

In conclusion, the thorough investigation of collaboration and communication dynamics within social housing project management reveals the critical significance of early stakeholder involvement. This involvement is particularly important for environmental consultants and wood constructors in determining strategy execution and project outcomes. Qualitative studies and stakeholder interviews reveal that proactive engagement of consultants from project inception develops a deeper awareness of objectives and constraints, resulting in more informed decision-making and successful strategic alignment.

This early involvement allows consultants to give expertise and ideas that improve the project's direction, particularly the adoption of sustainable practices and creative techniques. Furthermore, the findings highlight the need of clear communication channels and organised feedback mechanisms in guaranteeing ongoing collaboration and problem-solving throughout the project lifecycle. As a result, involving consultants in the early phases not only improves decision-making quality, but also strengthens overall project delivery. This demonstrates the interdependence of stakeholder involvement, strategy execution, and project success, emphasising the need of collaborative frameworks in social housing project management.

5.3 Coherent process and governance

In the following part, the findings on stakeholder engagement and decision-making processes in circular housing projects will be presented. This chapter examines how stakeholders navigate the complexities of circular construction practices. Drawing on qualitative research and stakeholder interviews to investigate the role of r-strategies, government policies and quality assurance.

5.3.1 Stakeholder engagement and decision-making processes

In the endeavour to create circular housing solutions, circular housing projects stand at the forefront, embodying innovative approaches to construction and resource management. This chapter delves into the intricate process and governance mechanisms within circular housing projects, shedding light on how stakeholders navigate the complexities of circular construction practices. Drawing upon insights from qualitative research and stakeholder interviews, this chapter examines the role of r-strategies, the influence of government policies, and the quest for quality assurance in shaping the trajectory of circular housing projects.

"At the outset of each project, meticulous attention is devoted to establishing foundational parameters," Identifies the study's aims. Key aspects such as target audience, project costs, and building preferences are carefully determined, laying the groundwork for later decision-making processes. This proactive method is critical for aligning project objectives with corporate goals. This is consistent with what Santos et al. (2019) and Salvioni and Almici (2020) show that the active participation of stakeholders in the decision-making process ensures the incorporation of their opinions and concerns into the development and implementation of circular housing projects. Stakeholders have frequently noticed the recurring character of Trudo's decision-making processes. Decisions frequently alter before achieving consensus, stressing the collaborative nature of the process. This iterative technique aims to address concerns and improve outcomes by harnessing collective participation.

Trudo's project management strategy revolves around cultivating strong stakeholder engagement and open communication channels. The findings of the SNA also support this claim since the density value is 0.161 indicating that there is a medium density within the network among the stakeholders. Regular meetings and clear directives ensure that all

stakeholders are actively engaged throughout the project's lifecycle, promoting a culture of collaboration and shared accountability. Early contractor involvement is identified as a critical component leading to project success. Contractors are integrated into the project from the start, ensuring alignment with project objectives and supporting optimal design solutions. A study conducted by Z. Yang & Yang (2009) and Gu et al. (2023) underscores the significance of stakeholder engagement in housing projects.

This collaborative approach improves project efficiency while minimising delays. Furthermore, Trudo's comprehensive design review processes demonstrate a strong dedication to quality and precision. Each design detail is meticulously examined, with iterative adjustments performed until design integrity is established. This careful approach ensures that project deliverables achieve the greatest level of quality. Environmental sustainability is a key component of Trudo's project management philosophy, as indicated by proactive actions taken by environmental experts. Sustainability is considered at every stage of project development, from concept to post-construction review. This devotion to environmentally friendly procedures illustrates Trudo's passion for environmental care and responsible construction.

In the discussion of circular construction techniques, the usage of r-strategies such as R2 (Reduce), R3 (Reuse), and R8 (Recycle) emerges as a guiding principle for shifting construction paradigms towards circularity. Stakeholders in these initiatives show a proactive commitment to putting circular concepts at the centre of decision-making processes. According to one project leader, "These questions permeate every decision, guiding us towards more circular outcomes." This proactive approach indicates a paradigm shift towards environmental stewardship, in which project objectives are tightly linked to organisational goals. Contractors have a critical role in converting R0 (Refuse) and R2 (Reduce) into real results, balancing economic feasibility and environmental concerns. In the words of a developer, "Circularity isn't just about using green materials; it's about finding the right balance between environmental goals and project economics." This highlights the advanced decision-making processes used in circular housing projects. Stakeholders must navigate the complexities of R0 (Refuse) and R2 (Reduce) when choosing materials and planning construction. These decisions are critical to achieving long-term circular objectives.

5.3.2 The role of the government in navigating regulatory ambiguities

In order to achieve these long-term goals, the government's role in circular housing efforts remains critical, albeit beset with problems and uncertainty. Stakeholders like the environmental consultant and the projectlear express concerns about a lack of specialised knowledge and competence within government agencies, notably in fields such as timber building. As stated by a project leader, "There is still resistance in some branches," emphasising the need for better clarity and support from government institutions.

A notable tension arose between the architect’s design vision and the structural safety requirements for the "Matchbox" project. The architect, committed to maintaining the aesthetic integrity of the timber construction, resisted the placement of concrete posts for collision protection, which were suggested by the structural engineers to ensure the

building's safety. The building, located near a public road, posed a potential risk of vehicular impact, prompting the need for additional safeguards.

While alternative solutions were explored, such as placing a protective structure outside the building, the situation became more complicated when the municipality intervened. The government indicated that placing any protective elements outside the property boundaries was not permissible, as this area was public land. This created an additional challenge for the project team, who had to rethink their approach. Although the municipality's decision was technically correct, their response could have been more proactive in helping the project find a workable solution. The back-and-forth between maintaining architectural integrity, ensuring safety, and navigating municipality restrictions highlighted the complexities involved. It underscored the challenge of aligning stakeholder goals with regulatory constraints in circular housing projects.

Regulatory ambiguities exacerbate project uncertainties, necessitating increased collaboration and communication to promote innovation and adaptive decision-making processes (Z. Yang & Yang, 2009). While problems remain, stakeholders anticipate increasingly stringent regulations and increased pressure from European authorities to expedite the implementation of circular building methods. Collaboration among government agencies, industry players, and research institutions will be critical in overcoming barriers and realising circular housing projects.

5.3.3 Quality control

Environmental experts, along with other stakeholders, continue to express concerns about project quality control and decision uncertainty as the project advances. This underscores the importance of strong governance structures and ongoing evaluation processes. Various perspectives were gathered from the diverse stakeholders who participated in this research, shedding light on the domain's issues and initiatives. One major thread running across the discussion is the need for increased knowledge, particularly in areas such as soundproofing and structural design. As stated by one project leader, there is an urgent need to manage complications such as "noise between homes" and the installation of soundproof CLT walls and floors. This indicates a substantial difference between theoretical possibilities and practical implementations, with different perspectives on the ideal structural arrangements. The project leader's sentiment highlights the need for solutions that go beyond theoretical frameworks. These solutions must also demonstrate feasibility and effectiveness in real-world applications.

Furthermore, the scope of quality assurance extends beyond project launch, including regulatory compliance and adherence to early commitments made during the project's infancy. Z. Yang & Yang (2009) supports this claim by emphasising the importance of meticulous design review processes and environmental sustainability in project management. An environmental consultant emphasises the importance of quality assurance in ensuring that projects meet specified criteria even after they have received planning authorization. They want strict oversight to make sure that the promised circular measures are carried out. Furthermore, they stress out how important it is to be responsible for keeping environmental standards high after construction is done.

5.3.4 Self evaluation and feedback loops

In the pursuit of establishing robust feedback loops within stakeholder companies, there emerges a shared commitment to self-evaluation and continuous learning processes, as evidenced by the wood constructor's recognition of the need for post-project feedback mechanisms: "Once the building is up... Look back. What went well? What did not go well." Hamdan et al. (2021) and Andersen et al. (2004) emphasise the importance of a collaborative attitude in enabling knowledge exchange and shared experiences throughout the life cycle of a project.

The architect's emphasis on community engagement and the social aspects of building design is consistent with the idea that stakeholders play a critical role in sustaining relevant sustainability-related knowledge exchange, as expressed in the quote: "And also how socially important your building is in the community." This collaborative approach to information exchange, as highlighted by Kellogg and Keating (2011), is critical for maintaining effective strategies through knowledge transfer between designers and contractors.

In accordance with these ideals, the architecture firm has actively established an in-house feedback loop mechanism that incorporates circular principles into their design process. Through discourse, the architect discusses their firm's approach to sustainability, emphasising the incorporation of six fundamental principles that are in line with the r-strategies and the circular economy environment. Two concentrating on social issues, two on material and economic concerns, and two on ecological factors. These principles are methodically applied to architectural processes, with each design decision tied to the overarching theme of circularity. According to Li et al. (2018), stakeholders' function as intermediates in information sharing goes beyond internal collaboration to importing fresh knowledge from external contexts, enriching the feedback loop and improving overall organisational performance.

Furthermore, the architect emphasises the significance of both hard and soft data in creating the design process, assuring relevance to the urban setting and broader representativeness. This method not only creates a feedback loop within their initiatives, but it also serves as a self-evaluation tool. So, this is the wheel. By incorporating formalised feedback channels into project workflows, the company promotes continuous improvement and innovation, aligning stakeholder efforts towards common goals, and optimising project results.

In conclusion, this section has shed light on the complicated nature of circular housing projects, emphasising the critical role of stakeholders, government regulations, and quality assurance procedures in influencing their trajectory. By delving into the complexities of setting core criteria, encouraging stakeholder participation, and embracing R methods, stakeholders have shown a proactive commitment to circularity. However, obstacles remain, particularly in terms of government capacity and regulatory uncertainty. Moving forward, it is critical to solve these difficulties through increased collaboration, innovation, and stronger governance frameworks. Future circular housing projects can achieve even higher scores on the R-ladder, resilience, and societal impact by harnessing community expertise and cultivating a continuous improvement culture.

5.4 Conservation and environmental awareness

In the following section, the findings on CO2 emissions in construction and development projects will be given. This chapter examines several stakeholder views on incorporating circularity into practice, emphasising the importance of subsidies, regulatory constraints, material selection. And financial concerns in designing environmentally conscious projects.

5.4.1 CO2 emission

In the discourse surrounding CO2 emissions in construction and development projects, stakeholders offer diverse perspectives that underscore the complexities of integrating circularity into practice.

From the viewpoint of the environmental consultant, subsidies become one of the main forces behind circular building projects. They stress the importance of using existing knowledge strategically. In addition they highlight subsidy systems as effective ways to encourage people to adopt environmentally friendly practices.Their assertion that "By leveraging existing insights and subsidy mechanisms, we witness a rapidly growing market for circular solutions," highlights the transformative potential of incentives in shaping environmentally conscious initiatives.

Conversely, VolkerWessels perspective sheds light on the intricate interplay between circular objectives and project feasibility. They highlight the financial intricacies involved in adopting sustainable measures, citing elevated costs as a significant hurdle. Moreover, regulatory gaps, particularly concerning unfamiliar materials and standards, pose additional challenges. Their insight, "Regulatory frameworks are still aligning with conventional practices, posing challenges as we venture into new materials," underscores the need for regulatory alignment to support circular construction practices. This is consistent with the concerns expressed by Häkkinen and Belloni (2011) and Shen et al. (2010) about the costs and time required to obtain sustainability certifications, which can act as a barrier influencing developers' decisions.

5.4.2 Material use in project

The project "Matchbox" emphasises circular methods, as evidenced by the decision to use hardwood construction, which not only provides benefits in terms of CO2 storage but also adheres to the R-strategies namely R0 (Refuse). The project leader emphasises the necessity of careful material selection in order to reduce environmental effects throughout the construction process. For example, considerations go beyond structural elements to include façade coatings and window frames, with a conscious avoidance of typical aluminium in favour of solutions that comprise the most recyclable material. Matchbox" shows a dedication to lowering carbon emissions and promoting circularity in the construction industry by focussing on circular building materials and methods. For example, R7 is a strategy that is all about reusing things and R3 (Reuse). However, this isn't always possible because of a lack of materials. For example, the project developer said, "We wanted to use salvaged lake poles for the facade. They are plentiful along canals. You may cut gorgeous planks from them. However, I required 5600 m2, and no lumber source can

guarantee that quantity of used boards." This is in line with research done by Shen et al. (2010) and Maqbool et al. (2023), that say that the scarcity of ecologically friendly building materials leads to rising costs and shortages, highlighting the pressing need for sustainable supply chains to be developed. The project developer thus recommends scaling up the production of these types of renewable materials, stating that “Production facilities actually still need to be scaled up. To make it less expensive, so it's all complicated.”

In the pursuit of circularity within the construction industry, stakeholders are actively engaged in diverse strategies such as R1 (Rethink) and considerations regarding new material use. The project "Matchbox" serves as a compelling case study, with stakeholders articulating their perspectives on the matter.

The project leader underscores the imperative of circularity and experimentation, as there has been a notable shift towards embracing circular and bio-based construction methods. They stated, "In recent years, we have been increasingly engaged also in circular construction and bio-based construction, so to speak." This commitment is further evidenced by the project's inclination towards experimentation. As another project leader mentioned, "To see how you can shape that whole circularity thing, in the beginning, we did that in the form of experiments."

The endeavour to incorporate renewable materials into construction practices is evident in various initiatives undertaken within the project. For instance, project leaders mentioned constructing buildings with second-hand materials, with one stating, "For example, we built a workshop in WoensDorp-West, 100% with second-hand materials." This commitment extends to exploring collaborations and innovative approaches. This approach mirrors a broader trend of embracing sustainability and bio-based developments, reflecting ongoing collaboration and innovation within the sector.

5.4.3 Uncertainty and complexity

The decision to prioritise renewable materials in the Matchbox project is deliberate, as emphasised by a project leader: "Yes, at Matchbox we said from the very beginning, we are going to make an effort to build as much biobased there as possible." This strategic choice aligns with broader industry trends towards sustainability and environmental consciousness.

However, this might cause friction between the project leader and the contractor, as disputes arise over guarantees and practicalities, particularly in timber projects (Häkkinen & Belloni, 2011; Shen et al., 2010). The contractor's caution about potential issues like moisture resistance and fireproofing underscores the challenges faced in making sure that circular buildings last a long time and are durable. As the contractor remarks, "And the contractor says yes but I don't guarantee that. That's the kind of conflict you get. And especially in your timber building. If you say gosh, if it gets damp back there and it starts to rot then my building is basically gone."

Financial considerations also play a pivotal role in material selection, as demonstrated by the utilisation of subsidies and grants to mitigate the costs associated with circular building practices. Despite financial implications, stakeholders acknowledge the criticality of opting

for materials with lower environmental footprints, such as wood construction that sequesters carbon dioxide.

Moreover, the effective use of materials emerges as a critical factor, involving both construction materials and interior treatments. However, the interaction of architectural aesthetics and R-strategies such as R2 (Reduce), which focuses on using materials efficiently to reduce resource consumption, frequently complicates the process. Balancing aesthetic design and the goal of reducing material usage is a significant challenge. As stated by a contractor participating in the building in case of the project Matchbox, "Half of the columns in the facade are aesthetically pleasing. That is obviously not circular." This insight highlights the difficulty of matching aesthetic desires with circular material choices. While optimal material utilisation is critical for decreasing environmental impact, architectural design decisions may prioritise visual appeal over sustainability. As a result, achieving optimal material efficiency demands careful consideration and collaboration among stakeholders to align design decisions with circular objectives. Material efficiency and financial feasibility are in this case inextricably linked. As the contractor stated, ″Only the architect wants a certain look. So that's why all those aesthetic columns are in there. That really costs a lot. And for that money, you did. For example, the interior walls can be made of biobased material." This emphasises the necessity of excellent cooperation and the dialogue that goes with it.

Navigating the delicate balance between environmental stewardship and financial prudence, the project developer/manager grapples with the practical implications of circular initiatives. As mentioned earlier stakeholders recognize the financial strain of integrating sustainable elements into projects while striving to meet operational benchmarks. The project developer/manager highlights the pivotal role of subsidies in offsetting the financial burden of circular initiatives, citing the MIA grant as a notable example. Their reflection, "Subsidies serve as a lifeline in mitigating the financial strain of circular projects, exemplified by the MIA grant's contribution," emphasises the instrumental role of subsidies in fostering circularity.

In conclusion, the examination of circularity within the building industry, as demonstrated by the project "Matchbox," highlights both the progress gained and the problems that have to be faced. The emphasis on renewable resources and circular construction processes demonstrates a purposeful attempt to align with environmental goals, displaying a dedication to lowering carbon emissions and encouraging environmentally responsible practices. However, interaction among stakeholders reveals continuous difficulties, particularly about the balance between architectural aesthetics and ecological goals, as seen by disagreements over material assurances and realities. Despite these obstacles, the use of subsidies and grants is a critical lifeline in easing the financial pressure of sustainable efforts, demonstrating the interdependence of environmental stewardship and financial feasibility. Moving forward, effective collaboration and conversation among stakeholders will be critical in navigating these challenges and driving circular construction methods towards a more ecologically conscious future.

5.5 Cost and feasibility evaluation

In the following part, the findings on financial concerns and project feasibility in social housing projects will be discussed. This chapter investigates the complex relationship between economic constraints and circular imperatives. While focusing on problems, possibilities and techniques for aligning financial criteria with overall project circular objectives.

5.5.1 Financial

In the following section, this study will examine the complex relationship between financial concerns and project feasibility during the conception phase of social housing projects. Here, a look at the findings that shed light on the challenges, opportunities, and tactics for aligning financial criteria with building projects' overall sustainability aims.

The examination of financial dynamics within construction projects unveils a multifaceted landscape where stakeholders navigate between economic constraints and circular imperatives. As one project leader rightly puts it, "You can keep rents low as social housing," underscoring the commitment to affordability amid broader community development goals. Moreover, the discourse extends to the realm of circular economy principles, with environmental consultants advocating for cost-effective strategies that align with sustainability objectives, as expressed by one consultant: "Especially costs towards it. That you still find a golden meaning in that." The findings of this study resonate with the conclusions drawn by Jotjensen et al. (1986), which highlighted economic risk variables, emphasising the difficulties developers face in balancing financial considerations with circular ideas.

In the contractor's narrative, financial viability emerges as a pivotal concern, particularly regarding the adoption of circular construction methodologies. Problems like not knowing enough about the subject and unclear rules make it even more important to make practical choices that balance circular ideas with financial realities. A contractor's perspective encapsulates this struggle: "Sustainable construction can be done, but so far sustainability is often also more expensive."

Conversely, project developers and managers deliberate strategic pathways that reconcile financial metrics with circular benchmarks. This deliberation underscores the need for transparent communication to justify investments in circularity to stakeholders while adhering to financial benchmarks and return expectations. A project developer's insight sheds light on this process: "So that's how I try to tell it then say towards my colleagues. And towards my board. And towards my supervisory board."

Furthermore, the discourse highlights the imperative of flexibility in project execution. Stakeholders emphasise the importance of adaptive approaches, wherein adjustments to building programs and structural designs are made to optimise construction costs without compromising overarching project goals. A project manager's reflection on this process encapsulates the sentiment: "So there have been quite a few outside influences as well. Which ultimately led to this building coming up."

5.5.2 Feasibility

Transitioning from the discourse on flexibility in project execution, our attention shifts towards the assessment of project feasibility, particularly in the context of new social housing projects. Here, the exploration of project feasibility unfolds within a complex terrain, marked by technical intricacies, financial imperatives, and r-strategies. Within this intricate framework, stakeholders navigate a numerous of challenges and navigate nuanced decisions that significantly influence the trajectory of each endeavour.

In the pursuit of project viability, decisions often pivot on financial considerations rather than circular principles, exemplified by a notable instance in the Matchbox project concerning the adjustment of materials for acoustic isolation. Reflecting on this, a contractor notes, "The floor mass is not sufficient to counteract the noise resistance. So we had to add mass, of course using grind was a circular option. But in the end, we chose to put on foam concrete. That is, of course, in terms of making it feasible."

In addition, the project developer/manager stresses the delicate balance between financial parameters and R0 (Refuse) and R2 (Reduce), underlining the difficulty of balancing preset financial returns with the aim to prioritise environmental measures. As Shen et al. advocate, a good feasibility study is necessary in order to find the right balance (2010). This tension highlights critical periods when projects deviate from established financial criteria in order to embrace circularity, influencing the changing landscape of project evaluation and decision-making. Furthermore, the story dives into the numerous trade-offs inherent in construction decisions, such as using dry construction methods, demonstrating the complicated interplay between technical feasibility and budgetary pragmatism.

5.5.3 Subsidies

Building on the complexity of project feasibility discussed previously, an analysis of prospective subsidies emerges as an important route for improving project profitability. The role of subsidies in construction and development projects is paramount, significantly influencing their financial viability and feasibility. Subsidies serve as powerful incentives guiding decision-making processes and mitigating the financial barriers associated with high development and production costs. Building upon the arguments put forth by Zhan, de Jong, & de Bruijn (2018) and Kyvelou & Papadopoulos (2011), this study illuminates the importance of balancing stakeholder needs and diversifying funding sources.

One striking observation is the prevalence of subsidy schemes, which inherently shape project trajectories by providing clear incentives for stakeholders to pursue certain strategies. As one environmental consultant notes, "For that reason, you actually end up with an automatic subsidy scheme already. So that is quite an incentive to steer there, the project towards a circular goal"

Moreover, subsidies play a crucial role in addressing the financial challenges inherent in projects, particularly when upfront costs are high and production costs remain a concern (Abidin et al., 2013). By offsetting expenses, subsidies make projects financially viable, as highlighted by an environmental consultant: "So your development costs are currently still high and so is the cost of production, so it will be of significant value to get a subsidy”.

Understanding and leveraging various subsidy programs is essential for stakeholders. Subsidies like the MIA subsidy better known as the Environmental investment deduction that grants offer rebates and incentives that contribute to project feasibility and financial sustainability. A contractor explains, "Because of course you get the subsidy. And then you have your investment deduction, well then you have to be below certain MPG (Environmental Performance of Buildings) scores." Similarly, a project developer/manager emphasises the importance of subsidies, stating, "Matchbox is also a very expensive thing. But some of the more expensive will be offset by the MIA (Milieu investeringsaftrek) subsidy."

Furthermore, subsidies are increasingly becoming indispensable in project planning and execution, with stakeholders relying on these financial incentives to address cost challenges and enhance project feasibility. Project developers/managers recognize this trend, noting, "Especially in those MIA subsidy projects say. You just need them there in order to make a project feasible. So those are increasingly coming to the table."

In summary, the study of financial dynamics within social housing projects reveals a complex landscape in which stakeholders must balance economic limitations with circular imperatives. The report emphasises the complexities of integrating financial criteria with overarching sustainability goals, outlining obstacles, possibilities, and project feasibility strategies. Stakeholders negotiate a complex landscape in which decisions are based on financial concerns while also seeking to incorporate circular economy concepts and environmental sustainability. The discussion highlights the delicate balance between financial viability and sustainability goals, which necessitates open communication and adaptable project execution. Furthermore, the analysis emphasises the importance of subsidies in increasing project profitability and feasibility, incentivizing stakeholders to pursue circular practices, and mitigating financial hurdles. As stakeholders manage the complex interplay between financial concerns and environmental goals, leveraging subsidies and making pragmatic decisions will remain critical in ensuring the success of social housing projects while also advancing r-strategies.

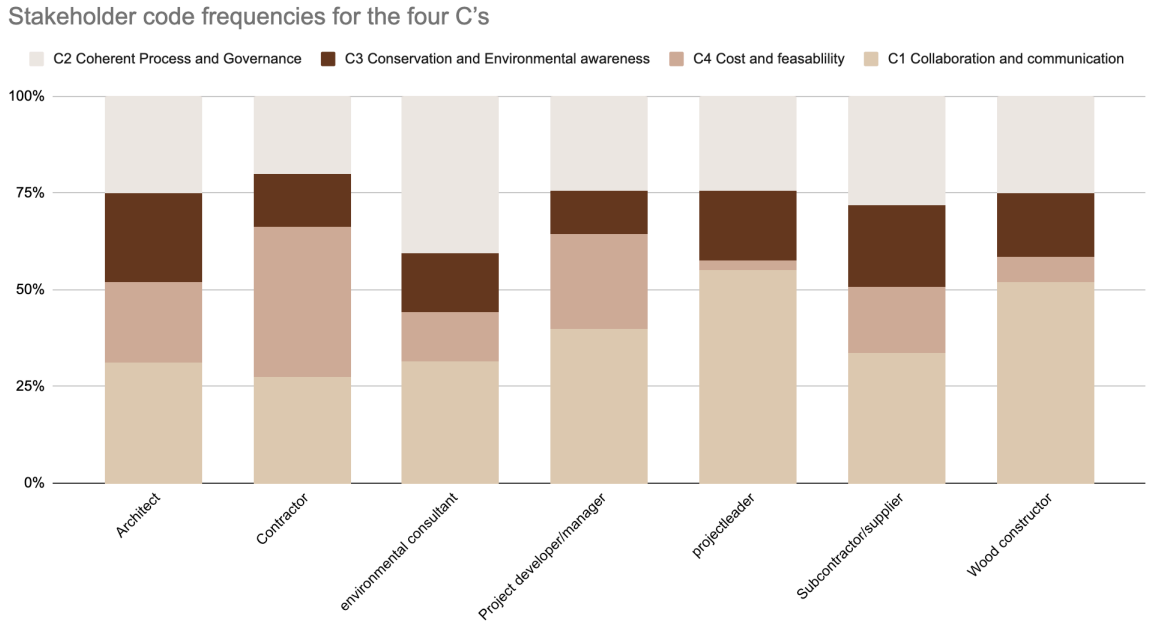
5.6 The synergy between the four C’s

This section goes into the intricate relationship between the four C's results. That will be referred to in the following manner: C1 represents collaboration and communication, whereas C2 represents coherent process and governance. C3 represents conservation and environmental awareness, whereas C4 represents cost and feasibility analysis. The findings highlight the complicated interaction of various elements, especially in social housing developments.They stress that balancing environmental goals with limited budgets needs strategic adaptability, smart use of subsidies, and a flexible approach to design and material choice. The way stakeholders manage these dynamics, adjust to regulatory limits, and use available resources has a significant impact on the integration of circularity and financial viability.

5.6.1 Stakeholder code frequencies for the four C's

Mapping the frequency of stakeholder discussions across the four C's provides valuable insights into their priorities and the dynamics of project management. By analysing the frequency of which stakeholders referenced Collaboration and Communication (C1), Cost and Feasibility (C4), Conservation and Environmental Awareness (C3), and Coherent Process and Governance (C2), a clear picture emerges of the stakeholders' primary focus areas.

Table 6 Stakeholder code frequencies



The results of this analysis, presented in Table 6, show distinct patterns. For instance, C3 (Conservation and Environmental Awareness) is consistently mentioned by all stakeholders, underscoring its central importance across the board. This may reflect the growing emphasis on circularity within the project, as well as its relevance to a broad range of actors, from government representatives to contractors.

On the other hand, there is a marked difference in how stakeholders perceive C4 (Cost and Feasibility). While this theme represents a key component of the decision-making process for some, such as contractors and project leaders, it is not equally weighted across the board. Specifically, contractors discuss C4 far more frequently than the project leader, who focuses more on C1 (Collaboration and Communication). This divergence may reflect differing priorities: the project leader may emphasise coordination and communication to ensure project success, while contractors are more concerned with the financial feasibility of the project.

Interestingly, the environmental consultant prioritises C1 (Collaboration and Communication) and C2 (Coherent process and governance) over C3. This could be explained by the interconnectedness of environmental goals and collaborative governance. Achieving environmental targets often requires extensive knowledge-sharing and collaboration

between stakeholders, which is further compounded by the financial implications of environmental considerations.

Key quotes from stakeholders illustrate this focus:

> "There is a lot of knowledge to share. To broaden that market's understanding as far as possible you definitely give the potential that many people are more willing to take action in that direction." (Environmental Consultant)

> "Many more experts must be trained, including within municipalities and provinces. Restrictions are already considered in the call for tenders. At the very least, that is what is described there." (Environmental Consultant)

These statements reflect the inherent link between knowledge-sharing (C1) and achieving environmental goals (C3). Stakeholders such as the environmental consultant stress that greater collaboration and communication are necessary to address environmental challenges and implement governance mechanisms that support circularity.

The Social Network Analysis (SNA) conducted provides another layer of understanding by examining the centrality of stakeholders within the network. According to Kim et al. (2010), higher centrality correlates with greater influence, suggesting that stakeholders with higher centrality scores will likely play a leading role in the project.

By linking the SNA centrality scores to the code frequencies, it becomes apparent that stakeholders with higher centrality scores tend to place greater emphasis on C1 (Collaboration and Communication) and C2 (Coherent process and governance). This is consistent with the idea that influential stakeholders, who are more connected within the network, frequently facilitate knowledge-sharing. These stakeholders motivate collaborative efforts, which are essential for addressing conservation issues.

Table 7 Stakeholder code frequencies linked with centrality score of SNA

	C1	C2	C3	C4	Centrality score
Architect	31,3	25	22,9	20,8	0,66
Contractor	27,5	20	13,8	38,7	0,72
environmental consultant	31,4	40,7	15,1	12,8	0,66
Project developer/manager	40	24,4	11,1	24,5	0,5
projectleader	55,1	24,4	17,9	2,6	0,5
Subcontractor/supplier	33,8	28,2	21,1	16,9	0,6
Wood constructor	52,1	25	16,7	6,2	0,77

Table 7 provides a detailed breakdown of stakeholder centrality and their corresponding emphasis on the four Cs. For example, stakeholders with higher centrality scores, such as the project leader and environmental consultant, are more likely to emphasise themes related to communication and Coherent process and governance.

The SNA results, therefore, suggest that stakeholders with greater influence in the network are better positioned to promote cross-sector collaboration and drive the project towards its environmental and governance goals. The role of C3 (Conservation and Environmental Awareness) as a central theme across all stakeholders highlights the network's alignment towards circularity. The environmental consultant’s preference for C1 and C2 may be due to the need for cross-disciplinary cooperation to meet environmental regulations. Achieving these goals often requires strong governance structures and the active involvement of various stakeholders, as reflected in their SNA centrality.

Surprisingly, the project leader has a relatively low centrality score in the network but demonstrates a strong interest in C1 (Collaboration and Communication) and C2 (Coherent process and governance). This suggests that, while the project leader may prioritise collaboration and environmental considerations, their influence within the stakeholder network is limited. To increase their impact and contribute to the success of the project, it may be beneficial for the project leader to collaborate with stakeholders who have higher centrality scores. For example, the wood constructor, who has a centrality score of 0.77, could provide the necessary influence within the network to support the project leader's initiatives.

In contrast, the contractor, who has a centrality score of 0.72, shows less engagement with C1 and C2 but scores high on C4 (Cost and Feasibility). This indicates that while the contractor may not be as focused on collaboration or environmental aspects, they could be a valuable partner in matters related to financial and cost management. Therefore, in situations where the project leader seeks to enhance financial decision-making, teaming up with the contractor could be advantageous.

However, differences in how stakeholders prioritise the four Cs reveal important insights into the project’s dynamics. As mentioned earlier, the project leader focuses more on C1 (Collaboration and Communication), while contractors emphasise C4 (Cost and Feasibility). These differing priorities may reflect their varying roles and responsibilities within the project.

The findings show that the four Cs are crucial to understanding stakeholder behaviour and priorities. The frequency with which each theme is mentioned shows what stakeholders value most, while SNA centrality scores show who influences the project's trajectory most.

5.6.2 Balancing circularity and financial feasibility

Chapter 5.4 underscores the pivotal role of circularity in construction, particularly in efforts to reduce CO2 emissions and utilise eco-friendly materials. This emphasis on circularity is crucial for addressing environmental impacts; however, Chapter 5.5 highlights that financial constraints frequently impede the adoption of these environmental measures. Specifically, as outlined in Chapter 5.4.2, materials such as hardwood and recycled components offer substantial environmental advantages, including improved carbon sequestration. Nonetheless, their high costs and limited availability pose significant financial challenges.

This financial tension is vividly illustrated in Chapter 5.5.1, where a contractor remarks that "circular construction is often more expensive," reflecting the inherent conflict between circularity and cost. The Matchbox project case study in Chapter 5.5.2 further exemplifies

how budgetary limitations can force compromises on environmental practices, such as substituting circular materials with more cost-effective alternatives for acoustic isolation.

To effectively integrate circular economy principles into social housing projects, it is evident that increased financial support and regulatory alignment are crucial. Without adequate funding, developers and contractors often face difficult trade-offs, prioritising short-term cost savings over long-term environmental benefits.

The findings suggest that stakeholder engagement, as highlighted by the SNA, is critical for overcoming the challenges associated with aligning circular and financial feasibility. By leveraging the strengths of key stakeholders and promoting a collaborative approach, social housing projects can better address financial constraints while advancing environmental goals, ultimately achieving a more harmonious balance between the four Cs.

5.6.3 The role of subsidies in bridging the gap

Chapter 5.5.3 highlights that subsidies play a crucial role in bridging the gap between circularity and financial feasibility. Financial incentives, such as the Environmental Investment Deduction (MIA), are very helpful for lowering the high costs that come with starting circular projects. These subsidies not only provide necessary budget relief, but they also serve as strategic facilitators for the project. They assist the incorporation of eco-friendly technologies and materials into social housing developments.

The findings presented in the chapter of C3 underscore the challenges associated with introducing new, environmentally beneficial materials. As detailed in this chapter, these materials often entail higher financial risks due to regulatory gaps and unfamiliarity. This analysis shows that subsidies act as a critical buffer, allowing stakeholders to prioritise r-strategies like R9 (Recover) and R0 (Refuse) for CO2 reduction and circular material adoption while maintaining project feasibility. Thus, subsidies are instrumental in reconciling environmental aspirations with financial constraints, making the pursuit of circular practices more feasible.

A closer examination reveals that the effectiveness of subsidies is intricately linked to stakeholder relationships, as elucidated by the Social Network Analysis (SNA) in Chapter 5.1. The SNA identifies constructors, architects, and environmental consultants as key players in integrating circular materials within the constraints of regulatory and technical requirements. The analysis demonstrates that a well-connected network enhances communication and resource sharing among these stakeholders, which is crucial for leveraging subsidies effectively.

The SNA findings suggest that a moderately connected network facilitates better coordination, allowing stakeholders to collaborate more efficiently in securing and utilising subsidies. For instance, contractors can benefit from the expertise of architects and environmental consultants in identifying and applying for relevant subsidies. This collaborative approach not only optimises the integration of circularity into projects but also helps overcome technical challenges and adapt to financial constraints.

In summary, the interplay between subsidies and stakeholder interactions, as revealed through the SNA, underscores the importance of a cohesive network in advancing circularity within social housing projects. Effective stakeholder collaboration enhances the strategic use of subsidies, thereby supporting both the financial feasibility and environmental objectives of these projects.

5.6.4 Flexibility and adaptation as key factors in circular project execution

A recurring challenge highlighted across the chapters is the tension between achieving R-strategies and maintaining financial feasibility. This issue is particularly evident in the need for flexibility and adaptive decision-making, as discussed in Chapters 5.4.3 and 5.5.2. Integrating circular practices into construction projects often requires navigating complex trade-offs between environmental objectives and practical constraints. Consequently, stakeholders must exhibit flexibility and adaptability throughout the project's stages to successfully balance these competing demands.

Chapter 5.4.3 explores this challenge through the example of the Matchbox project, focusing on timber construction. The discussion reveals how ambitious environmental goals, such as reducing CO2 emissions, can sometimes conflict with practical requirements. These include considerations like moisture resistance and fireproofing. These technical issues often lead to disputes among key stakeholders, including contractors and developers, who must reconcile these constraints while ensuring project feasibility. This highlights the need for ongoing negotiation and compromise in the pursuit of circular construction.

The SNA provides valuable insights into the dynamics of stakeholder interactions in this context. The SNA identifies constructors, architects, and environmental consultants as central figures whose roles are crucial in addressing these challenges. For example, constructors, positioned at the heart of the network, are pivotal in implementing circular materials while complying with regulatory and technical requirements. Meanwhile, architects and environmental consultants contribute essential expertise and guidance.

Similarly, Chapter 5.5.2 underscores the importance of adaptability in response to unforeseen events or technological advancements. These changes often require adjustments in construction processes or material choices. The Matchbox project’s shift from circular grind to foam concrete for sound isolation illustrates the necessity of flexibility in both technical and financial aspects. This case study demonstrates that when circular options become impractical or costly, stakeholders must be prepared to adjust their-strategies to a higher R principle, meaning a shift towards a linear economy. For example, instead of selecting R0 (Refuse), consider reusing products (R3) or using recycled materials (R8) to maintain balance. This approach promotes both environmental and financial sustainability.

The SNA further emphasises that maintaining robust connections and open communication among the core actors is essential for overcoming these challenges. A well-connected network facilitates effective collaboration, enabling stakeholders to address technical issues and financial constraints more efficiently. By fostering strong relationships and ensuring

coordinated efforts, stakeholders can better integrate sustainability with financial planning. This approach ultimately helps achieve a harmonious balance between the two.

Overall, the synergy between circularity, cost, and feasibility highlights the critical role of flexibility and stakeholder collaboration. The SNA reveals how effective communication and strategic coordination among key stakeholders are vital for navigating the complex interplay of these factors, thereby supporting the successful integration of circular practices within financial constraints.

5.6.5 Regulatory constraints and the need for policy alignment

The influence of legal frameworks on the integration of circularity into construction projects is a recurring theme across several chapters. Chapter 5.4.1 identifies regulatory gaps for new and unfamiliar materials as a significant obstacle to the widespread adoption of circular practices. These regulatory uncertainties frequently lead to higher costs and project delays. Making it more difficult to achieve environmental goals while also making money.

The findings indicate that regulatory frameworks play a crucial role in the implementation of circular measures. Specifically, the absence of clear guidelines for new, environmentally friendly materials can hinder their adoption. As stakeholders grapple with ambiguous regulations, they face additional expenses and delays that can disrupt project timelines and budgets. The difficulties encountered by contractors, as discussed in Chapter 5.4.1, illustrate the broader impact of regulatory ambiguity on the practical integration of circularity into social housing projects.

Chapter 5.5.3 proposes a partial solution to this problem through the use of subsidies. Financial incentives, such as the Environmental Investment Deduction (MIA), help to bridge the gap between current legislative requirements and anticipated circular outcomes. These subsidies give critical financial assistance, helping to offset some of the costs associated with using new, environmentally friendly materials. However, while subsidies provide a financial buffer, they do not address the underlying cause of regulatory issues. The necessity for regulatory harmonisation continues to be a fundamental impediment to effective sustainable integration.

The SNA in Chapter 5.1 adds further depth to understanding these dynamics. The SNA highlights the roles of various stakeholders. Key actors in the network, particularly those with central positions, play a crucial role in influencing regulatory interactions and advocating for clearer guidelines. For instance, constructors often face direct regulatory challenges and benefit from effective communication with architects and environmental consultants to address these issues collaboratively. Enhanced coordination among stakeholders can facilitate a more unified approach to advocating for regulatory reforms and navigating complex legislation.

The SNA underscores that a well-connected network of stakeholders can improve the effectiveness of subsidies and regulatory advocacy. By fostering strong relationships and

open lines of communication, stakeholders can better address regulatory uncertainties and support the integration of circularity into housing projects.

5.6.6 Interdependency between stakeholders and the importance of collaboration

The intricate interplay between circularity, cost, and feasibility underscores the critical importance of stakeholder involvement in construction projects. Previous chapters have emphasised the importance of effective stakeholder collaboration in meeting r-strategies. The Social Network Analysis (SNA) presented in Chapter 5.1 provides valuable insights into how stakeholder interactions influence this dynamic.

The findings from the SNA study indicate that network density and centrality are key factors in successful stakeholder collaboration. Central actors, including constructors, architects, and environmental consultants, play pivotal roles in closing the gap between circular objectives and financial constraints. The SNA reveals that these central players are crucial for facilitating communication and resource sharing across the network. Their significant positions enable them to lead discussions, negotiate solutions, and drive collaborative efforts that align financial feasibility with circular goals.

Chapter 5.4.2 highlights the challenges associated with incorporating the R principle R0 (refuse), R1 (Rethink) and R2 (reduce), such as eco-friendly hardwood and recycled components. These materials often require navigating complex financial and regulatory hurdles. Furthermore, the SNA underscores that stakeholders with a high centrality score are essential for overcoming these barriers. Their central roles enable them to address regulatory challenges, mediate conflicts, and promote initiatives that integrate circularity with financial considerations.

Similarly, Chapter 5.5.1 illustrates how financial constraints and cost considerations necessitate open communication and collaborative problem-solving. According to the SNA, a network with moderate density facilitates enhanced stakeholder interaction and resource sharing (Tabassum et al., 2018). This connectivity is crucial for managing financial concerns and supporting circular practices. The analysis shows that a more densely connected network allows stakeholders to coordinate more effectively, balancing cost and sustainability challenges through improved communication and collaborative efforts (Tabassum et al., 2018).

The conflict between R2 that is about to reduce the amount of materials used and aesthetic preferences, as discussed in Chapter 5.4.3, further emphasises the need for effective stakeholder communication. Architects' design preferences often clash with material efficiency and circular objectives, creating tensions among various stakeholders. The SNA demonstrates that stakeholders with central roles are better suited to mediate these conflicts and make sure a common goal is reached. Their ability to connect diverse groups and manage interactions is vital for reconciling design goals with environmental and practical constraints.

6. Discussion

In the following chapter, I will discuss the findings of my research, interpreting and comparing them to previous studies. Additionally, I will address the limitations of my research, explaining their implications. Finally, I will explore how my research can contribute to and inform future studies in this field.

6.1 Interpretation of results

In my research into new circular housing projects, I've delved into four overarching themes that have an influence on the project: Collaboration and Communication, Cost and Feasibility Evaluation, Conservation and Environmental Awareness, and Coherent Process and Governance. Furthermore, a Social Network Analysis is done on the network of the stakeholders that were involved in the case studies project “Matchbox”. Here is an overview of the important findings and how they can be interpreted in relation to my study questions.

6.1.1 Social Network Analysis

The centrality analysis in this study revealed significant insights into the stakeholder dynamics within circular housing projects. The constructor emerged as the most central stakeholder, with a high centrality score of 0.7778. Highlighting its critical role in connecting various stakeholders. This centrality underscores the constructor's influence in communication and decision-making processes throughout the conceptualisation stage of the project (Wasserman & Faust, 1994; Gu et al., 2023). Furthermore, the contractor (Node 3) and the architect (Node 5) also represent high centrality scores of 0.7222 and 0.6667. Emphasising their crucial contributions to the project's network. These findings support the hypothesis that key stakeholders play pivotal roles in project management. And align with previous studies that highlight the influence of central actors in stakeholder networks (Z. Yang & Yang, 2009).

The density analysis of the stakeholder network in the "Matchbox" project revealed a density of 0.1608. This value says that approximately 16.08% of all possible connections between nodes in the network are active, indicating a network that is moderately interconnected (Wasserman & Faust, 1994; Gu et al., 2023). This finding supports the hypothesis that circular housing projects involve a network of stakeholders with varying degrees of connectivity. Which is essential for effective collaboration and resource sharing. Interestingly, this moderate density deviates from previous studies that often report higher densities in closely knit networks (Z. Yang & Yang, 2009). The reason for a lower density could be the diverse roles and interactions among stakeholders involved in circular housing projects.

Notably, the SNA also illustrates collaborative subgroups within the stakeholder network, such as municipalities, consultants, engineers, and suppliers. These subgroups could demonstrate relationships that facilitate information exchange and resource sharing. That is crucial for effective project implementation and management (Wasserman & Faust, 1994; Gu et al., 2023). The fact that these subgroups formed supports the idea that stakeholders tend to stick together because they share goals and interests. Helping the network stay together as a whole. This finding aligns with previous studies that emphasise the importance of

collaborative dynamics in stakeholder networks and their impact on project outcomes (Z. Yang & Yang, 2009).

6.1.2 Collaboration and communication

Effective collaboration and communication emerge as key components of project success. Early stakeholder involvement promotes informed decision-making, and strong team interactions enable agile responsiveness. The findings indicate that transparent communication channels, including digital platforms and face-to-face interactions, are critical for problem solving and information exchange. This supports the hypothesis that creating a collaborative environment allows stakeholders to share their knowledge. In order to address challenges and drive innovation in circular practices for the built environment, aligning with the results of previous studies.

Interestingly, the data revealed an unexpected pattern in the formation of in-house feedback loops. During the qualitative part of this research, different kinds of stakeholders are mentioned. This deviates from previous studies, such as those by Hamdan et al. (2021), Andersen et al. (2004), and Kellogg and Keating (2011), which emphasise the sharing of knowledge. However, they fail to acknowledge the significance of feedback moments at the conclusion of a project.

6.1.3 Coherent process and governance

The findings indicate a significant correlation between stakeholder engagement and the implementation of circular housing projects. This suggests that effective collaboration and communication are crucial for aligning diverse interests and achieving circular goals (Z. Yang & Yang, 2009; Gu et al., 2023). This supports the hypothesis that strategic stakeholder involvement and clear governance mechanisms are essential for navigating the complexities of circular practices (Santos et al., 2019; Salvioni & Almici., 2020). Conservation and awareness of the environment are important parts of circular housing projects, and the R-ladder principles stress the need for an effect on the environment. Environmental consultants advocate for renewable materials and eco-friendly construction practices, utilising subsidies and information systems to achieve r-strategies. Creating a culture that cares about the environment can lead to good change and lower the damage that building activities do to the environment.

Interestingly, the data revealed challenges related to regulatory uncertainties and the lack of knowledge within the government, which may hinder project progress (Z. Yang & Yang, 2009). This deviates from previous studies, such as Häkkinen & Belloni (2011), which reported more supportive regulatory environments. Therefore, we could perhaps say that a well-defined process and governance framework are essential for navigating the regulatory landscape and completing projects successfully. Regulatory uncertainty and quality control challenges underscore the importance of clear guidance and help from governmental organisations. Developing a culture of regulatory compliance and quality assurance can reduce risks. Furthermore, by maintaining high levels of excellence in circular construction processes, we can improve the overall project outcomes.

6.1.4 Conservation and environmental awareness

The findings suggest a significant correlation between the adoption of environmentally friendly technologies and the challenges of integrating them into circular housing projects, highlighting the need to balance innovation with practical application (Häkkinen & Belloni, 2011; Shen et al., 2010). This supports the hypothesis that circular practices require careful consideration of construction methods and materials, aligning with previous research.

Surprisingly, the data showed that stakeholders didn't know much about environmentally friendly features. This could be due to insufficient market education (Maqbool et al., 2023; Gansmo, 2012). In comparison, studies like Shen et al. (2010) found that the market for sustainable housing was growing, but they didn't look into the knowledge gaps that existed.

Sustainability certifications like LEED or BREEAM add hurdles due to stakeholder costs and time requirements, influencing developers' decisions (Häkkinen & Belloni, 2011; Shen et al., 2010). The ongoing growth of circular regulations and building standards also presents challenges. This results in developers seeking guidance from experts (Shen et al., 2010; Gansmo, 2012).

The use of R-ladder principles emphasises the necessity of reducing, reusing, and recycling resources to reduce environmental impact. Environmental consultants promote the use of renewable materials and eco-friendly construction practices, utilising subsidies and existing information systems to emphasise R strategies. However, the scarcity of ecologically friendly building materials contributes to rising costs, underscoring the need for sustainable supply chains (Shen et al., 2010; Maqbool et al., 2023).

6.1.5 Cost and feasibility evaluation

A thorough cost and feasibility analysis is crucial for navigating the economic landscape of circular housing projects. This analysis is crucial for stakeholders as they balance economic constraints with environmental goals. Underscoring the necessity for clear and adaptable solutions to justify circular investments while keeping financial commitments. This interpretation aligns with the challenges and motivations identified in my research questions, highlighting the pressures stakeholders face.

The findings suggest a significant correlation between the availability of subsidies and grants, such as the MIA (Milieu Investerings Aftrek) subsidy. Moreover, it enhances the profitability and viability of the project. Stakeholders highlight that these financial incentives are crucial for managing project costs and ensuring feasibility. For example, a contractor pointed out the need to stay below certain Environmental Performance of Buildings (MPG) scores to benefit from investment deductions. In the same way, a project developer stressed that subsidies like the MIA help to lower the high costs of environmentally friendly building methods. This makes projects a good investment.

It came as a surprise that subsidies have become so important that stakeholders are relying more and more on them to deal with cost problems (Dwaikat & Ali, 2016; Ionașcu et al., 2020). As a result of government rules and market forces, this trend is part of a larger movement towards sustainability. The valuation of property considers economic factors (Jotjensen et al., 1986). Overall, these insights underscore the necessity of flexible financial strategies to support sustainable investments in the built environment.

6.2 Comparison with previous studies

This section compares the findings from this study with existing literature, highlighting similarities, differences, and contradictions. It also explains how these findings contribute to the existing body of knowledge in the field of circular housing projects.

6.2.1 Similarities

Previous studies done by Santos et al. (2019) and Salvioni and Almici (2020) emphasised the critical importance of active stakeholder engagement in decision-making processes for project success. Consistent with previous research, this study emphasises the need for strong stakeholder engagement, ongoing decision-making, and early contractor involvement. This agreement emphasises the need of collaborative approaches in achieving circular economy goals.

In addition, Häkkinen & Belloni (2011) and Shen et al. (2010) explored how to include circularity into building practices, highlighting the use of renewable materials. This research supports these findings by addressing the prioritisation of renewable materials and strategic linkage with larger circular goals. This emphasises the importance of environmental factors in construction projects.

Lastly, previous research done by Z. Yang & Yang (2009) and Gu et al. (2023) mention the importance of quality control and governance systems for project success. Similarly, this study's findings emphasise the need for robust governance and constant quality assurance, which is consistent with the literature.

6.2.2 Differences

This study also highlights some critical differences. Unlike Santos et al. (2019) and Salvioni & Almici (2020), who emphasise the primary role of stakeholder engagement in early project stages, This research found that the impact of stakeholder involvement is significant during the early stages of the project. Additionally, the findings diverge from J. Yang & Yang (2014) by saying that, while continuous education is vital, adaptive learning tools that change as the job goes on are more important than ever.

Building on stakeholder involvement, something unexpected is discovered in the SNA. While previous research by Z. Yang and Yang (2009) (Gu et al., 2023) indicated that a project manager, who expertly managed the project's numerous moving parts, is at the centre of the

project and the network, The results of my study suggest a different point of view, emphasising the role of the constructor. The SNA revealed that the constructor had a centrality score of 0.78, while the project leader scored 0.50. This indicates that the constructor is an important component of the stakeholder network. Perhaps because the constructor is responsible for the building's core, it must communicate with many stakeholders. It will also have an impact on the aesthetics designed by the architect, as well as the use of materials provided by the supplier. This will then have implications for how the contractor builds it. This topic requires further investigation to fully understand the constructor's role in these networks.

Contrary to Häkkinen & Belloni (2011), who stress the effectiveness of established collaborative decision-making frameworks, this study indicates that flexibility is crucial. Furthermore, the ability to pivot quickly in response to unexpected challenges is crucial for the success of circular housing projects. This research also identifies a more specific role for government support in addressing regulatory ambiguities and quality control. This is in contrast with Z. Yang & Yang (2009), who focus primarily on internal project governance.

One possible explanation for this distinction is that my research emphasises the changing complexity of regulatory environments and the need for external guidance. As circular housing projects gain popularity, government involvement in establishing clear regulations and quality control measures becomes increasingly important to ensure consistency and compliance. When considering circular development projects, we must keep in mind that we are dealing with a "relatively new" way of building.

Additionally, the findings reveal differences in the importance and effectiveness of certification and subsidies. Although subsidies are frequently mentioned in the literature as being crucial to promoting circular behaviours (Salvioni & Almici, 2020), this is not always the case. This study found that the availability and accessibility of these subsidies are inconsistent, leading to challenges in project financing and implementation. These differences could underscore the need for more research into streamlined and accessible certification processes. In order to fully understand the problem of adopting subsidies for circular housing projects.

6.2.3 Contradictions

In comparing the findings of this study with the existing literature, several contradictions and differences have surfaced. This could provide significant understanding of the intricate nature of circular housing initiatives. While previous research emphasised the efficacy of establishing collaborative decision-making frameworks (Häkkinen & Belloni, 2011), these study results suggest an alternative perspective. Emphasising the critical importance of flexibility and the ability to shift in response to unexpected challenges for the success of circular housing projects. In addition, some studies indicate that circular housing projects use a more linear decision-making process. However, this study stresses the ongoing and often difficult process of reaching an agreement with all stakeholders. Particularly in combining economic feasibility with circular goals or r-strategies. This difference may be due to the complexity of the dynamics within these fields. The introduction described a research gap on stakeholder engagement in this field, which this study has shown.

Moreover, previous studies like Z. Yang & Yang (2009) primarily focused on internal project governance. While this research identifies a more specific role for government support in addressing regulatory ambiguities and quality control, This study suggests a shifting culture in which external regulatory frameworks and government involvement are increasingly vital. This is necessary to navigate the complexities of circular construction practices.

Compared to Salvioni & Almici's (2020) findings, which emphasised the role of stakeholders in fostering sustainability and regulatory compliance, this study provides new evidence that substantial knowledge gaps and a lack of specialised governmental support hinder the effective implementation of circular practices. This may be because regulations are changing and governments in different areas offer different amounts of support. Again, showing how hard it is to use circular building methods together.

When looking at the analysis of the stakeholder dynamics and comparing that with the social network analysis another contradiction is seen. While studies show contractors typically play a central role within the network and have a significant influence on the decision-making (Gerding et al., 2021), my findings diverge from this. Although the contractor in my case study has a centrality score of 0.72 and focuses primarily on C4 (Cost and Feasibility), their engagement with C1 (Collaboration and Communication) and C2 (Coherent Process and Governance) is relatively limited.

Interestingly, in my case study the wood constructor stands out with the highest centrality score of 0,77. With this exceeding the centrality score of the contractor and the project leader of 0,65. This might be because the wood builder worked hard to include circular practices, especially when it came to C3 (Conservation and Environmental Awareness), which was important to many parties. The wood constructor's importance may come from their ability to bridge the gap between environmental objectives and practical implementation. This demonstrates their critical role in decision-making and collaborative efforts. Their influence is likely due to the growing importance of circularity and sustainability in the project.

The contradictions between the literature review and the results of this study show that circular development practices are changing, and they also show how important it is to change old frameworks to fit the needs of current building projects.

6.2.4 Contribution to existing body of knowledge

This study enhances our understanding of stakeholder engagement in circular housing projects. The study emphasises the importance of iterative decision-making procedures and contractor involvement from the start. By giving granular insights into the operational dynamics of effective stakeholder involvement, this study simultaneously strengthens and expands on current theoretical frameworks.

Furthermore, this study provides a comprehensive evaluation of the challenges inherent in material selection processes. The study contributes to our understanding of the actual challenges of achieving circularity in construction projects by providing specific examples of

conflicts between aesthetic desires and circular methods. This nuanced approach calls into question the widely held belief that aesthetic and environmental aims are naturally compatible.

Additionally, the study sheds light on the critical role of government support and the complications that arise from legislative uncertainties in circular construction methods. The report promotes more proactive government involvement by emphasising the importance of enhanced regulatory frameworks and specialised knowledge. This fresh perspective adds a new dimension to the current literature, emphasising the necessity of government intervention in promoting circular building practices.

The study examines the importance of financial mechanisms, including subsidies, in promoting circular construction projects. The study confirms current notions about the importance of financial incentives by describing the influence of subsidies such as the MIA award on alleviating financial restrictions. These specific examples provide useful insights that can help shape future policy development in the field of circular construction.

Furthermore, by incorporating data from Social Network Analysis (SNA), our study delves deeper into the complex web of relationships between stakeholders in circular housing projects. The study provides a new viewpoint on stakeholder interactions, motivations, and problems by analysing network topology, centrality measurements, and relationship dynamics. This incorporation of SNA contributes to the previous research by giving a comprehensive knowledge of the collaborative dynamics inherent in circular housing programmes.

6.3 Limitations

To better understand stakeholder engagement in circular housing projects, it is important to acknowledge the many limitations and biases that may have influenced the study's findings. Shedding light on the elements that could have influenced the conclusions' robustness and generalizability.

6.3.1 Biases

Several biases could have influenced the conclusions of this study, needing a thorough investigation. The use of the Snowball Sampling Method (SSM) may have introduced Sampling Bias because it relied on existing contacts to find new respondents. This might have led to a group that wasn't really representative, especially if some stakeholders were over- or under-represented in the interviews. However, as evidenced by my study participants group, I interviewed more than seven distinct types of stakeholders, providing a diverse perspective on my research issue.

Furthermore, Self-Report Bias may have occurred during qualitative interviews, when participants made socially desirable claims or overstated the benefits of collaboration as a result of their engagement in the study. In addition, Researcher Bias poses a risk because my personal ideas, beliefs, and experiences could have unintentionally influenced study

design, data collecting, and outcome interpretation. To retain objectivity, I must be aware of and mitigate these prejudices. Finally, Publication Bias may have been induced by predominantly citing material from Scopus or Google Scholar, thereby ignoring useful insights from grey literature or unpublished studies.

6.3.2 Data collecting

The extensive method of data collecting, including literature reviews, case studies, and qualitative interviews, may result in gaps that impact the findings' robustness. For example, focusing just on the conceptualisation phase may have missed important dynamics in other stages of the project lifecycle, reducing the study's depth. While addressing potential constraints in data collection, it is important to remember that this constraint was a well-thought-out decision made at the start of the research to ensure the study's practicality. The study frameworks were developed by focusing largely on the conception phase of circular housing projects, allowing for a structured and regulated scope of analysis. Despite this deliberate focus, it is probable that perhaps certain dynamics in other stages of the project lifecycle were not fully investigated, which could affect the conclusions' comprehensiveness.

This awareness emphasises the significance of balancing the depth of analysis with the practical restrictions of the research setting. While focusing on the conception phase gave helpful insights into the early stages of project planning, it is important to recognise the potential limits in collecting all stakeholder interactions throughout the project lifecycle.

6.3.3 Methodological

Using Social Network Analysis (SNA) to investigate stakeholder interactions may not fully capture the complexities of human relationships and motivation. Furthermore, employing qualitative data for SNA input may have raised subjectivity when creating network links, reducing the study's accuracy. Limited resources, particularly access to stakeholders, may have impacted the study's scope and depth. This constraint may have resulted in a failure to address critical aspects of stakeholder participation in circular housing programmes, diminishing the findings' comprehensiveness. The use of a single case study, "Matchbox," may reduce the findings' generalizability. While it offers information specific to one project, it may not apply to other circular house attempts or conditions.

A notable limitation of this study is that it focuses on a construction project that primarily uses timber as the building material. During the Social Network Analysis (SNA), it was observed that the timber constructor had a high centrality score of 0.77. It is vital to note that this grade is based on a project involving timber construction. It is acceptable to anticipate this in situations where a different construction material is employed. The timber constructor's centrality is likely to be lower.

The timber constructor's high centrality score is due to the fact that timber building is still fairly new, as was pointed out in the introduction. Timber, although gaining popularity in circular building practices, remains less familiar than traditional materials, such as concrete and brick, which have been used extensively in the past. As a result, there is a knowledge gap regarding timber construction techniques, causing stakeholders to rely more on the skills of the wood constructor. This dependency may have inflated the constructor's centrality within the network, as stakeholders tried to find help and work together to solve new technology and legal problems.

6.4 Implications

The findings of this study provide a substantial contribution to resolving the research gaps highlighted in the introduction by giving a better knowledge of stakeholder participation and the application of circular economy (CE) principles in social housing projects. One of the key shortcomings was the lack of emphasis on stakeholder participation in circular projects when compared to CE in building and the built environment. This study fills that gap by providing thorough insights into the responsibilities, motives, and contributions of key stakeholders during the design conceptualisation stage of circular housing projects.

The study emphasises the importance of constructors and a wide range of stakeholders, including project developers, environmental consultants, architects, contractors, and government agencies, in ensuring the success of circular housing projects. Constructors serve as central hubs, overseeing the development process from beginning to finish while navigating the complex interplay of sustainability imperatives, financial considerations, and regulatory compliance. This increased understanding of stakeholder dynamics, as well as the importance of good communication and strategic planning, paves the way for the creation of more successful stakeholder engagement frameworks in CE activities.

My study also discusses significant challenges that stakeholders encounter when implementing R-ladder principles, such as financial constraints, regulatory ambiguity, supply chain limitations, and technical complexities. These practical challenges have frequently hampered the use of circular approaches in housing projects. By identifying these issues, the study closes a gap in understanding the challenges to applying R-strategies and offers suggestions for potential solutions.

Future research can build on these findings by looking at the various stakeholder networks involved in CE projects. Detailed frameworks for stakeholder involvement can be developed by using case studies from successful projects to build best practices and scalable models. My research can help with this by providing a comprehensive picture of the various risk factors involved in circular housing initiatives. Furthermore, greater research might look into effective financial incentives, subsidies, and regulatory frameworks to support the adoption of CE principles. Comparative studies across regions could help identify the most effective policies and practices.

Additional study might involve investigating creative cooperation models and governance frameworks that encourage stakeholder synergy. This involves looking into the inclusion of new stakeholders, such as environmental consultants, and their impact on project outcomes.

Longitudinal studies on the implementation of circular housing projects can also shed light on the long-term success of R-strategies and stakeholder engagement by following project development from conception to completion.

In terms of the application into the processes, the findings can be utilised to create practical recommendations and frameworks for involving stakeholders in CE projects, ensuring that varied perspectives are considered from the start. This can assist project managers in better achieving the collaboration within the team and addressing various aims and motives. Policymakers can use study findings to look into the legislation and policies that uphold CE principles.

Furthermore, the study highlights the significance of improvement within the built environment. This could include stakeholder training sessions to help them better understand CE principles and how to apply them in new housing projects. The findings, which stress the importance of community engagement, can help to design ways for incorporating local habitants of the area into circular housing projects, ensuring that social benefits and environmental goals are taken into account.

6.5 Future directions

Based on the findings of this study, numerous possible areas for future research have been highlighted to better understand and execute circular housing projects. Exploring these topics will yield significant insights and practical answers for improving the efficacy and efficiency of circular housing programmes.

Future research should assess the impact of various subsidy programmes and financial mechanisms on encouraging a circular economy in the building sector. This research could concentrate on optimising these financial mechanisms in order to improve project feasibility and stimulate widespread adoption of circular practices and r-strategies. Understanding how different financial incentives affect stakeholder engagement and project success is critical for creating more effective circular-strategies. This knowledge will be especially valuable in making circular housing projects more financially viable and appealing to investors, allowing for wider implementation.

Another key area for future research is to investigate supply chain dynamics for sustainable and bio-based construction materials. Identifying bottlenecks and potential for improvement can help assure a consistent supply of environmentally friendly resources, hence promoting the use of R-ladder principles. This could be done by looking into innovative supply chain models that increase the availability and affordability of circular resources. This would benefit circular housing projects by lowering material costs, decreasing delays, and ensuring uniform quality, resulting in more reliable and circular projects.

The development and execution of effective feedback loops and continuous improvement methodologies in circular housing projects can significantly increase project flexibility and resilience. A future study should investigate how these procedures might be included in project workflows to promote continual learning and innovation. Furthermore, a closer look at

the importance of stakeholder feedback in enhancing circular practices and overall project success.

In addition, it would be extremely valuable to investigate how Social Network Analysis (SNA) behaves when applied to projects involving different construction materials, such as concrete or brick, rather than timber. In this study, I observed that the timber constructor had a high centrality score (0.77), Most likely because using wood in construction is new and there isn't much information about it yet. This raises the question if this kind of central role would still be important in projects using more common materials, where stakeholders might not need as much specialised knowledge. Combining this with research into how SNA centrality scores change when traditional materials are used could provide valuable insights into how material choices affect stakeholder dynamics, knowledge-sharing, and collaboration. As noted in the analysis of stakeholder engagement across the four C's stakeholders with higher centrality often drive collaboration and governance efforts. Investigating these dynamics in projects using traditional materials may reveal whether the established patterns remain consistent. It may also demonstrate whether the influence of certain stakeholders diminishes as the materials become more familiar and the knowledge gap closes. This line of research could significantly contribute to the understanding of how material selection shapes stakeholder interaction and project success.

By following these study pathways, scholars and practitioners can improve techniques for effective implementation of circular housing projects. This will eventually contribute to the larger aims of circular development and environmental stewardship, ensuring that circular housing initiatives are not just theoretically sound but also feasible and effective in real-world implementation.

7. Conclusion and recommendation

In the following chapter, all of the sub-research questions will be answered that contribute to the study's main research question: "What are the variables that influence stakeholder engagement in new housing projects, and how can the use of R-strategies be maintained during the project's conceptualisation phase?"

Through a thorough examination of these sub-questions, a thorough grasp of stakeholder engagement and the practical application of R-strategies will be given. In addition, a recommendation letter will be supplied, providing practical insights and suggestions based on the research findings.

7.1 Enhancing stakeholder engagement with the constructor at the core

This section will provide an answer to the following sub-research questions:

Which stakeholders from various backgrounds actively engage and contribute to the design conceptualisation phase of a circular housing project?

This study found that the constructor plays a central role, acting as a centre for collaboration among the stakeholders. This centrality allows the constructor to oversee construction processes, align r-strategies such as R0 (refuse) and R2 (reduce), and navigate financial and regulatory challenges.

Environmental consultants, contractors, project developers, managers, architects, and designers each bring unique expertise, supporting innovation and circular practices. Effective collaboration and governance frameworks are essential for overcoming challenges and advancing circular housing initiatives. Emphasising the constructor's pivotal role and fostering stakeholder engagement can significantly contribute to achieving the environmental and social goals of circular housing projects.

In conclusion, the active engagement and contributions of various stakeholders, coordinated by the constructor, are critical to the success of circular housing projects. Wooden construction is a relatively new way to construct, my study shows that many stakeholders in such projects may lack the essential knowledge and competence. A constructor plays an important part in this process by sharing their expertise of this revolutionary construction material and the processes related with it, allowing for a smoother transition and ensuring that all stakeholders are well-informed. A strategy that includes a variety of perspectives towards the project fosters innovation. Furthermore, it fits with circular imperatives, which are critical for creating a more sustainable and equitable built environment.

7.2 Understanding stakeholder engagement by balancing financial feasibility, regulatory objectives and R-strategies

This section will provide an answer to the following sub-research questions:

What are the fundamental motivations and objectives that encourage the active involvement and contributions of various stakeholders throughout the conceptualisation phase of a circular housing project?

Stakeholders are driven by various fundamental motivations and objectives during the conceptualisation phase of circular housing projects. In practice, we see that intrinsic motivation is a primary reason. Furthermore, financial feasibility is important, since my research shows that stakeholders appreciate the value of subsidies in overcoming high development and manufacturing costs.

Sustainability imperatives also drive stakeholders, who aim to align project goals with broader environmental objectives. Environmental awareness influences decision-making, with a focus on adopting green practices such as R8 (recycle) or R3 (reuse) and utilising subsidies to support circularity. Another significant goal is regulatory compliance, as stakeholders strive to close regulatory gaps and keep up with changing requirements. This involves seeking regulatory clarity and government support to foster innovation in circular housing projects.

Community participation and social effect are major motivators in circular housing initiatives, with stakeholders emphasising the importance of information sharing, R-strategies, and ongoing feedback loops. Ideally, these systems promote innovation and sustainability by encouraging active cooperation and learning. However, the reality is frequently more complicated. Financial restrictions, legislative complexity, and conflicting interests impede the full realisation of these objectives. Economic pressures often require revisions to R-strategies, notwithstanding a goal for continued stakeholder engagement.

In some projects, such as Matchbox, key players such as constructors take the lead, expediting decision-making but frequently limiting broader community engagement. In actuality, the vision of broad participation can fall short due to power dynamics and limited resources. Despite these challenges, efforts to foster continuous learning and feedback loops continue, but with greater constraints than originally envisioned.

In summary, stakeholder involvement in circular housing projects is driven by financial feasibility, circular imperatives, regulatory compliance, environmental awareness, community engagement, and continuous improvement. These diverse motivations highlight the collaborative effort required to achieve a successful implementation of r-strategies in new housing projects.

7.3 Key challenges and opportunities for stakeholders in advancing R-ladder principles in circular housing

This section will provide an answer to the following sub-research questions:

What are the key challenges and opportunities stakeholders encounter in implementing the R-ladder principles, in housing projects?

The key challenges stakeholders face include financial constraints, regulatory ambiguities, supply chain limitations, and technical complexities. These issues have an impact on project costs, timelines, and material supply.

Despite these obstacles, stakeholders find opportunities for innovation, collaboration, and community engagement. Experimenting with circular and bio-based construction (R0 and R2) promotes circularity and ongoing improvements. Initiatives like using second-hand materials (R5 and R8) and local engagement enhance social and environmental responsibility, improving project outcomes. Furthermore, it improves the social cohesion of the community.

Feedback loops and self-evaluation help stakeholders identify improvements and optimise results. In addition, government support and policy alignment offer opportunities to overcome regulatory hurdles and advance circular practices. When government agencies, businesses, and research institutes work together, it's easier to share information and use R-Ladder principles. The balance of challenges and opportunities shapes stakeholder decisions and project outcomes.

In summary, addressing challenges and opportunities in implementing R-ladder principles is crucial for circular housing projects. Innovation, collaboration, and community engagement drive transformative change in the construction sector, leading to a more circular future.

7.4 The future of R-strategies in circular housing projects

This section will address the study's main research question. The previously answered sub questions will contribute to answering the research question, which is:

What variables influence stakeholder engagement in new circular housing projects, and how can R-strategies be sustained during the conceptualisation phase?

Finally, the successful implementation of circular housing projects is dependent on the complex interplay of collaboration and communication, cost and feasibility evaluation, conservation and environmental awareness, and coherent processes and governance. Stakeholders, such as environmental consultants, contractors, project developers and managers, architects, and designers, all influence this process. As well as a plan for keeping R-strategies in use during the important conceptualisation period.

The stakeholder engagement in this research has highlighted the need for developing collaborative partnerships. Furthermore, maintain open communication channels throughout the project conceptualisation stage. Projects can benefit from the experience and expertise of a wide range of stakeholders. In addition, the findings underscore the importance of stakeholder participation in decision-making processes. This ensures the consideration of diverse perspectives during the project's planning and execution. In parallel, the research on the conceptualisation phase has highlighted the early incorporation of R-strategies into project planning especially the R0 (refuse). Therefore, making decisions ahead of time based on well-known standards that put R-strategies first is necessary to ensure that project goals are feasible.

Notably, the study found that in timber construction projects, the wood constructor plays a critical role. According to the Social Network Analysis (SNA), the wood constructor has a high centrality score, indicating their influence in the project. However, the project leader's centrality score is lower. As a result, in projects that use timber construction, the project leader must work closely with the wood constructor to gain leverage and ensure the project moves forward effectively. This dynamic emphasises the value of strategic partnerships in projects where specific stakeholders have specialised knowledge.

However, as the analysis has shown that regulatory ambiguities, limited government knowledge, and uncertainties about circular standards all pose important challenges that must be overcome. Increasing collaboration, innovation, and strengthening governance structures can achieve this. Furthermore, while stakeholders have demonstrated a proactive commitment to circularity, there is a clear need for sharing knowledge. Additionally, capacity-building efforts and continuous improvement processes are needed to optimise R-strategies and improve project outcomes.

Moving forward, stakeholders in the housing sector must embrace a comprehensive approach that emphasises collaboration, innovation, and environmental responsibility. Housing projects that integrate stakeholder engagement and apply R-strategies such as refuse (R0), reduce (R2), remanufacturing (R6) and recycle (R8) can address the specific barriers identified in this study, including financial constraints and regulatory fragmentation. By building on the expertise of stakeholders, such as constructors and architects who play central roles in decision-making, projects can better navigate the complexities of circular development. This allows them to contribute more effectively to sustainable urbanisation. As we manage the complications of urbanisation, the findings of this study provide a road map for transforming the future of housing into a more circular built environment.

7.5 Recommendation report

01 | Introduction

This document provides methods and ideas for increasing stakeholder engagement in new housing projects. In order to effectively adopt R-strategies (Refuse, Rethink, Reuse, Repair, Remanufacture, Repurpose, Recycle, and Recover) throughout the conceptualization stage. The recommendations are based on a thorough investigation of stakeholder participation in circular housing projects and studies of the existing literature. Four themes were indentified as critical for developing stakeholder engagement and sustaining R-strategies as can be seen below.

Collaboration & Communication

Coherent process & Governance

Conservation & Environmental awareness

Cost & Feasibility evaluation

By tackling the issues related to these themes, this document presents ideas which can lead to a more circular and efficient approach to home building. This approach not only encourages environmental governance, but it also improves the financial viability and social impact of initiatives. The recommendations include feasible measures for incorporating important stakeholders, maximising subsidies, and increasing communication and collaboration throughout the project's conceptualization stage.

02 | Engaging diverse stakeholders

Stakeholders with diverse backgrounds, including constructors, project developers, environmental consultants, architects, contractors, and government entities, play a crucial role in the design conceptualization phase of circular housing projects. To enhance engagement and collaboration among these stakeholders, consider the following strategies:

Central role of the constructor:

- Use the constructor's central location as a hub to facilitate communication and collaboration.
- Encourage constructors to monitor the alignment of R strategies, financial considerations, and regulatory compliance throughout the project's lifecycle.

Foster collaboration and innovation:

- Create platforms for regular stakeholder meetings and workshops to share knowledge and innovative practices.
- Implement governance frameworks that promote transparency and accountability, ensuring all voices are heard and considered.

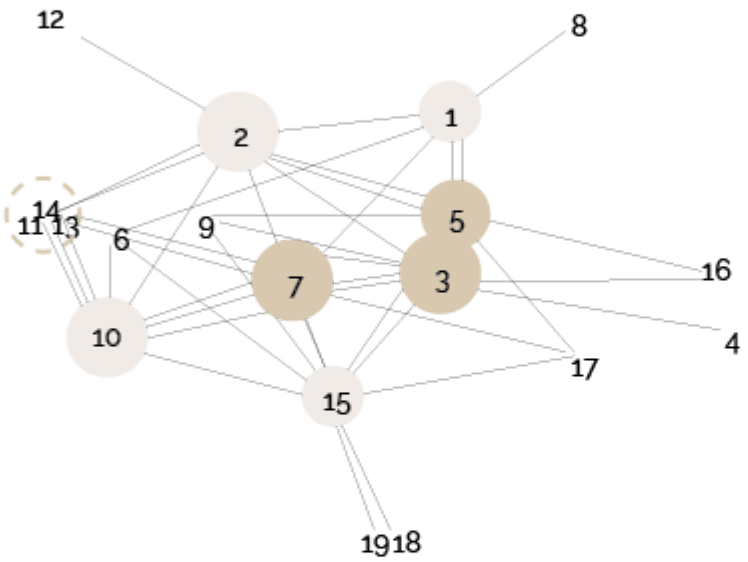
Community participation:

- Engage local communities in the project development process to gather diverse perspectives and foster a sense of ownership and responsibility.
- Develop community engagement initiatives that reflect stakeholders' commitment to social and environmental responsibility.

03 | Improving network connectivity

Insights from the social network analysis highlight opportunities for enhancing stakeholder connectivity and communication to improve project outcomes. Currently, the network shows a medium-density of around 16%. Key roles are played by contractors, architects, and constructors, who serve as central connectors. They facilitate effective communication and coordination, aligning project goals with sustainability objectives.

Project leaders, developers, and environmental consultants also play crucial roles, contributing to network cohesion and effectiveness. Their participation makes sure that environmental impact and environmental standards are taken into account in strategic decisions and encouraging new ideas throughout the whole project lifecycle. Another thing to note is the cluster's potential, as shown below around ID 11, 13, and 14.



ID	Stakeholder
1	Project developer
2	Environmental consultant
3	Contractor
4	Home owners
5	Architect
6	Instalation specialist
7	Constructor
8	Landscape architect
9	Client
10	Project leader
11	Municipality
12	Cost experts
13	Consultants
14	Engineers
15	Suppliers
15	Colleagues
17	University
18	Concrete supplier
19	Fire department

Increased involvement of the municipality:

- Involve the municipality from the start of the project to ensure their input and support throughout the project lifecycle.
- Enhance communication channels between the municipality and other stakeholders to facilitate timely decision-making and project approvals which is supported by the cluster above.

Enhanced collaboration with the fire department:

- Link the fire department with suppliers, constructors, and the municipality for earlier approval of materials.
- Establish connections between the fire department and the university to support the development of new materials. This collaboration will ensure that research efforts align with regulatory and safety standards, providing both innovation and assurance.

POTENTIAL OUTCOME

By implementing these improvements, the density of stakeholder connections will increase to 25%, a 9% improvement. Resulting in a better engagement within the network.

04 | Addressing financial feasibility

Financial constraints are a significant challenge in circular housing projects. To mitigate these challenges and enhance project feasibility, consider the following approaches:

Utilize subsidies effectively:

- Identify and leverage various subsidy programs, such as the Environmental Investment Deduction (MIA) subsidy, to offset high development and production costs.
- Educate stakeholders on available subsidies and how to apply for them effectively to ensure financial sustainability.

Feasibility assessments:

- Ensure that a feasibility assessment of the costs of circular materials is completed early in the project. This will ensure that at a later stage, stakeholders know if it is realistic.
- Balance stakeholder needs by integrating financial support mechanisms that align with sustainability imperatives.

05 | Overcoming regulatory and technical challenges

Regulatory ambiguities and technical complexities often pose hurdles to the successful implementation of R-strategies. To address these issues:

Seek regulatory clarity:

- Engage with government agencies to clarify regulatory requirements and ensure compliance.
- Advocate for supportive policies that promote sustainable construction practices and reduce regulatory barriers.

Enhance technical capabilities:

- Invest in research and development to explore new materials and construction techniques that align with R-ladder principles.
- Provide training and resources to stakeholders to improve their technical expertise and capacity to implement circular practices.

06 | Promoting continuous improvement and innovation

Implement feedback loops:

- Establish mechanisms for regular feedback and self-evaluation to identify areas for improvement and optimize project outcomes.
- Encourage stakeholders to share best practices and lessons learned to promote continuous learning.

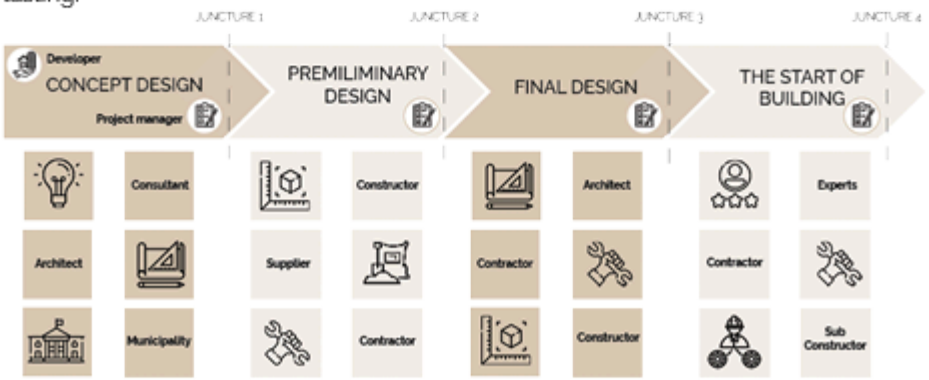
Encourage adaptive decision-making:

- Develop adaptive decision-making frameworks that allow stakeholders to respond flexibly to emerging challenges and opportunities.
- Foster strategic partnerships that enable collaborative problem-solving and innovation.

06 | Timeline for stakeholder involvement

The timeline for the conceptualization stage of a project emphasizes early stakeholder involvement. This is needed to enhance the project outcomes and ensure the effective use of R-strategies. Early involvement of stakeholders is critical throughout the process, ensuring engagement and being in line with the project's goals. Consultants are recommended to be involved early in the concept design stage. These type of consultants include, environmental, financial, and technical consultants. This early commitment makes it possible to collaborate with the municipality to look into potential funding and ensure that project ideas comply to the rules.

Following the initial concept design, Stakeholders, like material suppliers and constructors, are intorduced in to make sure that the calculations and feasibility assessment are done correctly. The timeline aims to maintain stakeholder engagement throughout the project phases. Making sure that their ideas are always taken into account to make the project more feasible and long-lasting.



07 | The wheel of circular engagement

The "wheel of circular engagement" serves as a framework to guide and ensure the successful implementation of R-strategies in circular housing projects. This wheel consists of several key elements that are crucial for maintaining circular ambitions. Furthermore, fostering collaboration among stakeholders is also a product of the wheel. The following elements are essential components of the Wheel of Circular Engagement.

Critical stakeholder selection | Begin by carefully selecting stakeholders whose motivations align with the project's vision for circular housing. Ensure their commitment to sustainability and circular principles.

Early stakeholder involvement | Involve relevant stakeholders early in the project to integrate circular principles from the outset. Assess the financial feasibility of circular options at this stage.

Proactive decision making | Make proactive decisions that support circular goals, ensuring alignment with sustainability objectives.

Supply chain | Evaluate the supply chain of materials, including the origin of materials and the availability of recycled materials to meet project demands.

Quality control | Implement a quality control document to maintain circular ambitions throughout the conceptualization and construction phases. Ensure decisions are followed through to implementation.

Sharing knowledge | Facilitate knowledge sharing among stakeholders, both within and between organizations. Foster a collaborative environment that promotes innovation and learning.

Feedback loops | Establish a feedback loop involving all stakeholders to review project outcomes. And discuss the potential lessons that can be learned from the project.

Data base | Document all the gathered information in a database to accumulate knowledge across circular housing projects. This can include various types of data, such as wooden details within the construction, but also what happened during critical stages of the project.

IMPLEMENTING THE WHEEL

Implementing the "Wheel of Circular Engagement" makes sure that each project builds on the lessons learned and successes of the ones that came before it. Stakeholders can work together to improve sustainable practices by encouraging openness, cooperation, and early decision-making. And reach the goal of making the built environment more circular. This method not only reduces the need to come up with new solutions, but it also speeds up the adoption of circular housing practices, which makes the future more circular.

08 | Conclusion

Achieving the goals of circular housing projects requires a collaborative effort from all stakeholders. By leveraging the central role of constructors, improving network connectivity, utilizing subsidies effectively, addressing regulatory and technical challenges, and promoting continuous improvement and innovation, stakeholders can significantly enhance their engagement and ensure the successful implementation of R-strategies during the conceptualization phase.

These strategies not only pave the way for more sustainable and resilient housing projects but also contribute to the broader goals of environmental stewardship. Through collective efforts and strategic planning, stakeholders can drive transformative change in the construction sector, leading to a more sustainable future.

8. Reflection

In this section, I conduct a reflective analysis of the research methodology used to write this master's thesis. Introspection and evaluation of problems encountered reveal information about the iterative nature of the research process. By investigating perspectives on methodological changes, coding strategies, and data analysis methodologies, we gain a better understanding of the dynamic progression inherent in academic inquiry.

8.1 Adjustment in scope of research

The evolution of my study scope from an initial concept to a focused focus indicates a substantial shift in approach and methodology, motivated by the need to improve feasibility and tangibility within the research setting. Initially, the study planned to conduct a wide investigation of circular development goals (CDGs) in housing projects, emphasising the necessity of stakeholder participation and the continuity of circular goals across project lifecycle stages. However, the ambiguity of the research scope made it difficult to operationalize the study's aims and define particular bounds for investigation.

In response to these limitations, the research scope was narrowed to focus solely on the use of the R-ladder framework in new social housing projects during the conception phase. This restricted focus gave greater clarity and specificity, allowing for more targeted research into stakeholder participation and the use of R-strategies to enhance circularity in housing buildings. By focusing on a specific framework and project phase, the study hopes to provide practical insights and recommendations that can help educate decision-makers and encourage innovation in sustainable urban development.

The shift from a broad analysis of circular development to a more specific examination of stakeholder engagement and R-ladder implementation required changes to the research questions and methods. The modified research questions direct the examination of stakeholder dynamics, motives, problems, and opportunities in the context of circular housing initiatives. The path from an initial notion to a defined study focus was not without hurdles. The process of turning theoretical concepts into measurable research objectives and procedures was especially notable.

8.2 Refinement of transcript coding schema

The first steps I took to code themes based on existing literature were very helpful; they gave me a base to build my study on. As I worked my way through the complicated information I had, themes like "Awareness and Education," "Collaborative Decision-making," and "Policy and Regulatory Assistance" helped me a lot. Yet, as I coded my transcripts more deeply, I became aware of how limited these broad ideas were.

While the initial coding scheme was helpful, it became clear that it was too broad to fully capture the details and subtleties of the data. The conversations and observations in the transcripts added levels of detail and context that the first coding scheme didn't cover well

enough. When I realised this, I changed how I was doing things, which led to the creation of more specific and focused codes. To improve the coding scheme, the data had to be carefully looked at to find patterns, themes, and sub-themes that kept coming up. I was able to get a better picture of the rich complexity of the talks and observations by making new codes that were tailored to the specifics of the data.

In a way, I see that this could have been avoided if my initial coding schema hadn't been based only on the broad results from my literature review. The literature gave me useful information and a decent place to start, but I needed to go into the coding process with an open mind and be ready to change things if the data showed me something different.

As time has gone on, I've learned more about how qualitative research is continuous and how important it is to be flexible and self-reflective during the coding process. By constantly changing and improving my method based on how the data is changing, I can make sure that my analysis stays rigorous, nuanced, and true to the research subject's complexity.

8.3 Adjustment in qualitative part of research

My research process experienced significant changes and modifications in terms of stakeholder selection and participation, demonstrating a dynamic approach to gathering ideas and encouraging collaboration in the context of circular housing efforts.

Initially, the objective was to use purposive sampling, as this was a strategic and intentional criteria appropriate for qualitative research (Curtis et al., 2000). This method sought to select participants based on their relevance to the research aims, guaranteeing the inclusion of stakeholders with various viewpoints and skills in urban development, project management, consulting, and asset management. However, as the research progressed, it became clear that the intricacies of stakeholder networks in circular housing efforts demanded a more flexible sampling strategy.

Therefore, I changed my approach to the Snowball Sampling Method (SSM) as a solution to the challenges of working with a complex and diverse stakeholder network. This strategy permitted immediate engagement with stakeholders that would otherwise be difficult to reach, allowing for the creation of trust and the collection of thorough data in complex research situations. Using SSM, the study approach was able to identify a broader range of stakeholders participating in circular housing efforts, such as project leaders, developers, architects, environmental consultants, contractors, builders, and wood suppliers.

Furthermore, through this method, participants shared ideas that altered my perception of the asset manager's role in the stage of the project I was considering. At first, I thought this stakeholder was crucial because they would provide long-term advice on the financial health of social housing projects, tenant management, and business continuity. The SSM process, on the other hand, revealed a different picture: participants repeatedly stated that the asset manager was not important at the conceptualisation stage of the project. This revelation was significant because it caused me to shift my focus away from my initial assumptions and towards a more nuanced understanding of how stakeholders interact in social systems.

The shift from purposive sampling to SSM reflects a more adaptable and responsive approach to stakeholder involvement. While purposive sampling initially provided a structured method for selecting participants based on predefined criteria, the use of SSM enabled a more dynamic exploration of the stakeholder landscape, allowing for the inclusion of actors who might have been overlooked using traditional sampling methods. This iterative approach to stakeholder selection emphasises the necessity of tailoring research methodology to the specific needs of the research setting, resulting in greater variety and depth of insights collected.

To sum up, the decision to switch from purposive sampling to SSM demonstrates a commitment to methodological flexibility and responsiveness to emerging discoveries. Using alternative sampling methods, the research process was able to overcome the challenges associated with engaging with complex stakeholder networks, resulting in a more comprehensive understanding of circular housing initiatives and the dynamics of stakeholder collaboration within this domain.

8.4 Social network analysis and coding

Conducting a social network analysis (SNA) was a critical component of my research, providing insights into the dynamics of stakeholder relationships. However, getting a grip on the world of SNA offered a learning curve, especially as it required the use of Python scripting, which I had learned in a prior course during my master's studies. The notion of building Python code to do SNA looked overwhelming at first, as I struggled with the complexities of network analysis methods and data manipulation techniques. It was a process of trial and error. I explored unfamiliar terrain, experimenting with various coding styles and seeking advice from internet resources and tutorials.

Despite the difficulties experienced during this process, determination and dedication motivated me to continue honing my coding abilities and comprehending the complexities of network analysis approaches. Each iteration of the code provided fresh insights and refinements, allowing me to gain confidence in my ability to translate theoretical concepts into practical applications. Through ongoing analysis and experiments, I eventually created a Python code that was capable of performing SNA on the stakeholder network. This success was a crucial milestone in my research. It shows the transformative impact of practical learning and the acquisition of new technological skills.

The ability to use Python code for SNA not only improved the analytical capabilities of my research, but it also broadened the range of insights gathered from the data. With a thorough understanding of stakeholder interactions gained from the SNA, I was better able to make meaningful findings and develop practical recommendations to guide future circular housing efforts. Looking back, learning Python coding for SNA was both tough and gratifying. It demonstrated the value of interdisciplinary learning, as well as the need for tenacity when faced with unknown problems. Moving forward, the abilities learned via this endeavour will surely continue to serve me well in my academic and professional pursuits, helping me to approach complicated research problems with confidence and proficiency.

8.5 Adjustment of conceptual framework

During my research, I made several significant modifications to my conceptual framework. Initially, my research topic was very broad, "circular development goals," and aimed to address the "whole project lifecycle" (see Figure 11). This scope, while ambitious, proved to be too broad and somewhat vague. The term "circular development goals" itself was not sufficiently precise. This could make things unclear and make it hard to stay on track with a research direction that is both focused and doable.

Recognising these limitations, I revisited my conceptual framework. By taking a deeper look into circular-strategies, I realised the need for a more structured approach. I refined my focus by adopting the "R ladder framework." A well-defined hierarchy of circular-strategies that provided clearer guidelines and a more concrete basis for analysis.

In addition, I narrowed the project lifecycle scope to focus only on the "conceptualisation stage." This adjustment allowed for a more manageable and focused study. Focusing on the early stages of a project, which are very important because this is when strategic decisions are made and can have the biggest effects.

These changes, illustrated in Figure 12, have resulted in a more precise and actionable conceptual framework. By focusing on the "R ladder framework" and the "conceptualisation stage," my research now had a clearer scope and direction. However, the factor coding aligned well with my qualitative research findings. I realised that redeveloping these factors into the four C’s would better reflect the specific context of my research. This redevelopment allowed the model to provide a clearer overview of my research and the processes involved.

Additionally, I changed the positions of key stakeholders within the framework. This change allowed for another view of the factors, resulting in a more comprehensive view of stakeholder engagement. It provided insights into how each stakeholder perceives the four C's I developed: collaboration and communication, coherent process and governance, conservation and environmental awareness, and cost and feasibility evaluation.

Furthermore, I integrated social network analysis into my framework. This integration shed light on the connections between the C's and the stakeholder motivations. This illustrates the intricate interplay between these elements. By incorporating these changes, my conceptual framework now offers a more nuanced picture. My research becomes more robust and useful by accurately portraying the dynamics in action.

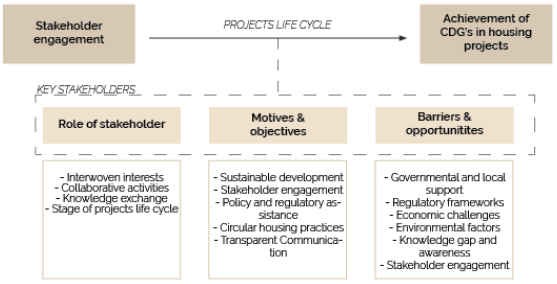


Figure 11 Conceptual framework version 1 (own work)

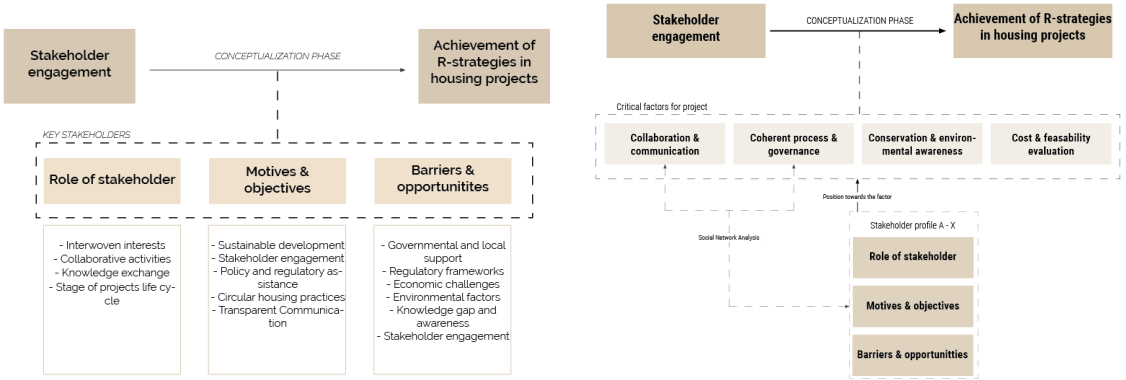


Figure 12 Conceptual framework version 2 (left) & Conceptual framework version 3 (right) (own work)

8.6 Refinement of research questions

During the course of my research, I made significant changes to the main research question and its subquestions. The original main question, *“What are the variables that influence the engagement of stakeholders in new housing projects, and how can the use of R-strategies be maintained during the conceptualisation phase of a project?”*, was revised to the more focused and streamlined version: *“What variables influence stakeholder engagement in new circular housing projects, and how can R-strategies be sustained during the conceptualisation phase?”*.

The decision to modify the main question came after further reflection on the direction and findings of my research. Initially, the focus was slightly broader, encompassing both stakeholder engagement and the implementation of R-strategies. However, it became clear that the phrase "how can the use of R-strategies be maintained" did not align perfectly with the detailed analysis I had conducted. This misalignment was mostly about how to involve stakeholders and the real issues that come up with circular housing projects. By refining the question, I was able to bring greater clarity and precision to the focus of the research.

This clarity is especially visible in the transition to sustaining rather than maintaining. This is because sustaining involves more than just preserving, it is promoting something over time

and allowing it to continue to develop. What's very crucial in the circular built environment. Furthermore, adopting the term "new circular housing projects" clarifies the scope of my research.

In addition, two sub-research questions were adjusted, specifically sub-questions one and three. Sub-question one was revised from *“Which stakeholders from various backgrounds actively engage and contribute to the design conceptualisation phase of a circular housing project, incorporating principles of the R-ladder?”* to *“Which stakeholders from various backgrounds actively engage and contribute to the design conceptualisation phase of a circular housing project?”*. The original question focused on identifying stakeholders and their contributions while also incorporating the R-ladder principles. In the revised version, the reference to the R-ladder was removed to streamline the question and focus only on stakeholder engagement during the conceptualisation phase. This change helped avoid unnecessary complexity at this stage of the research.

Sub-question three was revised from *“What are the key challenges and opportunities stakeholders encounter in implementing the R-ladder principles, and how do these factors influence decision-making and overall project outcomes?”* to *“What are the key challenges and opportunities stakeholders encounter in implementing the R-ladder principles in housing projects?”*. The original question emphasised both the challenges and the decision-making processes related to the R-ladder principles. In the revised version, the focus was narrowed to address the challenges and opportunities in implementing these principles. This change removed the added complexity of including decision-making in the question. This adjustment provided a clearer emphasis on the practical challenges of circular strategies in housing projects.

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Appendix

Appendix 1 Interview Protocol

Circular Housing Projects Stakeholder Interview Protocol:

Points of attention during the interview

- Maintain an assertive attitude during the interview
- Do not interrupt the speaker too much.
- Be flexible with my questions; sometimes a question can be asked in a different way to connect with the interviewee's story.
- Try not to steer the interview too much in the beginning. Many people tend to discuss something they are passionate about or dislike. Use this for your topic and identify the pitfalls.
- Use two devices to record the interview so that in case one malfunctions, you have a backup.
- Try to ask follow-up questions that delve deeper into participants' responses, seeking specific examples or experiences to enrich the qualitative data.

Section 1: Introduction

1.1 Thank participants for their involvement in the study.
1.2 Stress how important their ideas are for understanding how to work together with different stakeholders and keep the circular development goals in housing projects.
1.3 Give a short explanation of how the study looked at how different stakeholders work together and how the R-strategies are used throughout the project's life cycle.
1.4 Ask the participants to fill out the consent form and stress how important privacy and secrecy are.

Section 2: Understanding Stakeholder Engagement

2.1 Introduce Research Question 1 (RQ1).
RQ1: Which stakeholders from various backgrounds actively engage and contribute to the design conceptualisation phase of a circular housing project, incorporating principles of the R-ladder (Refuse, Rethink, Reuse, Repair, Remanufacture, Repurpose, Recycle, Recover)?

2.2 Ask the participants what they think about building projects that aim for circular development.
2.3 Ask them what they think about how involved stakeholders are in circular housing projects right now.
2.4 Look into the part of the project where the participant thinks their role as a key stakeholder is most important.

Section 3: Motivations and Objectives
3.1 Introduce Research Question 2 (RQ2).

RQ2: What are the fundamental motivations and objectives that encourage the active involvement and contributions of various stakeholders throughout the entire duration of a circular housing project?

3.2 Ask the participants why they want to be involved in circular housing projects.
3.3 Talk about how the participants' goals fit with the R-strategies.
3.4 Find out how the participants think their coworkers are aligning their goals with the R-ladder.

Section 4: Challenges and Opportunities

4.1 Introduce Research Question 3 (RQ3).
RQ3: What are the key challenges and opportunities stakeholders encounter in implementing the R-ladder principles of circular development goals, and how do these factors influence decision-making and overall project outcomes?

4.2 Ask participants to identify challenges stakeholders face in implementing R-strategies
4.3 Explore opportunities stakeholders see in contributing to circular housing projects.
4.4 Discuss how identified challenges and opportunities impact decision-making, involvement, and overall influence on project results.

Section 5: Overcoming Barriers and Collaboration
5.1 Find out what the participants think about how stakeholders are working together on circular housing projects right now.
5.2 Ask about the way they meet and how often.
5.3 Ask about creative methods or plans that have worked in the past to get around problems in circular housing projects.

Section 6: Future Directions
6.1 Find out what new stakeholders, like environmental consultants, might be able to do to help solve problems.
6.2 Talk about plans or-strategies that could make it easier for different groups to work together in the future.

Section 7: Wrapping up
7.1 Thank the participants for their thoughtful contributions.
7.2 Thank the participants who took the time to share their experiences.
7.3 Ask participants to share their additional thoughts or questions.
7.4 Remind participants to fill out the consent form so that their privacy is protected.
7.5 Say that you're looking forward to sharing your research results in the future.

Appendix 2 Interview plan

Circular Housing Projects Stakeholder Interview Plan:

Section 1: Introduction

Thank you for taking the time to discuss stakeholder engagement, motivations, challenges, and opportunities during the design conceptualisation phase of circular housing projects. Your knowledge and ideas are extremely valuable in understanding how to incorporate circular development goals, specifically the R-ladder principles (Refuse, Rethink, Reuse, Repair, Remanufacture, Repurpose, Recycle, and Recover), into the lifecycle of a housing project.

This study seeks to investigate the dynamics of collaboration among the various stakeholders involved in housing projects. We are particularly interested in learning how various entities, such as the government department, project manager, consultant, and real estate developers, collaborate during the design conceptualisation phase of circular housing projects. Our focus includes the concept of R-ladders and how they can be effectively integrated in the design conceptualisation phase. Your experiences and perspectives will help us understand the challenges, successes, and best practices for implementing sustainable and circular housing initiatives.

Your participation helps shape the narrative of collaborative efforts in the housing sector, and I appreciate your willingness to share your valuable insights. Before we proceed, I would appreciate it if each of you could take a moment to complete the consent form. Your consent is required, and your privacy and confidentiality will be maintained throughout the duration of this study. Thank you once more for your invaluable contributions to this research project.

Section 2: Understanding Stakeholder Engagement

RQ1: Which stakeholders from various backgrounds actively engage and contribute to the design conceptualisation phase of a circular housing project, incorporating principles of the R-ladder (Refuse, Rethink, Reuse, Repair, Remanufacture, Repurpose, Recycle, Recover)?

- Can you describe your role and responsibilities in the design conceptualisation phase of circular housing projects?
- How do you see the role of R-ladders in housing projects? Or how do you try to incorporate them into the projects you're involved with?

Section 3: Motivations and Objectives

RQ2: What are the fundamental motivations and objectives that encourage the active involvement and contributions of various stakeholders throughout the entire duration of a circular housing project?

- From your perspective, what motivates you to actively participate in circular housing specifically in integrating the R-ladder principles?
- How do you and your colleagues align your objectives with the R-ladder principles within circular development goals?

Section 4: Challenges and Opportunities

RQ3: What are the key challenges and opportunities stakeholders encounter in implementing the R-ladder principles of circular development goals, and how do these factors influence decision-making and overall project outcomes?

- Can you identify specific challenges stakeholders face when integrating the R-ladder principles into circular housing projects?
- What opportunities do stakeholders see in advancing the R-ladder principles within circular housing projects, and how can these opportunities be leveraged?

Section 5: Overcoming Barriers and Collaboration

- How do you assess the current state of collaboration among stakeholders in integrating the R-ladder principles into circular housing projects? For example, how often do you meet with specific stakeholders?
- Who do you contact if you run into any problems during the design process?
- How is the stakeholder meeting conducted? Is this face-to-face, online, or over the phone?
- How useful are these meetings for you on a scale of 1 to 6?
- Based on your experience, what innovative approaches or-strategies have proven effective in overcoming barriers in circular housing projects?

Section 6: Future Directions

- In what ways do you envision environmental consultants and other emerging stakeholders contributing to overcoming challenges associated with implementing the R-ladder principles in circular housing projects?

- What strategies or initiatives do you think could enhance collaboration between different stakeholders in the future?

Section 7: Closing Remarks

I appreciate your insightful contributions today. Your insights are critical to our research into collaboration and circular development goals in housing projects. We greatly appreciate your time and willingness to share your experiences. If you have any additional thoughts or questions, please do not hesitate to contact us. Before we conclude, please ensure that you have completed the consent form to protect your privacy. Thank you again for your valuable input; I look forward to sharing the research findings with you. Have a great day.

Appendix 3 Consent form

Rotterdam, 25/04/2024

Dear Sir/Madam,

This interview is part of a master's thesis for the master track Management in the Built Environment at Delft University of Technology. It is an investigation into the dynamics of cooperation between different stakeholders involved in housing projects. In particular, we are interested in how different entities, such as the government department, project manager, consultant and property developers, cooperate during the conceptualisation phase of the design of circular housing projects. Among other things, we focus on the concept of R-ladders and how they can be effectively integrated into the conceptualisation phase of design. Your experiences and perspectives will help us understand the challenges, successes and best practices for implementing sustainable and circular housing initiatives.

You are not obliged to participate in the study. You can always withdraw your participation in the study without giving any reason and ask for your data to be destroyed. You may also refuse to answer any question we ask.

Your participation helps shape the story of collaborative efforts in the housing sector and I appreciate your willingness to share your valuable insights. Before we proceed, I would appreciate you taking a moment to fill in the consent form. Your consent is required and your privacy and confidentiality will be maintained throughout the duration of this study. Thank you again for your valuable contributions to this research project.

If you wish to participate in this study, would you please complete and sign the physical statement?

Kind regards,

Bas de Boer

Studentnumber4589408

	Yes	No
(1) I declare that I have read the information letter at the start or this letter has been read to me. I have understood this information. In addition, I have been given the opportunity to ask questions about it and these questions have been answered satisfactorily.	☐	☐
(2) I hereby declare that I am voluntarily participating in this study. I understand that I may refuse to answer questions and that I may stop my participation in this study at any time without giving any reason. I understand that participating in this research means that my answers will be stored.	☐	☐
(3) I understand that the audio material (or its processing) and other data collected will be used exclusively for analysis and scientific presentation and publications.	☐	☐
(4) I understand that the stored data is kept under a code and processed anonymously.	☐	☐
(5) I hereby give separate consent that the anonymised data may be used by other researchers in the future.	☐	☐

I have read this form or the form has been read to me and I consent to participate in the study.

Place: Rotterdam Datum: 25/04/2024

_ (Full name, in capitals)

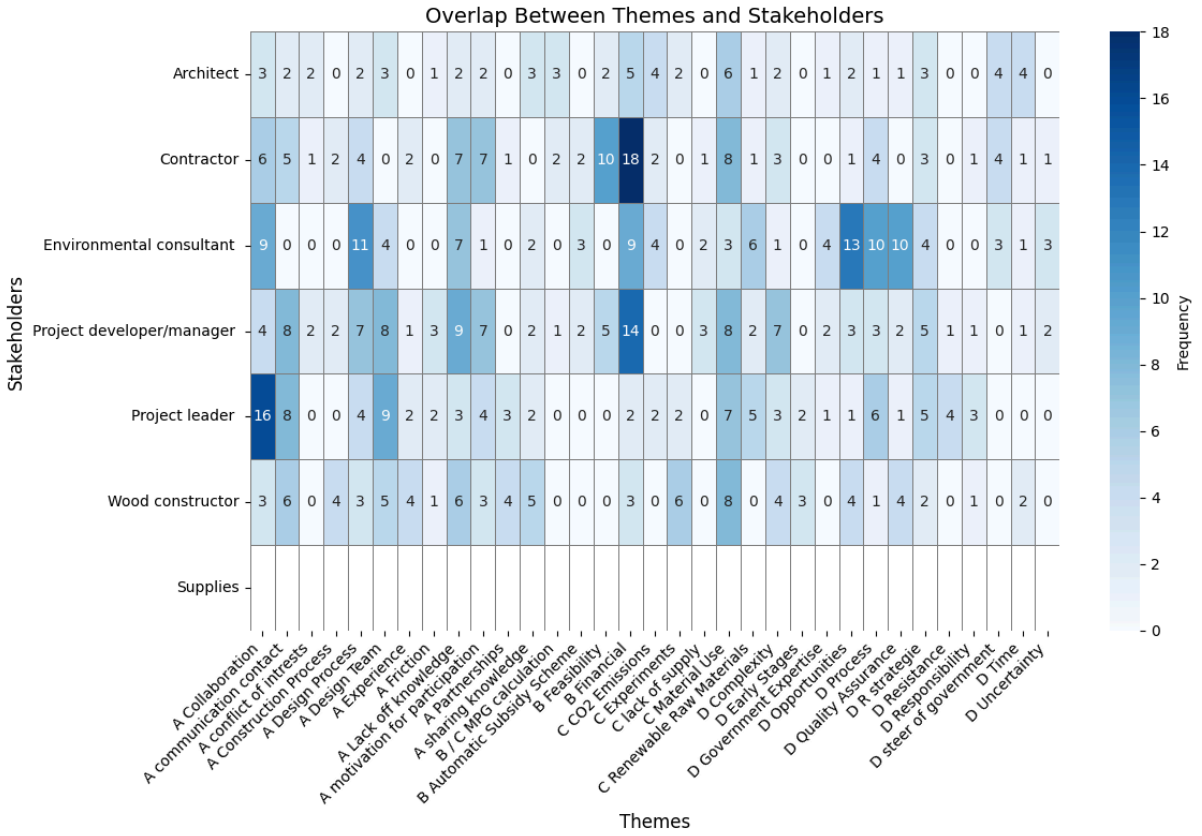
_ (Signature of interviewee)

'We have provided clarifications on the investigation. We declare our readiness to answer further emerging questions on the power enquiry.'

Name researcher

Bas de Boer

Appendix 4 Code distribution derived from qualitative data



Appendix 5 Python code for SNA centrality

```
import pandas as pd
import networkx as nx
import matplotlib.pyplot as plt
from matplotlib.cm import ScalarMappable

edges_df = pd.read_excel('SNA3.xlsx', sheet_name='Edges')

G = nx.from_pandas_edgelist(edges_df, 'Sources', 'Target', ['Weight'],
create_using=nx.DiGraph())

node_labels = {node: node for node in G.nodes()}

density = nx.density(G)

degree_centrality = nx.degree_centrality(G)
```

```
plt.figure(figsize=(12, 8))

pos = nx.kamada_kawai_layout(G)

node_sizes = [400 * len(list(G.neighbors(node))) for node in G.nodes()]
node_colors = [degree / max(degree_centrality.values()) for node, degree in
degree_centrality.items()]
nodes = nx.draw_networkx_nodes(G, pos, node_size=node_sizes,
node_color=node_colors, cmap=plt.cm.Blues)

nx.draw_networkx_edges(G, pos, edge_color='gray', arrows=True)
edge_labels = nx.get_edge_attributes(G, 'Weight')
nx.draw_networkx_edge_labels(G, pos, edge_labels=edge_labels,
font_color='red', label_pos=0.5, font_size=8)

node_label_positions = nx.draw_networkx_labels(G, pos, labels=node_labels,
font_size=12,

horizontalalignment='center', verticalalignment='center')

for _, label in node_label_positions.items():
   x, y = label.get_position()
   label.set_position((x, y + 0.02))

plt.title('Social Network Analysis Overview')
plt.axis('off')

sm = ScalarMappable(cmap=plt.cm.Blues)
sm.set_array([])
plt.colorbar(sm, label='Node Degree Centrality', ax=plt.gca(), shrink=0.7)

plt.text(0.5, 0.9, f'Network Density: {density:.4f}',
horizontalalignment='center',
        verticalalignment='center', transform=plt.gca().transAxes)

plt.tight_layout()
plt.show()
```

Appendix 6 Python code for SNA density

```
import pandas as pd
import networkx as nx

edges_df = pd.read_excel('SNA3.xlsx', sheet_name='Edges')

G = nx.from_pandas_edgelist(edges_df, 'Sources', 'Target', ['Weight'],
create_using=nx.DiGraph())

num_nodes = G.number_of_nodes()
num_edges = G.number_of_edges()

max_possible_edges = num_nodes * (num_nodes - 1)

density = num_edges / max_possible_edges

print(f'Number of Nodes: {num_nodes}')
print(f'Number of Edges: {num_edges}')
print(f'Maximum Possible Edges (N * (N - 1)): {num_nodes} * ({num_nodes} -
1) = {max_possible_edges}')
print(f'Network Density (Number of Edges / Maximum Possible Edges):
{num_edges} / {max_possible_edges} = {density:.4f}')
```

Appendix 7 Coding process raw data from qualitative research