A systems-thinking approach to explore the causes underlying the decision-making of premature demolition

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ABSTRACT

This study aims to provide insight into the causes underlying premature building demolition to improve the understanding of demolition decisions that might help reduce the number of demolitions in the construction sector.

This study adopted a System Thinking based Approach and a case study. The methods explored a Dutch university building situation as a system focusing on three core sub-systems (components). They were Processes: the building life cycle, project life cycle, and decision-making process, Actors: project stakeholders, and Values: the causality in both components that impact decisions.

The overall findings in the case study showed several significant causes that can potentially influence premature demolition. They were: the lack of an overall real estate (campus) development perspective in individual building projects, the low importance of a sustainability perspective in: policy, planning and stakeholders, the low ability of renovation alternatives, negative perceptions of buildings related to outdated design and second-handed use, and an inactive involvement of end-users throughout the project.

These were predominantly social causes, especially related to the factors among end-users. For example, negative perceptions of using renovated buildings, demand for new buildings, and poor sustainability promotion. However, they were also interrelated to other causes, such as functional requirements conflict based on physical/technical issues and design demands for attractive and modern buildings.

Thus, demolition decisions may be influenced by a combination of various interrelated causal motivations, primarily social causes but also other causes, such as function and design; the results also suggest the importance of a holistic view in the decision-making situation as the system, in order to understand the root causes of premature demolition.

***Keywords**; Systems Thinking, Demolition, Decision-making, Sustainable real estate (strategies), Circular economy*

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1 INTRODUCTION

1.1 Context

The construction sector is one of the largest waste producers. Construction and demolition waste (CDW) accounts for one-third of all EU waste. The CDW flow in the EU reached 374 million tonnes in 2016 (Eurostat, 2021) This type of waste accounts for almost a quarter of the total waste in the Netherlands (CBS, 2019).

The EU governments address sustainable development as an integrated approach to economic growth in the construction sector (EC, 2015). They want to reduce the environmental burden of this waste. As part of this, they commit to moving from a conventional linear model economy of 'take-make-waste' to a circular economy (CE) by 2030. The aim is to reduce the use of natural resources by recirculating existing materials and products.

The CDW stream recovery rate was set at 70% by 2020 (ETC/WMGE et al., 2020). The recovery rate is the percentage of recycled construction and demolition mineral waste. Mineral waste comes from extracting and processing mineral resources that account for most demolition waste (EP & EC, 2006) The rate is part of the European Commission's CE approach indicators. As of 2016, EU countries report increasingly high recovery rates above this target (Eurostat, 2022)

The Netherlands's recovery rate was already almost 100% in 2016. Many recycled materials are foundation materials for roads, new residential areas, and industrial zones. However, recycled materials can rarely be used to build buildings (Rijkswaterstaat & RIVM, 2015). The value of using recycled waste is still limited in its ability to accelerate the CE in the construction sector (López Ruiz et al., 2020). Therefore, reducing the number of demolitions in the first place can be a practical approach. It can capture resource values at a higher degree in buildings without generating demolition waste (Zhang et al., 2022). The economic values can be kept in the construction sector while contributing to reducing the demolition waste (ETC/WMGE et al., 2020). The environmental burden decreases as a result.

A building assembles many materials using different methods with different life cycles. Buildings are assets with a vital purpose as a financial investment in addition to the original purpose of protecting occupants from the external environment (Vimpari & Junnila, 2016). The building life cycle provides the view of a building for the course of its entire life. It can be divided into four stages: Production (raw material extraction and design), Construction (manufacturing and installation), Use (operation and maintenance), and End-of-Life (demolition and waste stream) (Nwodo & Anumba, 2019).

Demolition is the process of disassembling a building. The demolition process is usually the first step of the End-of-Life stage. This process artificially ends the service life of buildings. Many buildings are demolished before they reach the end of their physical (technical or real) lifespan (Thomsen & Straub, 2018). It often happens even if the buildings still provide usable space (Ellen MacArthur Foundation & Arup, 2020). Therefore, the demolitions are sometimes unnecessary, and their end-of-service life could be extended. Such a demolition case is defined as *premature demolition* in this study.

1.2 Problem statement

In the construction practice, many decisions are complex at different phases. They are subject to uncertainties. These uncertainties can be related to information, system behavior, and the choice of relevant players (Hoxha, 2020). These influence the complexity of the construction system.

A system is a collection of components organized for a common purpose. The components are a set of things working together and are part of an overall mechanism or an interconnecting network (Arnold & Wade, 2015). Namely, these components can consist of various elements and entities in construction practices. None of these on their own has an independent effect on the system. They are dynamic and interact in complex ways (Sterman, 2003).

Under the complex system, the decisions for demolition are made for various reasons related to factors such as the economy, society, and environment (Thomsen et al., 2011). However, how these factors can influence decisions for premature demolition is still unclear.

Several studies have been performed on decision-making to increase the circularity of the building life cycle (Bakht & El-Diraby, 2015; Erdogan et al., 2019; Doualle et al., 2020; Bettinelli et al., 2020). Decision-making tools and selection techniques are often used to support decision-making situations and their problems (Marcher et al., 2020). For example, Life Cycle Assessments (LCA) have been introduced for decision-making associated with products and services by assessing environmental impacts. This method can assess raw material extraction, manufacturing, and installation in the Production and Construction Stages, for instance (Matthews et al., 2014). Building Information Modeling (BIM) is also increasingly being used to form reliable information for efficient decisions on facility management in the Use Stage (Benn & Stoy, 2022). In the End-of-Life Stage, much waste management research has been conducted on decision-making to maximize material recovery of demolished buildings (Karmperis et al., 2013; Ziout et al., 2014; Alamerew & Brissaud, 2019; López Ruiz et al., 2020). However, interdisciplinary research has still been scarce on decision-making for demolition. This gap may also relate to the unclarity of the causes that influence premature demolition. Thus, there may be a need for further understanding of influences on the decision-making for the end-of-service life.

1.3 Objectives and questions

This study provides insight into the root causes of premature demolition in the decision-making for the end-of-service life. This insight aims to improve understanding of demolition decisions that may help prevent premature demolition. It can potentially increase circularity in the resource value of existing buildings. This approach could be efficient and practical for promoting CE in the construction sector. A further goal of this study is to accelerate sustainability in the construction sector by contributing to the reduction in the number of demolitions in order to limit waste and its environmental impact. These objectives led to the following main research question:

1.3.1 Main research question

"How can the root cause of premature demolition be understood
when looking at decision-making for the end-of-service life?"

To answer this main question, the sub-questions below will be addressed in this study:

1.3.2 Sub-research questions

1. What is the actual process of decision-making for the end-of-service life?
2. Who are the relevant stakeholders in the decision-making for the end-of-service life?
3. What are the expectations and impacts of the stakeholders in the decision-making for the end-of-service life?
4. What are the key variables in the decision-making for the end-of-service life?
5. What are the causal relationships between key variables that potentially influence the decision-making for premature demolition?

1.4 Study Approach

This study primarily uses a Systems Thinking based Approach to answer the questions above. Systems thinking is a way of viewing a complex system as a whole by looking at the entities and the interrelationships that comprise the system. The approach has been used in research to investigate complex environments and information, including construction practices (Shrubsole et al., 2019; Naveed & Khan, 2021; Sparrevik et al., 2021).

Since it is difficult to find reliable methods or approaches for demolition decisions in the literature, a case study of a building project was performed in April and May 2022. In-depth interviews were conducted. There was limited information on case study events and procedures that had not yet occurred before and during the study period. The outline of the course of action was already planned to take place later in 2022. The relevant information was still collected and referenced to illustrate the entire project in this study.

The case study method was also used along with relevant literature and preliminary expert interviews. These methods explored the decision-making for the end-of-service life as a system that potentially underly premature demolition by applying the system thinking approach.

Chapter 2 theoretically explains the systems thinking approach and the system's main components. Chapter 3 justifies the study's methodology, and chapter 4 describes the results. Chapter 5 then provides discussions, followed by chapter 6 conclusion.

2 THEORETICAL FRAMEWORK

This chapter first addresses the Systems Thinking Approach in Section 2.1. It is the core approach of this study. The core components of the system: Processes, Actors, and Values will be used and theoretically studied in the following order:

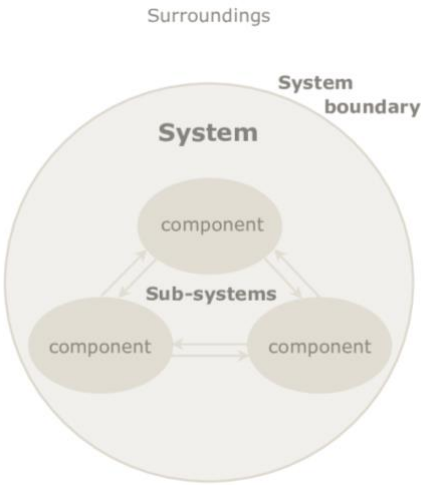
In Section 2.2: Processes, the processes related to buildings, their projects, and decisions are detailed. Section 2.3: Actors explains stakeholders related to construction projects. Section 2.4: Values describes the definitions and factors related to the lifespan of buildings. These components as a whole indicate the system that potentially influences the decision-making of demolitions. They are then illustrated as the conceptual framework in Section 2.5.

2.1 Systems Thinking

A system is a group of interrelated components that act according to a set of rules to form a unified whole. A boundary usually separates this (extensive) system from the surroundings (Boardman & Sauser, 2006). The system contains several sub-systems, all operating independently of each other. Sub-systems are groups of related elements and self-contained components in the extensive system. All elements in the system depend on the interactions between its sub-systems. In basic systems thinking terms, the sub-systems of the system interact in complex ways within the system boundary (Figure 1).

Figure 1

A System



Systems Thinking is a holistic approach to analyze the dynamics and complexity of systems. The approach identifies critical entities and understands their impacts in challenging environments. It can be practical for tackling interdependent challenges that characterize the modern world (Cavana & Maani, 2000).

2.1.1 Systems Thinking based approach

Many theories, frameworks, and strategies have promoted sustainability in various sectors over the last few decades (Bocken et al., 2016). The promoted sustainability perspective also increased the awareness of systematic thinking and modeling to address complex problems (Robinson, 2022).

The problems in projects in the construction sector are often characterized by recurring costs, overtime, and poor project management quality (Hao et al., 2008). Theoretical approaches can provide helpful context and guidelines for these problems. They contribute to improving resource efficiency and management at the economic level of sectors and countries (Sparrevik et al., 2021). However, these approaches often overlook a multidimensional perspective on all relevant individual entities over an issue —underlying values in a complex social, economic, and political context (Robinson, 2022). The multidimensional perspective is essential to acquire, create, maintain and dissipate the system (Haraldsson & Sverdrup, 2021). Thinking about complex problems without this perspective can lead to unintended consequences (Ellen MacArthur Foundation, n.d.).

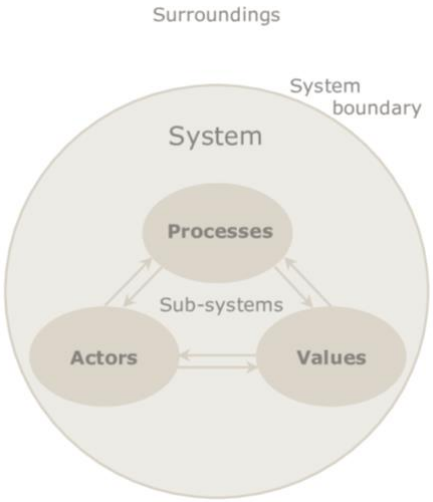
The systems of construction projects are increasingly demanding situations. The projects involve significant investments, complex processes, multiple stakeholders, and the impact of challenging requirements (Hao et al., 2008). Critical challenges can be seen in every process at all phases of a project (Wynn & Clarkson, 2018). These often involve each stakeholder's different needs and influences. These processes and stakeholders dynamically interact and behave as variables in the project. Their interrelations usually represent values that

influence the project as a whole (Bashan & Kordova, 2021). All activity, variability, and change in the system depend on the interactions between these sub-systems.

To understand such a complex system, three components can be defined as the core sub-systems of the system (Iacovidou et al., 2021). They are Processes, Actors, and Values. See Figure 2 for a visualization of this perspective. System thinking in this study was approached based on the three components.

Figure 1

Three core components in the system



Note. Three interacted crore 'sub-systems' in the system within the system boundary. Adopted from *A systems thinking approach to understanding the challenges of achieving the circular economy,* by E. Iacovidou, J.N. Hahladakis and P. Purnell, 2021, Environmental Science and Pollution Research.

Processes flow and interconnect within the system. Flows make patterns and run the system. They include all different types and times of processes in the system. These affect and are affected by actors (Wynn & Clarkson, 2018).

Actors are any stakeholders involved in the system. They are directly and indirectly involved in processing process flows and operations. Their interests primarily underlie socio-economic, political, and technological contexts and interact in various processes (Aaltonen & Kujala, 2010). Acknowledgment of the dynamics between stakeholders can reveal a firm grasp of the power relationships (Gregory et al., 2020). Their power is inherent in human interaction, social organization, and the formation of social change (Henrysson & Nuur, 2021). Understanding the dynamics is the key to identifying what drives patterns and creates barriers in the process flow (Iacovidou et al., 2021).

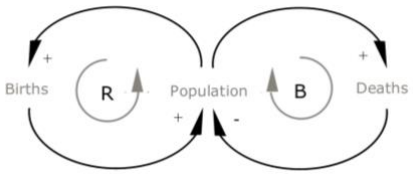
Values can refer to the positive and negative impacts of the system. These impacts in the environmental, economic, social, and technical areas are constantly influenced by each process, actors, perceived needs, and concerns, as well as society (Asquith & EEA, 2017). Thus, the 'Values' indicate the interrelationships of these constant changes (variables) of the 'Processes' and 'Actors' components in the system. They help evaluate the system with a multidimensional perspective (Bashan & Kordova, 2021). As a result, the values can provide critical insights to reflect the potential for triggering, influencing, and facilitating change in system relationships created (Iacovidou et al., 2021).

2.1.2 System Dynamics

Systems thinking allows static investigation of the dynamics of a system from qualitative information (Sterman, 2003) This method refers to a mathematical model and simulation called System Dynamics. Modeling system dynamics has been successful in many challenging areas of the world (Martinez-Moyano & Richardson, 2013). These include business, urban collapse problems, epidemiology, ecology, and environmental sustainability.

Figure 3

An example model of feedback loops



The modeling can illustrate essential characteristics of various issues underlying a system (Gonçalves, 2022). It usually works in a particular way with nodes in a *feedback loop* (Martinez-Moyano & Richardson, 2013). Feedback loops have either positive (reinforcing) or negative (balancing) polarity. By identifying polarity, loops can demonstrate possible dynamic behaviors of the system (see Figure 3). The loops visualize a very close reality as it efficiently simulates how a structure behaves over time (Pruyt, 2013). The visualization can suggest potential real-life problems or intervention points (Gonçalves, 2022).

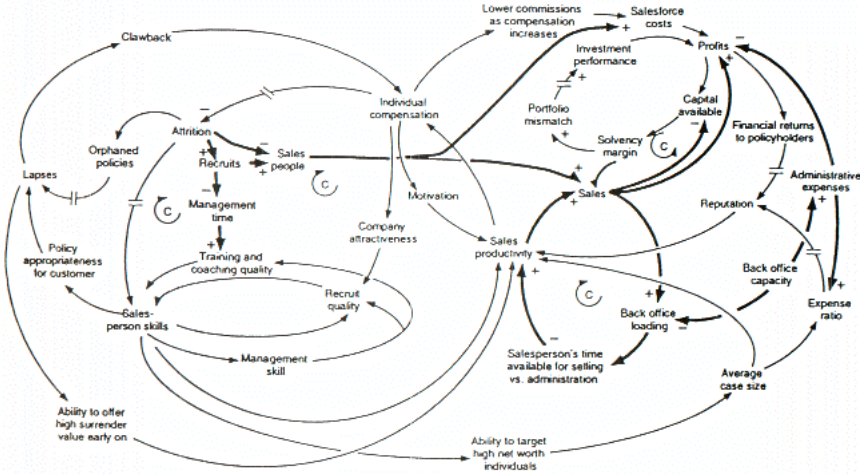
Causal Loop Diagrams (CLD)s are often used to model dynamic systems by mapping interacting variables holistically. The diagrams form chains of feedback loops (see example in Figure 4). It is a handy tool for

revealing the causal structure of the system (Haraldsson & Sverdrup, 2021). These also show the system's natural constraints and help raise more realistic expectations to address challenges (Martinez-Moyano & Richardson, 2013).

A CLD provides a 'big picture' of a problem by providing a snapshot of all the critical relationships in one sheet. The diagram corresponds to the core principles of systems thinking. It shows how different entities and elements of components (processes and actors) interact to generate a problem or how the problem interacts with a broader environment. Namely, the diagram visualizes the relationships (Values) of the variables in the Processes and Actors components. This approach can be a practical first step in adapting the system's perspective. It helps avoid the general analytical tendency of looking at things in isolation (Haraldsson & Sverdrup, 2021).

Figure 4

An example of Casual loop diagrams



Note. Causal loop diagram of a model examining the growth or decline of a life insurance company. Reprinted from *Introduction to System Dynamics: A Systems Approach to Understanding Complex Policy Issues,* by M.J. Radzicki and R.A. Taylor, 1997, U.S. Department of Energy.

2.2 Processes

This section helps to theoretically understand the system component 'Processes.' Three topics are addressed as relevant processes to decision-making for the end-of-service life: the building life cycle, project life cycle, and decision-making process.

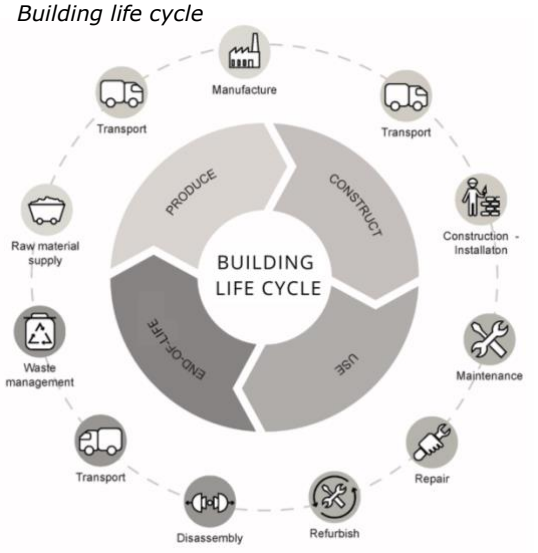
2.2.1 Building Life Cycle

In terms of the built environment, the life cycle is a course of a product, build, or service as its entire life. The building life cycle can be divided into four stages: Production, Construction, Use, and End-of-Life (Nwodo & Anumba, 2019). They are shown along with the processes of each stage in Figure 5. Understanding the entire life cycle helps ensure that various aspects are adequately considered (Kotaji et al., 2003). The aspects are not limited to construction costs but also include energy, materials used, and related environmental impact. The processes are interrelated. The results of each process affect and reflect the other processes, directly and indirectly (Vandenbroucke et al., 2015).

The Production Stage requires decisions about feasibility, investment location, and design. During the Construction Stage, decisions are made to resolve technical and transportation-related issues and optimize the use of accessible construction sites. In the Use Stage, the decisions are related to possible repairs, refurbishments, or demolition. Once the demolition decision is made during this Use stage, the building will be in the End-of-Life Stage. It means that the demolition process happens either after or without the Use Stage processes: maintenance, repair (restoration), and refurbishment. The two former processes are purposed to improve the physical condition of buildings.

Figure 5

Building life cycle



Note. Four building life cycle stages with processes. Adopted from *Circular Economy for a Sustainable Built Environment*, In TU Delft Open Courseware, n.d., Retrieved March 3, 2022, from https://ocw.tudelft.nl/course-readings/3-1-2-life-cycle-of-a-building/

The third process of refurbishment includes renovation and replacement. Renovation is to renew a building or structure by fixing existing features and adding new components in some cases. Replacements involve changing an entire room or building, sometimes called remodeling. These processes can extend the period in use by reusing existing buildings (Shahi et al., 2020). However, in reality, they are not always applied to all buildings (Vandenbroucke et al., 2015). If there are no decisions to implement these processes, a demolition decision will be made. In this case, the demolition process will start in the End-of-Life stage by implementing the decision. During this stage, decisions are made on ways of demolition, transfer, and waste stream. Such building demolitions without extending the period of the Use Stage are included as *Premature Demolition* in this study.

2.2.2 Project Life Cycle

Projects can be launched to manage the processes of the building life cycle. They include decision-making, coordination, teamwork, technical capabilities, benchmarking, and scheduling techniques (Al-Hajj, 2018). Every project has its life cycle and consists of four phases: 1) Project Start, 2) Project Planning, 3) Project Execution, and 4) Project End (Westland, 2006). These primary phases represent the project's high-level process, commonly called the 'Project Life Cycle.' It guides a project to develop from an idea into reality (S. Anantatmula, 2021).

1) The first phase is to start a new project. In the first place, the project has needs and specific problems. This phase focuses on investigating the feasibility of the project. 2) The planning phase focuses on preparing project details, planning activities, and designing work mechanisms. 3) In the third phase, the project is executed. The items and programs prepared in the planning phase are designed and worked on by the contractor. 4) The final stage of the project completes all the tasks required during project development and closes the process.

2.2.3 Decision-making Process

Decision-making is necessary for managing the building life cycle and project life cycle. According to decision theory, a situation faced with the need to choose between at least two options is known as a decision problem (de Almeida & Bohoris, 1995). A decision as a result of decision-making often implies a conclusion and the final solution to the situation (Saaty, 2008).

The decision-making process usually occurs in a series of phases leading up to the decision (Negulescu, 2014). According to Griffin (2017), the decision-making process is based on identifying and specifying the nature of the decision-making situation; determining possible solutions; choosing the best one; applying it in practice. The process usually involves four to nine stages or steps (Anderson, 2019).

As competition intensifies, businesses are operating in increasingly challenging environments. The current decision-making process is undergoing significant changes. This trend is seen in all sectors, including the construction sector (Robbins & Coulter, 2020). The decision-making situations are therefore accompanied by difficulties (Regan et al., 2005).

As a result, the difficulties create uncertainties in every decision-making process. The uncertainties can be related to a decision-maker, a set of viable solutions, or a set of environments. These are related to the component, the valuable feature of the solution, and the conditions under pursued actions (Tversky & Kahneman, 1981). These uncertainties often lead to unintended consequences of decisions (Lerner et al., 2015).

2.2.4 Decision-making Process Model

Decision-making process models can be applied to avoid such decisions. The various models are applied depending on the analyzed situation (Regan et al., 2005). These models are described in the literature. For instance, Simon (1960 and 1977) presents a decision-making model that consists of phases with steps. This model is still widely used in various sectors (Schilirò, 2018). They contain the typical steps and course of the decision-making process. The model can be applied to sustainable decision-making and various disciplines (Zavadskas et al., 2017).

According to Kozioł-Nadolna and Beyer (2021), models in the literature have different approaches and propose different phases for the decision-making process, but the general framework is consistent. Kozioł-Nadolna and Beyer (2021) then defined a model with steps according to the literature to analyze the determinants of the decision-making process in organizations.

Szafranko and Harasymiuk (2022) researched models that are widely understood and used in engineering activities and scientific research. As a result, they suggest a strategic decision-support model for the construction sector. It was developed based on their experience with relevant stakeholders and the research result on different sizes and complexity of construction projects.

The models of the above authors are shown below:

Table 2

Decision-making process models in the literature

Simon (1960 and 1977)	Intelligent Phase: Define a decision problem, determine requirements - Problem statement Decision Phase: Establish objectives, generate alternatives, determine criteria, select a method – Alternative Choice Phase: Evaluate alternatives, validate solutions
Kozioł-Nadolna and Beyer (2021)	Step 1. Identifying the problem or goal. Step 2. Gather relevant information and resources. Step 3. Identifying the alternatives. Step 4. Take action and implement the decision. Step 5. Review the decision and evaluate the results.
Szafranko and Harasymiuk (2022)	Steps: 1. Identifying the need to make a decision (define the aim). 2. Collecting information about the environment. 3. Building a model (in some cases, describing the situation with a mathematical language). 4. Generating solutions to the decision problem. 5. Making an evaluation of the variant solutions. 6. Verifying the model. 7. Obtaining feedback to correct the model. 8. Receiving the corrected solution. 9. Implementation

Based on these models, this study developed a model of the decision-making process with phases and steps (see Table 2). This model is intended to support the analysis of the decision-making process in this study, not only from a general perspective but also from an organizational and construction sector-focused perspective.

Table 2

Developed model of decision-making process in this study

Phase 1.	Information gathering to specify the nature of the decision-making situation:
	Step 1. Identify the need or aim.
	Step 2. Collect relevant information.
Phase 2.	Alternative identification:
	Step 3. Determine criteria.
	Step 4. Select a method to gather solutions.
Phase 3.	Decision-making implementation:
	Step 5. Evaluate variant solutions.
	Step 6. Obtain feedback.
	Step 7. Implement the decision.

2.3 Actors

In this section, the system component 'Actors' is described. The Actors in this study refer to stakeholders related to construction projects. They are detailed, followed by their groups, analysis, and involvement.

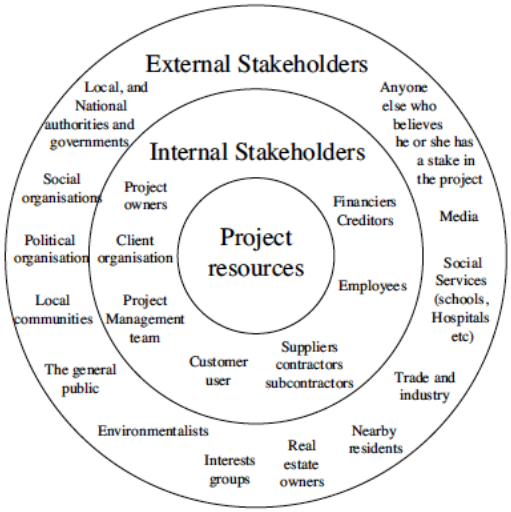
2.3.1 Stakeholders

Stakeholders play a critical role in any project. Many stakeholders are involved in the construction sector compared to others. This is due to the sector's nature which often requires relatively significant investment, many processes, and long-time horizons (Szafranko & Harasymiuk, 2022). In the projects, the stakeholders usually have different interests. The level of interest and the resulting impact on the project varies. These interests are often in conflict, and all are unlikely to be met (Olander, 2007).

Stakeholders in a project are often referred to as project stakeholders (Project Management Institute, 2013). Two basic types are distinguished, namely internal and external stakeholders (Olander, 2006). Internal stakeholders are directly involved in the project execution, and external stakeholders indirectly affect the project (Aapaoja & Haapasalo, 2014). Figure 6 shows the potential stakeholders of the construction project.

Figure 6

Potential construction project stakeholders



Note. Internal and external stakeholders in projects. Reprinted from *A Guide to the Project Management Body of Knowledge*, by Project Management Institute, 2013,

2.3.2 Stakeholder Groups

In the construction sector, managing stakeholders throughout the project lifecycle contribute to the project's success (J. Yang et al., 2009). It is essential to understand better the criteria that contribute to project success from the perspectives of various stakeholders (Davis, 2014). Recognizing multiple stakeholder groups needs to support managing stakeholders systematically (Yang & Shen, 2015).

Table 3 below shows potential stakeholder groups categorized in the literature as a framework to recognize relevant stakeholders.

Table 3

Potential stakeholder groups in construction project

Stakeholder Groups		Relevant stakeholders
Internals	**Senior Management**	Board, director, executive, executive management, investor, project executive, portfolio director, program director, owner, senior management, sponsor, top management, project sponsor, sponsor suppliers
	Project Core Team	Engineer, other organizational involvement (e.g., business departments), project leader, project manager, project personnel, project team leader, project team, team members, contractors, consultants
	Project Recipient	Client, consumer, customer, end users, users
	Externals	Communities, public, government, district council, environmental interest group, special interest group, media, competitors

Source: *Davis, 2014; Feige et al., 2011; Mohd Isa et al., 2016; Yang & Shen, 2015 .*

*2.3.*3 *Stakeholder Analysis*

With the introduction of a circular economy, the construction sector has recently focused on providing various services to the built environment (Pheng & Hou, 2019). It is to provide added value, such as convenience and comfort, not only the building as a single product (Norouzi et al., 2021). Stakeholders should therefore be interested in and consider various aspects. These make their understanding more challenging and add uncertainties to projects. (Aapaoja & Haapasalo, 2014).

Stakeholder Analysis provides a basis for understanding and assessing each stakeholder's different concerns and expectations in the project (Lehtinen et al., 2019). The basic process is to first list potential project stakeholders and then map them based on their power and interests in the project. The process can provide a visual of the stakeholders' structure. It can optimize organizational performance and contribute to improving project opportunities and issues (Silvius & Marnewick, 2022).

In many cases, stakeholders' interests in construction projects differ and depend on their roles and responsibility (Olander & Landin, 2005). Potential stakeholder interests and concerns in the project according to the stakeholder groups are shown below:

Table 4

Potential concerns in each stakeholder groups

Stakeholder Groups		Main concerns
Internals	**Senior Management**	Economic feasibility, corporate social responsibility, regulation, personal beliefs, organization image, return on investment
	Project Core Team	Availability of natural resources in energy and materials, workforce, knowledge; creative and client application of technologies
	Project Recipient	Well-being; lifestyle, cost-efficiency, personal beliefs, organization image
	Externals	Regulations and control, well-being, social equity; access to information, technology and knowledge, democratic share of information

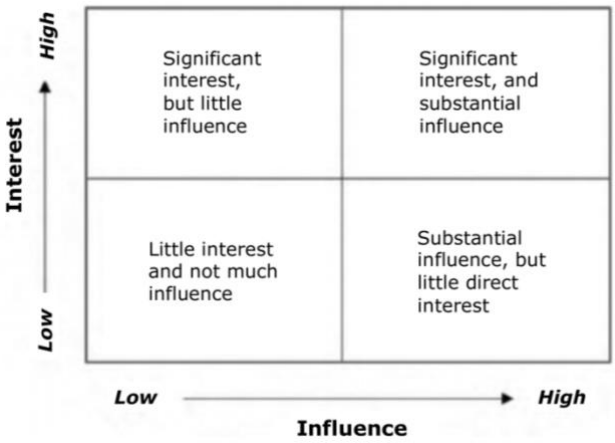
Source: *Davis, 2014; Feige et al., 2011; Mohd Isa et al., 2016; Yang & Shen, 2015 .*

Various stakeholder analysis tools have been developed for decision-making and strategic development in project management (R. J. Yang, 2014). Graphical models are commonly used, such as the well-known Power/Interest Grid (Murray-Webster & Simon, 2006). This matrix introduced by Eden and Ackermann (1998) facilitates stakeholder identification but is particularly useful for assessing specific categories of stakeholders in projects (Jolanta Maj, 2015). The analysis can be done by mapping stakeholder interests on the vertical axis and their influence on the horizontal axis, from low to high (see Figure 7). The result indicates the level of stakeholder interest and influence to identify influential stakeholders in the project.

Olander and Landin (2005) applied this grid to observe the changes in stakeholders' interest and power during different phases of projects' life cycles in various buildings. This approach revealed their level of involvement throughout the project life cycle.

Figure 7

Power/Interest Grid



Note. Stakeholders' interest versus influence grid. Adapted from *Making Strategy: The Journey of Strategic Management,* by C. Eden and F. Ackermann, 1998, (p. 121–5, 344–6), London: Sage Publications

2.3.4 Stakeholder Involvement

Continuous communication with stakeholders is crucial for effective stakeholder management in projects (PMI, 2017). It helps to encourage stakeholders to be adequately involved in decision-making and project activities (Edelenbos & Klijn, 2006). According to the Project Management Institute (2017), one-third of all projects fail due to a lack of communication.

Building relationships has also become an essential strategy to promote sector-wide sustainability in the construction sector (Bal et al., 2013). The relationships are usually built at different levels of involvement throughout the project. These different levels of involvement often influence the results of projects (Olander & Landin, 2005). The main stakeholders who primarily act and have a significant responsibility often change throughout construction projects. The changes can be seen in the phase of long-term and large-scale projects, from architects to consulting engineers and developers (Olander & Landin, 2005). When a project phase changes, important information, such as stakeholder requirements, may be lost (Butt et al., 2016). In the worst case, this result may be reflected as a construction project failure (Butt et al., 2016). It is important to ensure that the requirements set by stakeholders are followed up throughout the planning and execution phases (Edelenbos & Klijn, 2006).

2.4 Values

The system component 'Values' is described in this section. The Values in this study mean the impacts of relevant factors in the Processes and Actors components. To help understand the value (impact), this section addresses the relevant causes that affect the lifespan of buildings.

2.4.1 Building lifespan

During their life cycle, buildings experience changes in politics, economics, society, and the environment. These variables usually affect the lifespan of buildings. These influential factors can lead buildings to be demolished as a result (Dias, 2013a).

The lifespan of buildings has been approached from different perspectives in the literature regarding the main causes with their consequences. Through an analytical approach, they can be classified into seven categories below:

Table 5

Categories and definitions of building lifespan

Physical/technical	From the period that an asset is expected to last physically until physical replacement or major rehabilitation is required; the building structure and components are physically unrepairable or technically unusable.
Function	The period during which the building meets the appropriate functional or operational performance level; the need for assets is expected, or the functional value of the building is lost.
Social	The period during which a building continues with human desires. It includes the life of redevelopment, reconstruction, and remodeling.
Economic	An asset period dominated by economics and with a vital purpose as a financial investment; when assets are lower or at least at equivalent exploitation costs, and no alternatives exist to meet the cost performance.
Legal & Politics	When the building is unable to meet its statutory obligations. It includes the life of redevelopment, reconstruction, and remodeling by national policy. It is ruled by measurable building regulatory principles.
Design	When related design trends (perimeter, technology, and originality) are considered obsolete or archaic and no longer meet the current prevailing architectural trends or an aesthetic point of view.
Location	The period during which a region suffers devaluation due to either market changes, seismic risk, or city planning.

2.4.2 The lifespan causes

Various authors explain the main causes and relevant factors that define the lifespan of buildings from different perspectives.

Thomsen and Straub (2018) mention that a building lifespan correlates with age and building code, such as size and type of construction. However, just because a building is old does not mean it is close to demolition. They state that the lifespan can vary depending on the time-limited differences in building quality and architectural and environmental appeal. It can also depend on the associated degree of initial refurbishment and improvement.

Liu et al. (2014) explain the causes influencing lifespan by distinguishing between internal and external factors. The physical condition of the building is mainly considered an internal factor that affects the short life of the building. External factors, such as location, economics, and politics, are considered the primary reasons for justifying the useful life of the building.

Ji et al. (2021) describe that a building lifespan is the sum of the internal factors of the building itself and the site and surrounding environment (such as weather, humidity, salt, and disasters). It includes the degree of building maintenance-related regulations. They state that guidelines, redevelopment and reconstruction standards, asset value, and social demands can be significant factors.

Grover and Grover (2015) claim that the causes influencing lifespan are not directly related to asset wear or service degradation over time or use but rather that objects become obsolete or due to reduced usefulness.

The factors that affect the lifespan of buildings in the literature are summarized in each lifespan category in the Table 6.

Table 6

Factors influencing the main causes per lifespan category

Physical/technical	- The type of use, construction methods, ownership (and tenure), and culture. - The performance of maintenance activities. - Number of stories or floor area. - The urban renewal process quality of construction, structure, and components due to the aging and weakening of the building.
Function	Changes of usage in building space composition, center position, pillar spacing, and floor according to functions, uses, and needs (new stakeholders, society and lifestyle, advances in building technology).
Social	- Changes in social demands and perceptions in individuals, groups, and neighborhood-scale of preferences, values, and qualities; social behaviors and roles, subjective expectations (changing social conditions and needs) - Adoption of new safety regulations or standards (related to asbestos, fire resistance, or seismic resistance)
Economic	- Land price and value difference account. - Priority on the standards of physical deterioration or social motivation. - Various perspectives of diverse stakeholders. - Economic goals that are the main interest of investors
Legal & Politics	New proposals and changes to city planning, political jurisdiction, and building legislations; Legal regulations and the legal instruments related to safety concerns (management of building design and maintenance), economic and cultural conditions (changes in public or community interests)
Design	Changes in architectural style (e.g., new materials or construction trends), aesthetic attributes (images, fashion trends, etc.) and demographics (lifetime changing user requirements); fashion and style that change over time (for non-structural building elements such as interiors).
Location	Values of the areas that were justified by reinvestment or the investment in new or improved infrastructure due to certain activities such as commerce and submarkets; aiming at avoiding unprofitable development sites and gentrification.

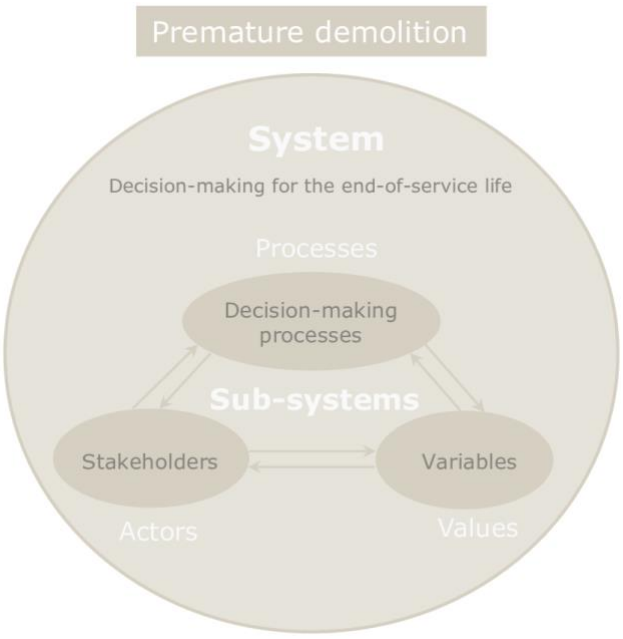
2.5 Conceptual Framework

In this chapter, all three components have been addressed: 'Processes' as the processes of decision-making for the end-of-service life, stakeholders in building projects as 'Actors,' and the impacts of relevant factors in Processes and Actors components as 'Values.' These components are indicated as the interrelated core sub-systems in the system that underlies potential demolition decisions.

To conclude this chapter, the relationship of the described theories is structured as the perceived conceptual model, shown in Figure 8. The model can help to understand how these components influence the underlying causes of premature demolition.

Figure 8

Theoretical relationships



3 METHODOLOGY

This chapter was written based on the theoretical background of the previous chapter. It contains the data collection and analysis methods used in this study. The outline of the methodology is introduced in the first section. Each method is further elaborated on in the following sections.

3.1 Overview

Data collection was executed through the literature review, preliminary expert interviews, and a case study. The literature review and expert interviews were initially conducted to gain background information. The literature review also supported both data collection and analysis throughout this study. The preliminary expert interviews in this study area led to finding a building project as a case study. The case study was then conducted through interviews and a group session with project stakeholders to gather relevant information on the selected building.

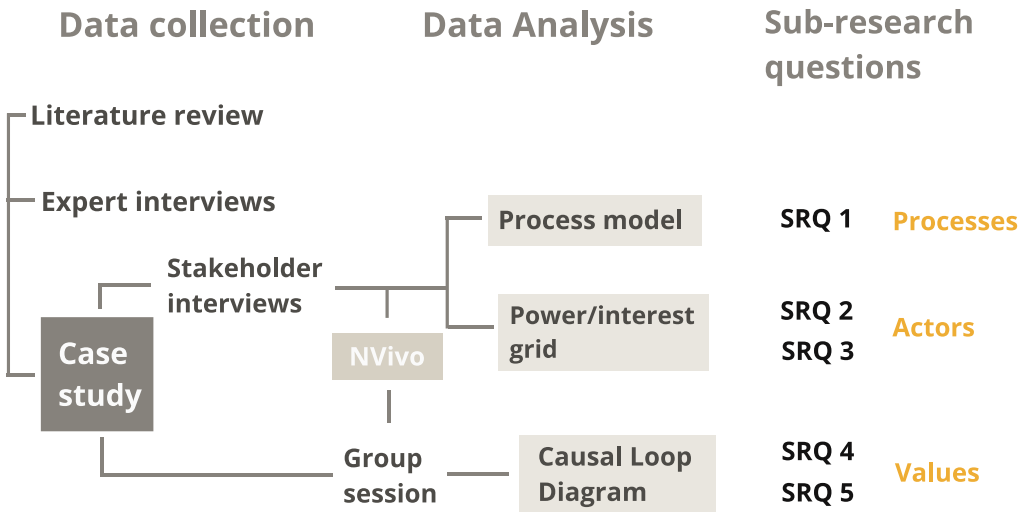
Case studies are often described as an intensive, systematic investigation of specific phenomena and an in-depth examination of a particular case within a real-world context (Crowe et al., 2011). This approach is often conducted in a narrative way. Researchers explore what happened in a program or project and why. The narrative explains human aspects and goals and presents the results of their complexity (Yin, 2012). It helps seek ideas about the subjects and to construct theories about their dynamics (Wang & Groat, 2013).

The interviews in the case study were semi-structured with relevant project stakeholders. This method involved a dialogue between the interviewees and the researcher. It was guided by a flexible interview protocol and supplemented by follow-up questions, probes, and comments. The technique allows for open-ended data collection to explore participants' thoughts, feelings, and beliefs about the topic (DeJonckheere & Vaughn, 2019). It contributed to delving deeply into the stakeholders' personal perspectives.

The data collected from the stakeholder interviews were mainly analyzed using the thematic analysis software NVivo. The software assists in providing a broad insight into what themes are in the data. It allows the researcher to drill down into the information for deeper analysis (Zamawe, 2015). Post-analysis data from NVivo was used in a group session. The session was then conducted with selected stakeholders to discuss the data to have a common understanding of the project elements with them. Group sessions are also helpful in providing stakeholders an opportunity to understand each other better and the project with a broader view (McCardle-Keurentjes et al., 2018). The structure of these methods is visualized below:

Figure 9

Methodology structure



This methodology led to answering the sub-research questions (SRQ)s according to each component in order to approach the main research question.

The data on the processes of decision-making for the end-of-service life were collected and examined: SRQ 1. The data regarding actors in building projects were analyzed to identify relevant stakeholders: SRQ 2. Their levels of interest and influence were then explored by the stakeholder analysis tool (Power/Interest Grid): SRQ 3. Using the analysis results from NVivo software and the group session, key (and relevant) variables and their interrelations influencing the decision-making for the end-of-service life were revealed in a Causal Loop Diagram: SRQs 4 and 5.

3.2 Literature Review

The literature review was actualized as a data collection method by identifying, recording, understanding, and transmitting the information in the literature. A literature review synthesizes and analyzes published research on a relevant critical issue. This helps provide insight into an issue or phenomenon and provides ground for generalizations (Stake, 2005). It is a standard format in related fields of academic research to examine a particular case (Boote & Beile, 2005).

The method supported the development of this study. It includes adding and verifying the study's arguments (Snyder, 2019). In the theoretical framework, the System Thinking Approach was first explored to explain the system's core sub-systems (components). Each component was structured by creating a list of fundamental keywords related to the main research question (see the list in Table 7). The list was then used to search for relevant sources and to proceed with the literature review.

Table 7

Leading keywords for the literature review

Components	Keywords
Process	Decision-making, building life cycle, building project, building circularity
Actors	Construction stakeholders, project stakeholders, stakeholder management
Values	Building lifespan, influential factors

First, a building was looked at from its life cycle and project life cycle. In the processes of both life cycles, decision-making was found to be a critical process. Actors in decision-making were sought at stakeholders related to construction projects. Their interests and influence seemed to be the key to managing stakeholders in the projects. The impact of both components as project values was found to relate to building lifespan. The related factors were then searched as potential influences leading to demolition decisions.

3.3 Expert Interviews

The interviews with three professionals relevant to this study area were individually conducted as a preliminary activity. The interviewee professionals are mainly project managers for construction projects in the Netherlands (see Table 8 below).

Table 8

The interviewed expert profiles

Interview Date	Job title(s)	Workplace(s)	Specialties
March 8, 2022	Project manager for consultant circular construction	Dutch construction company	Leading and coordinating design processes for large and complex buildings with a significant engineering challenge
April 1, 2022	Program coordinator and project manager and lecturer	Government institutions and a university in the Netherlands	Management of complex projects; Lecturing, International coordination, research management, urban development, real estate development
April 7, 2022	Area developer	Dutch real estate company	Renovation and new build projects in neighborhood-oriented work

The questions were asked via email, phone, and the online communication software Zoom, dependent on the interviewees' requests. The gained insight contributed to the development of this study direction. Expanding networks in the relevant research area assisted in exploring potential case studies and finding the case study for this study.

3.4 Case Study Approach

The first activity included the analysis of related documents, such as project reports and independent studies. The initial communication was conducted with a case study stakeholder in charge of tasks to develop projects. The case study background and relevant stakeholders' information were collected. The interviewees were then selected from the stakeholders.

The stakeholder interviews were conducted, followed by the group session. Both activities were performed through the online meeting software Microsoft Teams. Each interview lasted approximately one hour, and the group session lasted for one and a half hours. They were recorded with each participant's permission. These recordings helped to ensure accuracy and objectivity in the data collection (Jamshed, 2014). The transcripts were provided by Microsoft Teams and used for thematic analysis on the NVivo software. An online communication board Miro was also used to facilitate activities for the group session. The board is easy-to-use and helps visualize divergent activities as a shared workspace (Brucks & Levav, 2022).

3.4.1 Selected Case

The selected case study is a university building project in the Netherlands. Many universities aim to make their campus buildings as sustainable as possible by 2030 (EUA, 2018). The case study (CS) building was built in 1969. The appearance is concrete material and distinctive, which is typical for the 1960s and 1970s (Huuhka et al., 2015). The net area (the actual area of the building within four walls) is 14,800 m2. A lower part of the CS building was already demolished in 2021 as a separate project from this study case. The CS building was not planned to be demolished together with this part due to technical issues in their connected installation structures.

The CS building project was an ongoing project to decide whether demolish the building or not since 2020. This case study research was conducted in April and May 2022. A decision was planned to be made later in 2022. Since it was built, the CS building has carried out internal maintenance and repair (restoration), but no

renovation work has been done by the time of this study. Thus, if a demolition decision was made, it would be one for premature demolition.

3.4.2 Stakeholder Interviews and Power/Interest Grid

The relevant stakeholders of the case study (CS) building project were listed, and six were interviewed. Two interviewees per category were selected from each internal stakeholder group, as shown in Table 9. The categories were adopted from the theoretical framework mentioned in section *2.3.2*.

Table 9

Stakeholder interviews

	Interviewees	
SM	Development Executive	**1**
	Project Executive*	**1**
PCT	Project Developer	**1**
	Energy Consultant	**1**
PR	Client*	**1**
	Employee	**1**
	Total	**6**

** The interviewees are also members of the Executive Board in Senior Management groups*

All the interviewees were asked to provide their perspectives on relevant facts about;

a) their roles and expectations in the project
b) the project situation and processes.

See the prepared questions in Appendix A.

Note that the project executive and the client in Table 9 are also the executive board members* of the project. The project executive and the client provided both perspectives, their primary role, and the executive board. The information of other relevant stakeholders in the project was also provided during these interviews.

The answers related to the interview questions a) were analyzed to identify their levels of interest and influence by using the Power/Interest Grid explained in *2.3.4*. The levels were also identified per project phase and step in the CS building project.

3.4.3 Group Session and Casual Loop Diagram

Preparation: All collected data regarding answers to questions b) were analyzed using the NVivo thematic coding software. Initial Coding generated possible variables influencing the project (see Appendix B). The variables were listed on a Miro board to use in the group session. Three participants were selected, one from each internal stakeholder group: the development executive, the project developer, and the employee. The agenda of the group discussion was explained to the participants in their individual interviews.

Activities: First, each participant selected 5-10 variables from the list on the prepared Miro board using sticky notes. They were asked to choose the variables they consider critical elements in the project from their perspectives. The participants were then asked to discuss the chosen variables together while facilitated by the researcher. The most relevant variables were listed on the board during this activity (see Appendix C). This group session contributed to ensuring the validation of variables to develop a Causal Loop Diagram (CLD) described in *2.1.2*.

After the group session, the relationships of the identified variables in the Activities were examined. The different types of key variables were identified by a connection circle (CC). CC is an interrelationship diagram that is commonly used as a first step to developing CLDs (Dhirasasna & Sahin, 2019). Using the identified key variables in the CC as a guide, other relevant variables were also identified. These possible variables were refined into the Final Code (see Appendix B). A case study CLD was then developed with the Final Code in the modeling program, Vensim. The developed CLD visualized the cause-effect relationships of the relevant variables in the Process and Actors components. They indicated the impact of relevant factors of both components as the Values in the decision-making situation (system). Their relationships were also classified into possible categories that define the different lifespans of buildings described in *2.4*. The steps to build the CLD including the created CC can be seen in Appendix E.

3.5 Ethics

The participants in this study were informed about the study's purpose, aim, and methodology. It included how they could contribute to the research and how that would be used. The informed consent was secured. In addition, the respondents were free to withdraw from the study at any time. They were anonymized to minimize the risk of harm. The respondents were asked for their agreement before recording the interviews and the group session. The recordings were not shared by the researcher except with the supervisors of this study. The respondents agreed with the researcher not to utilize any additional security measures for the storage of the information. The results were shared with the participants. They will be provided with a copy of this study document upon request.

4 RESULTS

This chapter presents the results obtained by implementing the methodology mentioned in the previous chapter. The three core components of the case study are addressed in the same order as the system thinking-based approach in the theoretical framework: Processes, Actors, and Values.

4.1 Processes

The stakeholder interviews provided information relevant to the processes of decision-making for the end-of-service life in the case study.

The findings were mainly gathered from all the answers regarding questions b) the project situation and processes perspectives, presented in *3.4.2*. They are explained along with the building life cycle, project life cycle, and decision-making. Both life cycles are first illustrated, then the decision-making process.

During the study period for this case study, these processes were still ongoing. As mentioned in *1.4*, some steps and phases in the processes did not yet happen before and during this study period; April and May 2022. These processes were already planned and outlined. They were collected during the stakeholder interviews and included in this study. They will be conducted later in the year.

4.1.1 Life cycles of building and project

The theoretical life cycles found in this study were:

Building life cycle stages *- Production, Construction, Use, and End-of-Life*

Project life cycle phases *- Start, Planning, Execution, and End*

During this study period, the building life cycle of the case study was in its *Use Stage*, and its project life cycle was in the *Start Phase*. The project started in 2020 and was underway to decide whether to demolish or refurbish (renovate) the building.

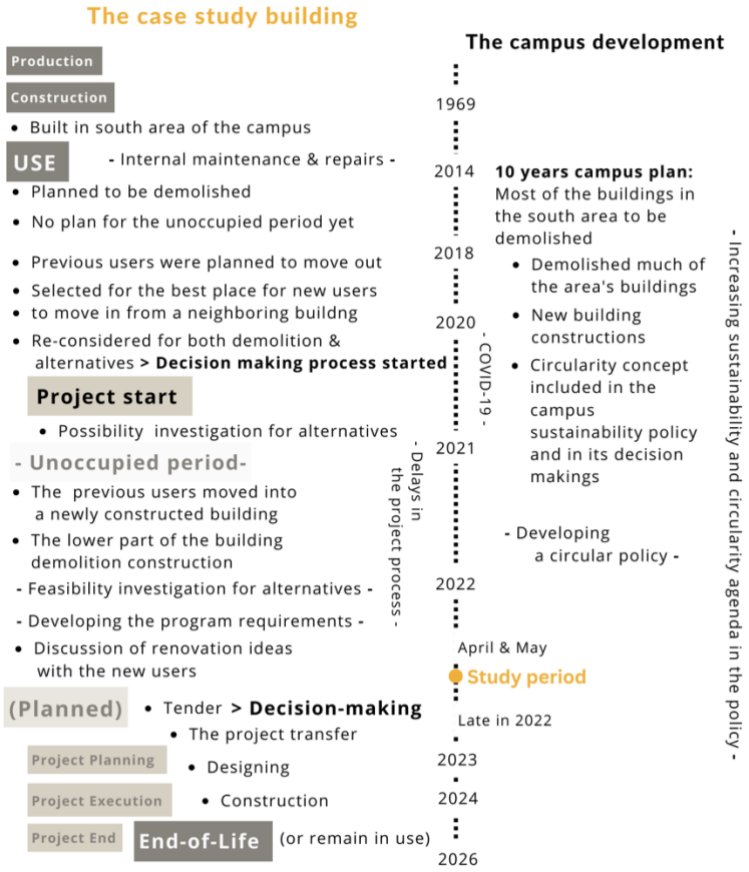
Essentially, the case study was in the middle of the project to decide whether to proceed with the building's life cycle to the End-of-Life Stage or remain in the Use Stage.

Although its building life cycle was in its "Use Stage," the CS building was actually unoccupied due to the following consequences. At the beginning of 2021, the previous user of the CS building was moved out. In the summer, the lower part of the CS building was demolished. As a result of these two events, the CS building was not in use for more than a year between the beginning of 2021 to this study period. This particular period is defined as the unoccupied period of its Use stage in this study.

Figure 10 presents the overview timelines of both life cycles within the campus development (the system boundary). The figure mainly illustrates the events in the Use stage that are potentially the most relevant to a decision for the building end-of-service life.

Figure 10

The building and project life cycles in the case study.



4.1.2 Decision-making process

The decision-making process in the case study is described below according to the seven steps in three phases, proposed in 2.2.4. The steps in the last phase (Steps 5 to 7 in Phase 3) are the planned processes and will happen after this study period. These will be indicated with (Plan) and may be explained in the future tense.

Phase 1. Information gathering to specify the nature of the decision-making situation

Step 1. Identify the needs or aim:

The case study (CS) building needed to provide space to be used for the new users (the project recipients). They were the university faculties moving from a neighboring building on the campus.

The building was originally planned to be demolished when the campus development was planned in 2014. Meantime, sustainability and circularity have risen to be high on the agenda of the campus development policy. The demolition decision was revisited to seek more sustainable options for the CS building. In 2020, the CS building project was then launched to decide whether to demolish the building or not.

It was unclear whether demolition or renovation were better options to increase the circularity of the CS building. The considered circularity included such as material use, energy efficiency, limiting environmental impact, and biodiversity.

With the increased sustainability agenda, the circularity concept was added to a campus sustainability policy for the campus development projects. Therefore, a circular policy was urgently being developed to compare the building circularity of demolition and renovation for the CS building.

Step 2. Collect relevant information:

Since the CS building's completion in 1969 (during its Use Stage), internal maintenance and repairs (restoration) have been carried out. These included maintaining interior lighting, stairs, and railings. However, by this study period, no refurbishment, such as renovation and replacement, took place (See *2.2.1* about these processes).

Based on the condition, an investigation was initiated into the current technical/physical information of the CS building. First, material comparisons were conducted to investigate the least environmental impact in the case of demolition. Wood was found to be the least environmental impact material among concrete, steel, and wood. Renovation was considered a possible sustainability alternative for demolition by technical investigation and analysis. The collected information of technical issues in existing usage and the renovation possibilities of the CS building is shown in Table 10. Additionally, Energy efficiency, advised by an employee, was also taken into account.

Table 10

The Physical/technical information from the investigation

Current condition of CS building	Renovation possibilities
- Few rooms (3) - Small stores - Concrete material façade that cut the sunlight	- Retain 75 % of the building by adding square meters in a collect way - Keep existent three rooms and add one bigger room with a new unit
	Renovation impossibility; demolition possibility
- Specific (outdated) floor shape/layout - Low ceiling to have new installations, interior, and ventilation/pipes - Low building height compared to surrounding buildings	- New building façade - New floor shape/layout - Solve indoor climate installation issues - Match the height with the other higher buildings

The project recipient' requirements (the program requirements) were also collected; see Table 11. They were based on the demands for their education, research, and support activities. The program requirements were still being developed and needed to be completed to include them in the decision-making.

Table 11

The project recipients' demands per relevant categories

Function	- Large vertical floors with easy movement between rooms to make encounter meeting opportunities between students and staff - Building usage in conventional research way (own their workspace) - Building space functional values for space current and future end-users over decades
Social	- Inspirational and sustainable image building - Owning a new and proud building as their identity
Economic	- The same or lower running cost than their previous building - Attract new students and staff for increased marketing
Design	- A modern building appearance like surrounding buildings - Building transparency to obtain clear and open atmosphere

The collected information revealed the conflicts between the renovation possibilities and the program requirements (see Table 12). Although the CS building still provided usable space, it did not provide usage to meet the program requirements. Therefore, the building required to be improved as sustainably as possible while fulfilling the program requirements.

Table 12

The demands conflicting with sustainability perspectives per relevant categories

Function	- Possibility needs more than adding one room to ensure the conventional way of working - Needs the existing building skeleton into large vertical floors by demolition for creating encounter meetings
Social	- Negative public perception of owning and using a second-hand building - High awareness of sustainability but low scarification of one's desires for it
Economic	- Renovation often costs more than demolition - Cost burden by increased sustainability and circularity aspects
Design	- New building preference for their identity and quality of education and work - A renovated building provokes comparisons with newer buildings.

Phase 2. Alternative identification

Step 3. Determine criteria:

Attempted process with the determined criteria - Criteria were first developed to find potential variant solutions by weighted scaling (see Table 13). The developed criteria and weighting were attempted to assess the three variant solutions.

Table 13

Developed variant solutions, criteria and weights

Criteria	Weights		
Work environment functionality, Functionality research environment, Architectural, Installations, Flexibility, Square meter ratio, Durability, Control	worse, bad, average, good, better	limited possibilities, more limited options, average, capabilities, better options, best options	most complicated, complicated, average, simple, easiest
Variants			
1. complete demolition and new construction 2. partial demolition, partial replacement, and partial renovation (max. 60% demolition) 3. limited demolition, limited replacement, and large-scale renovation (max. 30% demolition)			

However, the project was still unable to determine weights per criteria to assess the variants from their knowledge and the investigation information. Therefore, they could not come up with definitive solutions.

Further investigation - An in-depth investigation was also ongoing to gain the technical and functional feasibilities for further investigation of renovation possibilities. It focused on aspects such as the reusability of building skeletons, the consequences of adapting techniques, and cost-effectiveness. The results needed to be sufficient to provide integrated advice to the decision-makers and plan/implement this CS building project.

Step 4. Select a method to gather solutions:

Tender - Meanwhile, a tender was then decided as a strategy to find possible solutions for the requirement conflicts between the project recipients and the sustainable perspective. The tender will happen after this case study period in late 2022. Five or six selected architects will be asked to propose their design ideas. Their design ideas will be expected to provide CS building usages that balance the program requirements and sustainable perspectives. They will be considered regardless of demolition or renovation construction options. Namely, this tender will focus on exploring possible solutions regardless of construction options, as long as both requirements can be balanced for building usage.

Phase 3. Decision-making implementation

(Plan) Step 5. Evaluate variant solutions:

The project will evaluate the possible solutions from Step 4; the design proposals from the architecture competition. Apart from the criteria determined in Step 3, adequate criteria will be first required to select the best building design as a solution. The criteria will then be used with the completed project requirements. The project requirements will also reflect their voices and opinions, such as negative perceptions about existing building appearance and renovated and second-hand buildings.

(Plan) Step 6. Obtain feedback:

The evaluated solutions will be passed on to the project recipients. Their feedback will be obtained to make adjustments between the solutions and their requirements. This step was included in the plan to prevent possible problems in the coming project phases.

(Plan) Step 7. Implement a decision:

Once a decision is made after the adjustments, the decision needs to be approved by the campus representative. The approved decision also needs to be permitted by the administrative organizations. The permitted decision will be set to plan and then implement.

4.2 Actors

The answers relevant to the question type a) their role and expectations in the building project, mentioned in *3.4.2,* were collected from the stakeholder interviews in the case study. These were analyzed to identify relevant stakeholders and their influence in the case study (CS) building project. In this section, they will be listed and shown respectively.

4.2.1 Relevant stakeholders

The relevant stakeholders in the CS building project are listed in Table 13. The table is shown according to stakeholder groups and their primary roles. The following Table 14 shows their primary concern and interest.

Table 13

Project stakeholders and their main roles in the case study

Stakeholder groups	Stakeholders	Main project roles
Senior management (SM)	Executive board*	• Decision making
	Development executive	• Provide advice to Executive Board • Make sure consistency between the campus and detailed plans
	Project executive	• Provide advice to Executive Board • Ensure the agreement with the project recipients for the decision • Supervise the sustainability achievement of the clients
Project core team (PCT)	Project developer	• Develop detailed plan • Communicate with the key stakeholders
	Sustainability consultant	• Develop Circularity policy
	Energy consultant	• Energy management (calculation, procurement, maintenance)
	Engineering consult contractors	• Investigation of material circularity • Advice on technical & functional feasibility
	Architectures (select 5-6 for a tender)	• Propose design idea in a tender
	Project manager	• Manage project planning and implementation
	Design team	• Design from the tender
	Installation & construction contractors	• Construct building • Install applications in building
Project recipients (PR)	Clients: two faculties	• Develop program requirements for building
	End-users: students and campus staff	• Use the project building for research & education • Provide opinion
	Employees: Facility managers	• Oversight of all campus facilities management • Provide opinion
	Campus supervisors	• Approval of plans
External	Municipality	• Proceed permission

** The stakeholders are also the members of Executive Board in Senior management group.*

Table 14

The stakeholders' main concern and interest

Stakeholder groups	Stakeholders	Main concern/interest
SM	Executive board (EB)	• Balance of the user demands and sustainability perspective • transparency in the decision-making process • reliance on advice from the project experts
	Development executive (DE)	• Quality of a decision • Balance of the user demands and sustainable perspective • Conviction of the user for sustainability perspective compromise • End-user opinion on the change of the board's mind • User dissatisfaction • Changing their perspective on renovated buildings
	Project executive (PE)	• Support the board in achieving their sustainable goal • Decision making as she is one of the board members • Meeting decision with multicriteria
PCT	Project developer (PD)	• Performance of the project • Demolition decision • Technical feasibility for renovation • renovation is the most sustainable (circularity) option; less impact on environment, that matches campus sustainability goals.
	Sustainability Consultant (SC)	• Sustainability perspective level on a decision along with the circularity policy
	Energy Consultant (EC)	• Involvement in the early process to provide advice
	Engineering consult contractors (ECC)	• Quality of the investigation and analysis
	Architectures (A)	• A presented proposal to be selected in the tender
	Project manager (PM)	• Ease of the project planning and implementation
	Design team (DT)	
	Installation & construction contractors (ICC)	
PR	Clients (C)	• Fulfillments of the requirements for the education, research & support activities • Cost-effectiveness for housing function • Sustainability goal achievement as faculty • Extra cost or the unfulfillments over the sustainable achievement level • Building transparency to increase the interaction between students and staff
	End-users (EU)	• Discomfort with Using re-used (second-hand) building • Attractive building appearance • The same working condition (having one's own workspace) to the current environment
	Employees (E)	• Own work in the use stage prospective • A quality of a decision that meets to prove
External	Municipality (M)	• A quality of a decision to provide permission

4.2.2 Level of interest and influence

The relevant stakeholders were assessed based on the listed main roles and interests by Power/Interest Grid, described in *2.3.4*. Their level of interest and influence is presented in Figure 11. Potential stakeholders with the most impact on the project can be identified in the upper right corner. The analysis details can be found in Appendix D.

Figure 11

The stakeholder interest/influence matrix

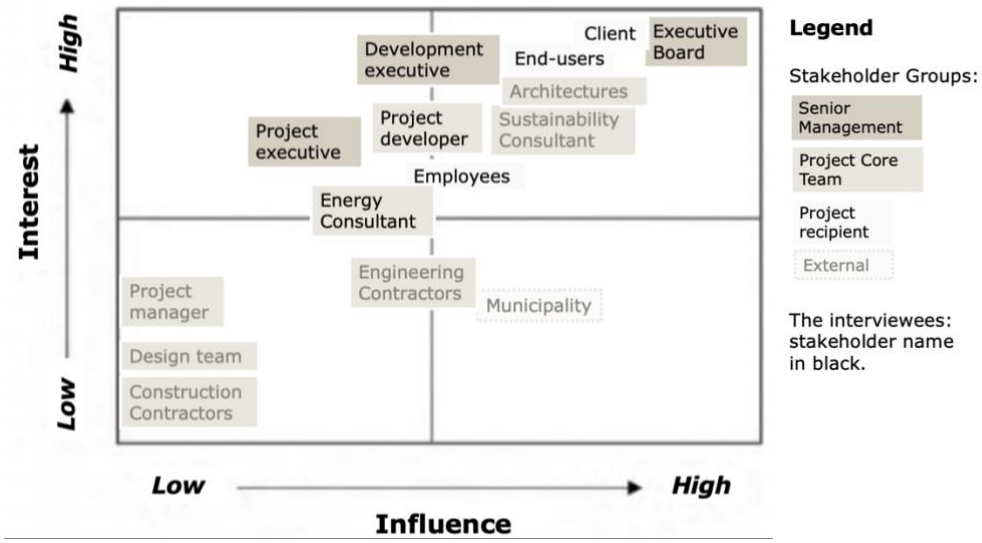


Table 15 illustrates the interest and influence of each stakeholder at different steps and phases of the decision-making process in the project.

Table 15

The interests and influence of each stakeholder in each project step and phase

Project phases		Start							P	E	AE
Decision-making process		Phase 1		Phase 2		Phase 3					
		1	2	3	4	5	6	7			
Stakeholder groups	Stakeholders										
SM	EB	✓			✓	✓	✓	✓			
	DE	✓	✓		✓	✓					
	PE					✓	✓	✓			
PCT	PD		✓	✓	✓						
	SC	✓	✓			✓					
	EC		✓								✓
	ECC		✓	✓							
	A				✓	✓					
	PM								✓	✓	
	DT								✓	✓	
	ICC									✓	
PR	C	✓	✓			✓	✓				
	EU					✓	✓				
	E					✓	✓	✓			✓
External	M							✓			

P: Planning, E: Execution, AE: After the project end phase (Use stage of building life cycle)

4.3 Values

This section addresses relevant variables and their cause-and-effect relationships in the case study. The relevant variables indicate relevant factors influencing the case study. They were identified in the results of the Processes and Actors components. Their causal relationships indicate the impacts of both components as the 'Values' component in the system.

First, the key variables identified in the Connection Circle (CC) will be described. The relationships of relevant variables visualized in the Causal Loop Diagram (CLD) are then explained.

4.3.1 Key variables

In the created CC, twelve key variables of four different types were identified (See table 16). They were considered to be critical elements in the project by the selected stakeholders in the group session.

Table 16

Identified key variables

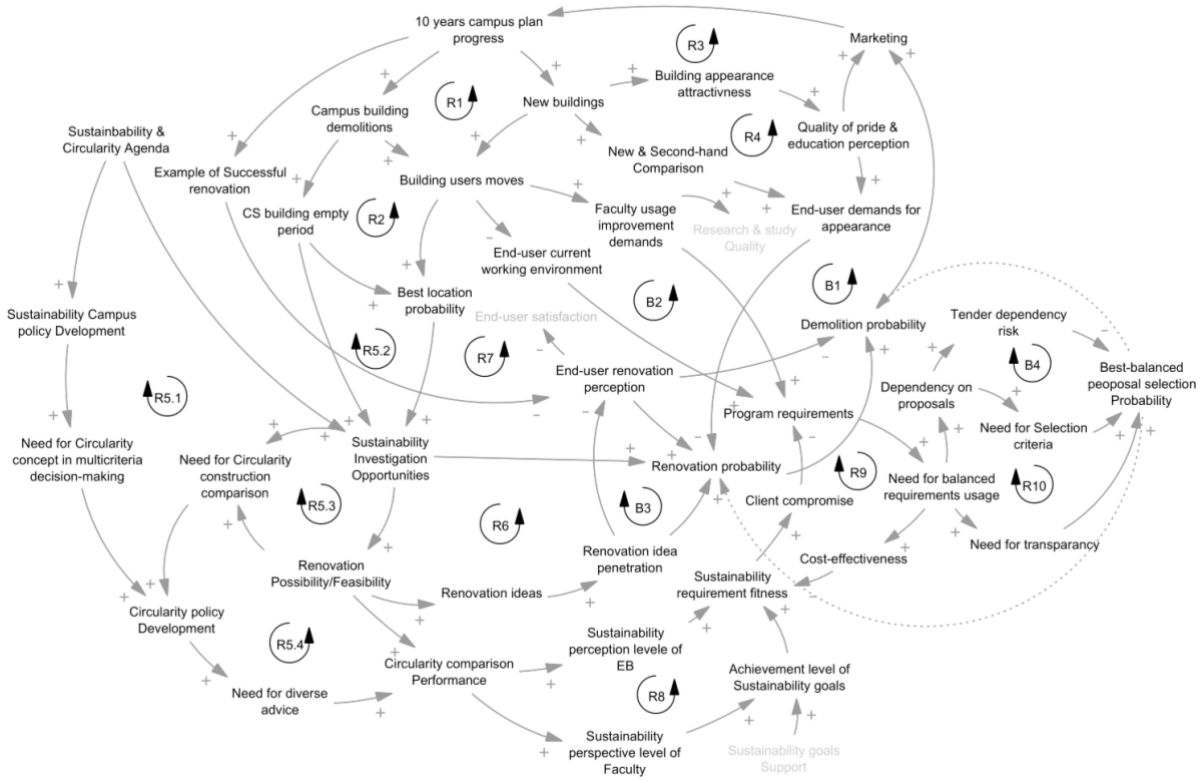
Type	Description	Key variables
Outcomes	The variables affected by other variables rather than driving other variables	- Need for sustainable promotion on campus - Possibility of renovation construction - Priority on sustainability requirements - Acceptance of building appearance
Potential key effect	The variables most affected variables by other variables	- Possibility of requirements balanced building usage
Driver	The variables that drive other variables rather than being affected	- Example of successful renovation building - Feasibility of renovation ideas - Transparency of processes - Priority on client requirements - Cost-effectiveness
Potential causes	The variables that most drive other the most	- User perception of renovated buildings - Need for diversity in expert advice

4.3.2 Causal relationship

The developed CLD illustrates the cause-and-effect relationships between all identified relevant variables in the case study (see Figure 12). Their relationships are detailed below the figure. They are indicated with possible categories mentioned in *2.4: – Physical/technical, Function, Social, Economic, Legal & Politics, Design, and Location.*

Figure 12

Developed Causal Loop Diagram



R1. Campus development loop – *Location:*
As the ten-year campus development plan progressed, the demolition of campus buildings and the number of new buildings increased on the campus. As a result, the need for building users to move was reinforced within the campus.

R2. Campus development consequence loop – *Location:*
With the increased user moves, the previous case study (CS) building user was moved out to one of the newly built buildings. Subsequently, the demolition work of the lower part of the CS building was also carried out. The CS building has become empty since the beginning of 2021. These consequences of the development have extended the unoccupied period of the CS building. However, it also increased the fitness of the CS building as the best location for the new users (faculties) to move in. These circumstances reinforced this project of the CS building to launch.

R3. Appearance comparison loop – *Design/Social:*
The increased number of new buildings can also increase the building comparison between new and old or second-hand on the campus among the (new) end-users, such as students, researchers. It is because end-users often receive a positive image of new buildings compared to renovated buildings (the development executive and project developer, personal communications, May 16 and 17, 2022; Rakhshan et al., 2020). Providing a renovated building was a concern for the project as the second-hand building could give them an inferiority complex. Therefore, this comparison potentially further accelerates the end-user's desire to use a building with an attractive appearance.

R4. Appearance potential effect loop – *Design/Social/Economic:*
New buildings usually increase the attractiveness of the campus, which increases the perception of quality education (the project executive, personal communication, May 24, 2022; Price et al., 2003). Also, building appearance plays a role as a symbol of the end-user pride for where they work, research, and study (the client, personal communication, May 17, 2022; Gorgolewski, 2008). The increased perception of quality

education can increase marketing rates by 10% to attract future users such as new students and staff. Eventually, the increase can also add value to the ten-year campus plan in the long run. These potential effects increase the demand for a new building, thus driving the case for demolition. It also indicates the contribution to expanding marketing opportunities.

B1. Appearance demand-effect loop – *Design/Social/Function:*
The increased end-user desire for an attractive appearance can decrease the probability of renovation for the CS building. One of the appearance demands is transparency in the building space due to the existing concrete façade. The concrete design was perceived as an ugly and outdated building design. The environment surrounded by concrete does not provide much brightness and an open atmosphere. It was investigated that the façade change is only feasible by demolition but not through renovation. Therefore, the increased appearance demands can reinforce the demolition probability.

B2. Clients vs. End-users perspective loop – *Social/Function:*
One of the reasons users move to other locations is to improve their current facility usability (the project executive, personal communication, May 24, 2022; de Groot et al., 2011). Therefore, users move drive the requirements (program requirements) of the project recipients, the clients, end-users, and employees. The program requirements were primarily for improving facility usage for their education, research, and support activities. The clients requested more encounter opportunities between students and staff as a significant improvement, for instance. On the other hand, the demand of end-users, especially researchers, was to secure owning one's working space. However, this cannot be guaranteed when moving to a new location. If their current work environment is lost due to this move to the CS building, the desire can increase to own one's workspace among them. Ultimately, both clients and end-user demand opposingly increase their program requirements for the CS building.

Additionally, a recent external survey, conducted by the university in the case study, found a growing awareness of sustainability among the end-users. However, the survey also revealed that regardless of the generation, they are less willing to contribute to sustainability when they are forced to sacrifice their desires.

R5.1 – 4. Campus sustainability development effect loop – *Physical/technical/Social:*
5.1) Over the past decade, sustainability demand in the construction sector encouraged sustainability & circularity as high agenda on the campus. The increased importance also promoted the development of a campus sustainability policy. The policy has promoted the need for the circular concept in the campus development's decision-making. 5.2) The high sustainability agenda then promoted opportunities to investigate circularity possibilities for the CS building. The investigation was started when the CS building was selected as the best location for the new users to move in. 5.3) The opportunities opened up an in-depth investigation for renovation. They increased the probability of renovation and feasibility for the CS building. It increased the need to compare the construction options between demolition and renovation. These then urgently reinforced the need for developing a circularity policy. 5.4) The sustainability consultant was the only one in charge of developing the circularity policy. This fact increased the need for diverse advice for comparing the circularity level of the two construction options. The diversity of advice and the increased renovation investigation can be expected to improve the analytical quality of the respective circularity levels of the CS building demolition and renovation.

R6 & B3. Renovation promotion effect loop – *Social:*
The increased renovation investigation also increased the renovation ideas for the CS building. Over a few months, the idea drawings were shared with the executive board, and the clients (new faculties who will move in and own the CS building). This sharing promoted renovation ideas among the stakeholders. The promoted ideas in the executive board can have an impact on increasing the probability of a decision for renovation. The promotion also could improve the end-user perception of renovated buildings. They had negative opinions of the renovated building. These were low pride and a negative image of secondhand buildings. Decreasing their negative perception also had the potential to increase the renovation probability. However, the promotion was not directly conducted to the end-users. Their negative perception increased the demolition probability.

R7. Renovation perception effect loop – *Social:*

An example of a successful refurbishment building was also the potential to lower negative end-user perceptions. In the progress of the ten-year campus plan, a neighboring building of the CS building was renovated and turned out to be a success. There was concern among the project core team that end-user satisfaction could be decreased by providing a renovated CS building. Therefore, the example was expected to decrease the negative perceptions of end-users. This may also lead to a decrease in demand for the CS building as a new building.

R8. Sustainability perspective promotion loop – *Social:*
The increased quality of circularity comparison analysis can raise the level of a sustainability perspective among the executive board on decision-making for the CS building. It also can increase the perspective level among the clients. They had their faculty sustainability goals, and the increased perspective can accelerate their achievement level. Their goal was supported by the project executive with a sustainability background. These reinforcements can be set to increase the fitness of the sustainability requirements in the decision.

R9. Two-side requirements conflict loop – *Social/Economic:*
The increased fitness of the sustainability requirements drove the need for clients' compromise to reduce the increased program requirements. The increased compromises primarily reflect in lower cost-effectiveness and less fitness with the program requirements. However, the client was concerned about the added cost burden due to the increased sustainability level. The increase in the fitness for the program requirements can facilitate cost-effectiveness, but it can also reduce the sustainability level of the CS building. Therefore, these opposing requirements drove the need for building usage that balances both requirements.

B4. Proposal situation loop – *Social:*
The increased need for balanced requirements usage increased the dependency on proposals in a tender. The project development stakeholders decided to ask for balanced design proposals for the CS building in the tender. Since architects make presentations to the decision-makers, their presentation skills can influence the decision regardless of the quality of the proposals (the development executive, personal communications, May 16, 2022; Clark, 2008). It is the risk of depending on the tender (van der Meer et al., 2022). Therefore, the increased dependence on the tender can decrease the probability of selecting the best-balanced proposal.

R10. Rational decision-making loop – *Social:*
The increased dependency on proposals spurs the need for selecting criteria to evaluate the design proposals in the tender. Criteria to assess variant solutions by weighted scaling were developed in the early project phase. As the process was attempted but was unable to determine solutions, the tender mentioned above was then decided to gather possible solutions. Therefore, it was further necessary to select the criteria for supporting the selection of the best-balanced design solutions. The project did not determine the criteria yet during this study period, but it may also help mitigate the tender risk. Additionally, the executive board required transparency in the project process for decision-making to increase the probability of selecting the best-balanced solution for the CS building.

5 DISCUSSION

This chapter consists of three sections. The first section describes the main findings in the case study that potentially influence premature demolition. The second section discusses theoretical lessons that can be learnt about categories of causes from the case study. The limitations and recommendations of this study are then provided.

5.1 Potential causes of premature demolition

Table 17 below shows the main potential causes for premature demolition decisions. They were identified by examining all results in the three core components: Process, Actors, and Values. These are presented with possible relevant categories that are interrelated and overlapping.

Table 17

Main potential causes influencing premature demolition decisions

Identified causes	Possible categories
Lack of perspective on alternatives regarding the end-of-service life	**Social**
Lack of holistic view of campus development in individual buildings	**Social, Location**
Comparison of renovated and new buildings	**Social**
Attractive appearance demands: due to the effect of the building image on user identity and modernity and openness in new buildings	**Design, Economic, Social**
Negative perceptions of second-hand owning and using	**Social**
Low importance of sustainability in policy, planning, and stakeholders	**Social**
Low availability of renovation alternatives to meet the project recipient's functional requirements	**Function, Physical/technical, Social**
Inactive involvement and communication of end-users throughout the project process	**Social**

First of all, the case study (CS) building was initially determined for demolition as part of the campus development plan in 2014. A decision-making process regarding the building's end-of-service life did not happen in the first place as there was no consideration of alternatives other than demolition. It means the building demolition was first considered 45 years since it was built, without extending its lifespan. In 2020, the project for the decision-making regarding the CS building's demolition or not (alternatives) was launched by revisiting the decision. From this point of view, the absence of perspective on alternatives regarding the end-of-service life could have directly caused premature demolition. There are two main possible reasons for the lack of perspective on alternatives.

First, there was a lack of a holistic view of campus development in individual buildings. The campus development plan did not consider the influence and role of individual buildings on the campus as a whole. This was a location-related cause leading to possible demolition. As planned, most of the buildings around the CS building were demolished and became new and modern designs, which can promote marketing. Therefore, if an alternative (renovation) option is selected, the CS building will be one of the few renovated buildings in the area. As a result, the building would have a negative impression compared to the surrounding new buildings due to its outdated and ugly concrete design and second-hand usage. Thus, these were social and design-related causes that potentially influence a demolition decision. This perception significantly impacted the decision-making process as a driving force in favor of demolition.

On the other hand, the lack of a holistic view also provided an opportunity to consider alternatives for the CS building. It caused the unoccupied period due to the effects of the user moves and other constructions within the development plan. Consequently, these processes provided an opportunity to start the end-of-life decision-making process with alternatives. However, the demolition of the CS building remained a possible

option since decision-making focused on finding a solution that would balance the needs of project recipients and a sustainable perspective.

Second, in 2014, the sustainability perspective was of low importance. As a result of the increased sustainability agenda on the campus development, the decision of the CS building was considered with renovation alternatives. Without this perspective, the decision-making process could have become stakeholders' interest centered. There were more preferences for demolition compared to renovation among the project stakeholders. The reasons were functionality, cost-effectiveness, and ease of progressing the project and realizing the wishes of the business operator. However, these reasons were not considered priority aspects in the decision due to the increased importance of the sustainability perspective. Therefore, the greater importance of a sustainability perspective may have contributed to preventing demolition decisions.

Furthermore, the low availability of renovation alternatives indicated the potential to drive a demolition decision. Although the CS building still provided usable space, it needed to be improved in physical elements and functionality to meet the project recipient's requirements. The investigation into renovation availability found that improvements were impossible by renovation, such as new building façade and floor shape/layout. The low availabilities led a renovated CS building to possibly become an undesired building with inadequate functionality and low cost-effectiveness. Thus, renovating the CS building was challenging to satisfy the project recipients, and needed to encourage their compromise. These "low renovation availabilities" and "high functional requirements without compromise" were recognized as the conflicts between the sustainability perspective and project recipients' requirements in the decision-making processes. The conflict was a social-related cause that was affected by functional factors based on physical/technical issues that potentially drove a demolition decision.

Throughout the decision-making process, there was no active involvement of the project recipients, especially the end users. Their compromise for using a renovated or second-hand building was perceived as essential to avoid demolishing the CS building. However, their involvement was passive by only including the negative perceptions of second-hand as their voice. Employees' advice, such as energy efficiency to increase building circularity, was proactively incorporated but only in the early phases of the project. Renovation ideas were also shared only with the client and executive boards as the project progressed. However, that information sharing was not done to the end users. These insufficient communications with the project recipients, especially the end-users, did not support the probability of increased renovation, which could lead to the prevention of demolition decisions.

5.2 Cause classification

As described in the previous section, the eight key causes in Table 17 indicated potential influences for demolition decisions in the case study. They were predominantly categorized as social causes but overlapped with other causes, such as functional and design categories. Therefore, this section focuses on theoretical discussions learnt from the case study on the three categories of potential causes: functional, social, and design, and also indicates other interrelated causes.

Functional causes

As shown in *2.4.2*, relevant factors influencing the functional causes of the lifespan of buildings were also found in the case studies. The functional requirements of the client and end-users in the case study were mainly based on the architectural space configuration, such as floor size and floor layout, according to the functions, uses, and needs. These functional requirements were one of the potential factors driving the demolition decisions of the case study (CS) building. It can be related to the following three main interrelated parameters that influence the lifespan by functional causes mentioned by Silva et al.(2022):

(i) Functionality is generally related to user requirements. It considers the relationship between user needs and the building's ability to meet or perform a particular degree of demand.

(ii) Serviceability. This relates to the degree to which the building is suitable or worthwhile to serve its occupants' requirements.
(iii) Suitability. It is defined as the ability of a building to support a function or activity required by its users.

These indicate that the lifespan by functional causes is influenced based on the suitability of both levels of functionality as demand and serviceability as supply.

This relationship can be applied to the case study as follows: There were discrepancies between (i) the level of functional requirements of the clients and end-users and (ii) the level of serviceability that CS buildings can provide for architectural space composition according to their functions, uses, and needs. It was reflected as (iii) the low suitability of the building that influenced a potential demolition decision. These align with the three parameters. This point of the results may suggest that the imbalance between demand and supply levels can influence a functional cause for a decision of premature demolition.

Social causes

Forster-Kraus et al. (2009) and Rodi et al. (2015) state that the building's suitability decline due to social change based on people's perceptions. Demand for buildings has changed as social changes have occurred over time. As a result, buildings face reduced supply to meet rising user expectations (Bryson, 1997; Ohemeng & Mole, 1996).

The potential social reasons for building demolition are fundamental to user lifestyles and the social role of housing and family, amenities, schools, transportation, jobs, and proximity to familiar attractions (Sarja, 2010). It is rooted in social trends caused by changes in neighborhood identity and local culture (Awano, 2006). Among the end-users and employees in the case study new buildings were recognized as representing high-quality education and work raising their image and identity. On the other hand, they had negative perceptions of second-hand buildings and inferior feelings from comparing the renovated and new buildings on campus. These were found as potentially significant factors for a demolition decision.

With the sustainability agenda rises, second-hand products are becoming more acceptable (Buerke et al., 2017). The awareness of sustainability was also increased among the end-users, such as students and researchers of the case study university. However, there still seems to be a typical perception of prejudice, rejection, or dislike of second-hand ownership and use when it comes to sacrifice for their interest (Sheth et al., 1991). Such perceptions in society may underlie social causes influencing buildings for premature demolition.

From a circular economy perspective, building demolition has drawbacks and creates waste, as detailed in *1.1*. Those disposals, management, and reuse have environmental and financial impacts. As in the case study, such demolition can be more likely to happen without a sustainability perspective. Introducing new policies and guidelines, such as promoting a circular economy based on Sustainable Development Goals (SDGs), can contribute to extending the building service life (Goubran & Cucuzzella, 2019). However, it can cause the imposition of strict burdens to meet a new policy on stakeholders. The sustainability perspective of the case study building conflicted with the project recipients' requirements. The stakeholders were struggling to seek compromises on the requirements to realize the CS building more sustainable. Such a burden may lead stakeholders to be unable to sustain the building over the long term (Dias, 2013b). As a result, demolition decisions may be facilitated for such social reasons.

According to Farahani et al. (2019) economic or financial reasons for the end-of-service life often take the place of socially motivated criteria. These financial-related reasons are usually seen in stakeholders' interests, such as investors, clients, and owners. They are often primarily concerned with economic goals, ignoring the social value of users and the cultural value of buildings (Watson et al., 2016).

In the case study, the executive board and client were highly interested in cost-effectiveness as the nature of their project management role. Their perspective took into account the end user's social value and the building's sustainability value. The cost-effectiveness of their economic goal was based on prioritizing end-

user satisfaction and building sustainability. However, there were no active involvement and communication of the end users throughout the case study project.

Sufficient stakeholder engagement can be essential in ensuring satisfaction and increasing the level of their sustainability perspective (Jeffery, 2009). In some circumstances, owners may wish to demolish buildings and force out unwelcome tenants to revitalize and improve the property's appeal. (Thomsen & Van der Flier, 2006). Disregarding user and building values for the one-sided economic reasons by such influential stakeholders can result in decisions for unnecessary demolitions. It aligns with the theory indicated in *2.3.3* that the lack of involvement and poor communication among all stakeholders can lead to project failure.

Design causes

The end-of-service life due to aesthetics and architectural trends is associated with a high degree of subjectivity and personal opinion (Wilkinson et al., 2014). As described in *2.4.1*, the lifespan with design causes can be defined as visuals becoming outdated from an aesthetic point of view. It is the case if a building is considered obsolete or archaic and no longer meets the prevailing architectural trends (Grover & Grover, 2015). Aesthetics are related to changes in architectural style, and changes in a building's aesthetic attributes, such as image, and fashion trends, make the building aesthetically out of date (Arenibafo, 2017).

The CS building of the 60-70s typical concrete architectural style no longer satisfied today's prevalent architectural trends of openness. The building was perceived as an aesthetically outdated and ugly design. The demands for an attractive appearance drove a potential demolition decision for constructing a new building. This is based on the fact that new buildings can usually reflect the aesthetics and aesthetic attributes of the period and increase new marketing rates (Winters, 2007).

Demographic fluctuations affect the aesthetics and aesthetic attributes period. As user requirements change over their lifetimes, it is only a matter of time before buildings' fashion and style are decided (Silva et al., 2022). In the case study, the client wanted a sustainable building with modernity and openness that would satisfy the next generation and current end-users over time. It is theoretically uncertain whether demolishing the CS building and constructing a new one with the current aesthetics would still meet the expectations of future generations.

Pourebrahimi et al. (2020) claim that these changes in style, architecture, or aesthetic ideals are inevitable. As such, today's attractive buildings will inevitably become objectionable sometime in the future from an aesthetic point of view. Therefore, premature demolition may become more frequently if demolition decisions are made every time from this frequently fluctuating aesthetic point of view.

5.3 Limitations and future research

As explained, the case study was still in the decision-making phase for the building's end-of-service life. The interviewees mentioned their interests and roles by depicting the project's past, present, and plans. Thus, the causal interrelations shown in the results included the potential influence of the processes that did not take place yet as well as a decision. However, the ongoing case study was able to research the interest and perception of the interview participants' projects in real-time. Through the case study period, this study's purpose and perspectives were also shared with the stakeholders. This may have led to an increased awareness of the importance of their underway decision-making that can contribute to increasing or decreasing the number of demolitions.

One particular case was studied in-depth in this study. Due to limited responses for participation, the case study was only one project. Thus, the external validity of the research is relatively low for two reasons. First, a case study is only generalizable to theoretical propositions but not populations, primarily when only one case is studied (Baxter & Jack, 2015). Secondly, the generalizability of a qualitative model is limited, which requires improving the validity (de Gooyert & Größler, 2018).

For the above reasons, a suggestion for future research is to conduct this study in multiple projects and validate the drivers of premature demolition with the feedback mechanism in causal loop diagrams.

Another suggestion is to research various causal relationships and loop characteristics. This research can provide further insight into necessary changes or improvements in the systems. Understanding the dynamics and complexity within the system supports the prioritization of actions to prevent premature demolition.

Lastly, the decision-making processes in the case study required criteria selection to evaluate architectural proposals. This aspect of the decision-making process was not covered in this study. Therefore, it is advisable to carry out similar studies while taking different approaches that focus on how to determine adequate criteria to select such design proposals as variant solutions for a sustainable building.

6. CONCLUSION

This study explores the causes underlying premature demolition by improving the understanding of demolition decisions. It aimed to provide insight into the causes that can contribute to reducing the number of premature demolitions. The potential causes were explored by developing a conceptual framework within the context of specific components: Processes, Actors, and Values, as the core sub-systems of the system. The framework was applied to the case study, an ongoing Dutch building project dealing with decision-making for the end-of-service life. As a result, this study identified eight significant causes that potentially influence demolition decisions.

The main research question, "*How can the root cause of premature demolition be understood when looking at the decision-making for the end-of-service life?*" will be answered after providing answers to the following five sub-research questions:

Sub-question 1: What is the actual process of decision-making for the end-of-service life?

The decision-making for the end-of-service life in the case study started when the building was unoccupied for more than a year. Seven steps in three phases of the decision-making process were adapted to implement a decision to demolish the building or not.

Phase 1: The building needed to be suitable for new users while aiming to increase its circularity: Step 1. Information about the building's current physical/technical condition and its renovation possibility was then first investigated and collected: Step 2. The results found functional conflicts between the project recipient's requirements and the sustainability perspective. These were influencing a potential demolition decision. They were also related to factors affecting the different lifespans of buildings: Physical/Technical: 6, Function: 5, Social: 4, Economic: 4, Legal & Politics: 0, Design: 4, and Location: 0.

Phase 2: To solve the conflicts, possible solutions were explored. First, the criteria to scale weightings, such as functionality, flexibility, and durability, were developed and attempted: Step 3. However, further investigation was needed, and the method of architecture tender was selected to identify alternatives: Step 4. The focus of the method was to find the best-balanced usage of the building for the conflicts; regardless of the demolition or renovation construction options.

Phase 3 (planned processes after this study period): A decision will be made by evaluating the architectural proposals in the tender: Step 5. However, the project will first need to find adequate criteria for selecting the best building design as a solution. Once a decision is made, feedback will be obtained before implementing the decision to forestall potential problems in the future processes of the project: Steps 6 and 7.

Sub-question 2: Who are the relevant stakeholders in the decision-making for the end-of-service life?

Fifteen stakeholders in four different groups were identified as relevant stakeholders to decision-making for the end-of-service life: Senior Management, Project Core Team, Project Recipients, and External. They were analyzed according to their interests and role characteristics based on the project life cycle.

Sub-question 3: What are the expectations and impacts of the stakeholders in the decision-making for the end-of-service life?

The stakeholders' level of interest and influence varied within and between the project phases. The influential stakeholders who have high interest and influence on the project were identified. They were mainly the stakeholders in the Senior Management, such as the executive board, and Project Recipients, such as the client and the end-user.

The executive board and the client had a high interest in the cost-effectiveness of the building. However, they had to make a decision by prioritizing the Project Recipients' requirements for their activities and increasing the sustainability level. This perspective made the project challenging to find possible solutions. As for the

end-users, the negative opinion of the renovation alternatives that they considered second-hand buildings had a significant impact on a potential demolition decision, even though they did not have direct authority over the decision-making.

There were also influential stakeholders in the Project Core Team. They were rather than those who had their primary responsibility in the later phases, but the ones who had them in this project's Start Phase. The latter aimed to support the increase in building sustainability levels and Project Recipient satisfaction. They influenced the relevant stakeholders' involvement in the project process to achieve these aims.

Sub-question 4: What are the key variables in the decision-making for the end-of-service life?

The key variables were examined by identifying possible cause variables and affected variables. They were identified as influential factors of the Processes and Actors components within the campus development boundary. The critical cause variables were related to sustainability and user perception, and the affected variables showed the conflicts between them. Potential relevant variables were then also identified based on their interrelationships.

Sub-question 5: What are the causal relationships between the key variables that potentially influence the decision-making for premature demolition?

The relevant causal relationships were identified as the Values of the decision-making: the impacts of the Processes and Actors components. The identified relationships revealed relevant factors influencing a potential demolition decision regarding campus development, sustainability perspectives, building appearance, and end-user perceptions. They were interrelated and overlapping potential causes in different possible categories: Physical/Technical: 2, Function: 4, Social: 11, Economic: 2, Legal & Politics: 0, Design: 3, and Location: 2.

These were predominantly categorized as potential social causes and especially driven by factors related to the end-users, such as negative perceptions of using renovated (second-hand) buildings, demands for new buildings, and poor sustainability promotion. These were also design-related causes. The numbers of these identified categories of causes differed from those associated by looking at only the Process components. They were driven by potential factors related to the functional conflicts based on physical/technical issues; see the answers for the sub-research questions 1 and 2.

All things considered; the main research question can now be answered. The root cause of premature demolition can be understood by looking at relevant decision-making processes for the end-of-service life as a system, focusing on the core sub-systems (the Processes, Actors, and Values components).

The overall findings in the case study showed potential causes that can influence premature demolition. The influential factors can be found as variables of the Processes and Actors components in decision-making system within the boundary. The causal relationships of relevant variables help indicate the Values of the system. The potential causes can then be revealed by looking at all system components rather than individually.

This study outcome required such a holistic perspective looking at potential causes influencing demolition decisions. This suggests that a systems thinking-based approach could be a practical way to explore the causes of premature demolition. This approach has led to the understanding that demolition may be decided under the combined causality of multi-diverse factors.

The potential causes for demolition decisions overlap in different categories. They may be primarily categorized into social causes but can be interrelated with other causes, such as function and design categories.

In the case study, the physical/technical issues were first found due to the low possibility of renovation to change and improve, such as the facade and floor layout. They were identified as potential factors influencing a demolition decision. However, they became functional issues between users and sustainability to meet

both requirements. This conflict further revealed the social dilemma regarding the efficient usage of space from a sustainability perspective. While there was a growing awareness of sustainability among users, the willingness to sacrifice their conventional space usage for sustainability was low. These influential factors can then decline functional suitability. As a result, it may be justified as the main functional cause of the demolition decision, subconsciously ignoring other obscure types of interrelated causes.

Regarding the attractive appearance demand, it was identified as a potential design-related cause influencing demolition decisions. This actually interacted with the location-related cause that was the unintended result of newly developed buildings. As a result, superiority or inferiority between buildings on the campus arose. The potential inferiority feeling was rooted in the negative perception of renovated or second-hand buildings. The negative perception was a significant social-related cause for a demolition decision in the case study. However, this was exaggerated by the location-related cause, which also affected an increase in the potential design-related cause; the demand for attractive or new buildings.

These interrelated causes make it difficult to divide them into distinct or isolated categories. From this point of view, it can be said that premature demolitions are caused by criteria that are not mutually exclusive; the criteria coincide, and each does not limit the other.

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8 APPENDICES

Appendix A. Stakeholder interview questions

The questions below were prepared for the semi-structured interviews with the stakeholders of the case study on 16-24 May 2022.

Question type a) their roles and expectations in the project:

1. What are your job title and main role?
2. What are your roles or responsibility in the case study building and this project?
3. What are your expectations, interests, or preferences in the case study building and this project?
4. What are your concerns about the case study building and this project?

5. What is your preference for the decisions for the case study building?
6. What do you think about how the demolition and other option decisions affect you (your role and interest)?

Question type b) the project situation and processes:

7. How do you perceive the situation of the case study building towards the decision-making from your perspective?
8. What key variables can be driving the decision to demolish the building?

Appendix B. NVivo coded results

Example responses	Initial Coding	Final Code
• *we made a campus plan and it's like a 10-year plan for what's are we going to do the next 10 years on our campus* • it's also resulted in investment program for the next 10 years • *Our board just agreed on that a plan and one of the projects and the plan is the new future of the Spinoza building* • *we have several projects in the 10-year plan as our campus plan*	10 years campus plan agreed with the board	**10 years campus progress**
• *we do also demolish some buildings on our campus right now. But not the building* • *And I think it's one and a half, two years ago that we decided to go for this spot. Except instead of this spot? Yeah, we demolished it in 2018.* *And then we demolished this and all this demolishing was in the plans in 14 and 2015 already.*	Current demolition of some buildings on the campus, All demolition in 2018	**Campus building demolitions**
• *And then the is built a new building on this plot. And then these users move to that new building.* • *the board decided what we proposed is that on the location there will be the new housing of two of our faculties* • *At the time is also If there is a big difference between demolished and new and reuse. And then we have to be in the buildings, for example, the people from the brother building are moving to the building location* • *when one of the two options takes longer than the other, people stay longer in the building there now. So, we cannot rebuild that one.*	Moving, Duration of moving gap, Effect from longer construction duration on inability to rebuild	**Building user moves**

• *What we decided couldn't we just checked the possible locations. And we discussed it with, no various people and made a decision that it must be the building location. That was the best location for this.* • *A different focus or for the hard HAD light zone because from the purpose not like the building itself was looking up and thought about, OK, what can we use for the power bus and what use and what need to be done for this building now. So, first of all you are looking for a suitable location for what you guys needed. So then screen building what's so this building.* • *At first, we looked at the location. So, we looked at different locations for a new building. There's the start of our search was looking for a new building for the users of a building. And we should explode for a few locations and we just made a list of positive negative points per location and that we discussed with some people for what they think about it. And then the building location had the most positive points. And that was Also the most the location that was most named or called by others. Before the development that we wanted to do*	Determination of the location choice for the purpose, Location suitability of the CS building for the purpose, Process of selecting the best location for the purpose	**Best location probability**
• *Height mismatch between the building and a brother building but then twice as high, like but the same kind of stores and so like the way the building looks now, it's not suitable for the faculties and that we agreed upon and that if we keep it in a way that it is now, even though if we solve all the technical problems, it's not a suitable building for the faculties.* • *About function, that is for the user side. It can be so that the users want a certain function of the building, about education and research, and the building has now a specific shape and specifical area on one floor. There are small floors, so the function of the future users can be different from the possibilities that the building has now the suitable area because the future users the day I want big spaces* • *And to meet each other when you have vertical floors the meeting each other is difficult because you have to go down or up to meet each other at the coffee rooms or that's a bit difficult. You move a bit easier than then you have to go vertical movement* • *It's building with relatively small stores and our faculties are wants bigger floors and they want more meeting, more connection and that's impossible to realize in the building as we see it now*	Gap between height mismatch and the end-user suitability, Gap between current building structure and the future user's demands	**Faculty usage improvement demands**
• *I mean, they think of students investigated that and this is actually what they found because that these researchers, although they also want to make changes in the world and but not if it's their workspace. So, it's kind of weird, isn't it?* • *need my own workspace. So, it's really strange, isn't it? They say I want an office for myself. But you have to really, really consider all the sustainability aspects of the building. But as I say, but that doesn't match. Sorry because. And then they say. OK, as long as I get my office.*	Demands of owning an office for research themself	**End-user current working environment**
• *the requirements program is in progress. We're right now in these months also. Until June and maybe even July, we are working on the requirements report.* • *what we do is we regardless of whether we use the existing building or we want to buy a new building at on the same spot. If we if we make a small step back, we will for now only look at our requirements, the requirements with regard to what the users will need in the in the future. And that would mean that how will the building fit our research?* • *Activities or education activities and or support activities because those are the main three activities of faculty has and in with regard to those three, we want the building to fit the requirements that we need to perform or activities in the best possible way* • *but also very important is the requirements of the building for the end users, like the two faculties. That is a really important topic also for our board to decide if they agree on this plan*	Progress of the program requirement, Faculty demands of fitting all requirements in the best way, Faculty activities: Research, Educational, & Support, The requirements of the building for the end users	**Program requirements**
• *And we see every time we make a new building for faculty, the year after we completed it,* • *attract new students. What we see is when we have a new building, the presentation of students, new students increase with 10%* • *And that's one of the reasons that the faculty wants to have new building, because they have the image also is important for them*	New building attractiveness for future campus employees, Increasing the number of new students, The importance of having an image	**New buildings**

• *we have to do something about the look and feel of the building because when you look at it now a lot of people think, you have to demolish it completely because it's not an architecture that a lot of people like* • *At the moment they think it's terrible building* • *physically attractive. So that would be a large or sense of. beauty is it's very subjective, but nevertheless people would like it to be a building. I would like to go to*	Appearance of the building	**Building appearance attractiveness**
• *And it's also like this because a lot of our faculties got new buildings the last couple of years like the and it got brand new buildings. So, wait and one of the faculties who's in the building, we also changed existing building and they said so some people said not all, but some people said, everybody got a new building and we got a secondhand building and they're not satisfied with that can happen here as well* • *that's also an aspect and this is to when you look at the buildings around the building, they're all brand new. We have one building at from 2014 is like a building with a lot of glass and white and it looks very modern. And we have another building. Just last year we completed. It's also it looks very open and very attractive. And this is like a concrete structure from the 60s or 70s*	Appearance comparison of the other buildings, Comparison between newly and old built buildings	**New & Second-hand Comparison**
• *the esthetic reason has another aspect, because for the faculties who are housed there, it's more of like their image or their like* • *then a lot of people think they the quality of the education must be a good as well because they are very nice building* • *building. So, for them, it's really important that they can identify themselves with the building and also to have a like an image thing that it can connect to their education. our building should be inspirational and they should be of course sustainable. But and that's why a lot of our faculties want to have their own building, because they want to* • *And to show themselves to the world that they are here and you have to be when you come to our faculty, then you have. You are in this building.*	Role of the building as a symbol and identity of the end-users, Provision of good image impression, Benefits of being educated in a new and nice building, Image of high-quality building equals high-quality education	**Quality of research & education perception**
• *Their marketing to the new students and to* • *we have more students and we are more attractive to stuff because when they come to the like the open days at the university and they are received in a nice building,* • *One of our arguments is as well that if you want to be attractive these days to future staff, you have to*	Marketing role of the building for future users	**Marketing**
• *there are a lot of buildings are old who are very beautiful and we like to keep. But this is old and a lot of people think it's very ugly* • *Not very transparent, so it's really from the sixty 70s, the last century. So, you can sort of imagine what the building is right now. It's a lot of concrete that has concrete floors. Uh, so nothing at all, as what you would expect from a modern building in this era*	Unpleasant perception on the building appearance apart from being old, Need for transparency in the building	**End-user demands for appearance**
• *We have to the buying process of this with it. but it's like you have the European requirements to do that. So, it's very strict and you have to tell up front what how do you. A value the plants that are given, and so it's very important to have the rights, criteria to* • *years ago, in the plans was both demolished and at that location we going to build new and, in the meantime, sustainability cut higher on the agendas*	Strictness of the European Sustainable Requirements, Increased sustainability on higher agenda	**Sustainability & Circularity Agenda**
• *all the projects and all the things you want to do on the campus the next 10 years and all the things we want to achieve with the campus, for instance, we want to be very sustainable and circularity is, of course, a major topic* • *We have like a policy from the university as a whole and they are based on the SDGs from the United Nations of course*	Major topic of Sustainable and Circularity, University sustainable policy based on the SDGs	**Sustainability Campus policy Development**
• *And now we said, well, this this is not the only solution. Uh, to demolish and make new, it's important to be circular as well as to be one of the multicriteria in the decision.* • *So, we have to get someone who has the knowledge and can help us how to make the decision.*	Circularity as multicriteria in decision making, Enough expert help	**Need for Circularity concept in multicriteria decision-making**

• *we have the other location was a parking place. So, on that location, we also could directly start with building that was that was not a building or a difficult situation. That was just a parking place. We could directly start so by choosing the location building, we choose the difficult route. I think because then we get to the point what to do with the building. What I think 8 years ago all decided to demolish that part of the plan story, we had. Uh, in that time we had another a director of our yeah, comes of 70s and then that's director we mentioned that a few times. But he didn't make a decision or he didn't give us orders due to make a plan. So now the building is empty* • *That's much earlier. I mentioned to him you have to think about what to do with the building because when you build the other building and the and the users move. Then you have an empty building. So, that's and nobody thought about it or nobody did anything till that. We came to the possession of campus development. And then we were thinking about what to do with the building. This I mentioned with the with the cursor. This is the building. What's still there?*	Process to consider the usability of the CS building, Low attention to consider the empty period at the CS building	**CS building empty period**
• *And then again, we have also very good examples on our campus where we did a beautiful transformation of an existing building to something that's like a new building* • *That we could renovate this Erasmus building that is 20 stories. 2020 levels. And that we can that we could renovate it in two phases and there's the upper part. And then the lower part it in two sessions,*	Existing building transformation into look like a new, Two phases renovation on the neighbor building	**Example of Successful renovation**
• *To which the sustainability what is high on the agendas of every two one? we get more applause to renovate the building, then to demolish it and build a new one* • *And on that point, we invited technical consultant. And to do a little search, research for us what the impact is the environment impact is uh on demolish it and rebuild it in steel and concrete or in wood is what he did for us. And woods, of course, has the most of less impact. Environment but. And reuse it. Renovating it is just not. And just better.*	High agenda for Sustainability positive recognition, Asking experts for research on renovation feasibility	**Sustainability Investigation Opportunities**
• *Circularity became new item to take knowledge and take into account* • *Need for circularity knowledge in both options and that's the point that we said, OK, but we don't know enough about circularity.*	New to circularity knowledge to take into account	**Need for Circularity construction comparison**
• *And if you think we cannot change that and, renovation project, then it can be an argument to say, I don't think it's a suitable here for our beautiful campus. And so, we have to demolish the building* • *How far the demands of our faculties can be met? a lot of it, the building has to become bigger and it's now so we have to in any* • *we did some uh, technical investigations to what does it means to renovate it with users in it*	Impossibility of changes in the appearance of the building by renovation, Technical investigation on the meaning of the renovation for users	**Renovation Possibility/Feasibility**
• *But we have like 4 major topics on sustainability and one of them is circularity. So, we cannot decide completely what and demands we have. But when you translate those, it seems like that to a construction project we can. more or less decides on what our criteria are on that as long as it helps on the theme of the circularity* • *circularity is new for us and there is no policy. So together we make the policy and then they have to execute. we have. It's been written right now, but it's not finished before. We have to make the decision. They are making the policy and they are writing down. For example, in 2000, forty 50% of all things must be circular our info the policy is written in the Department of Campus Development*	Decision making on the criteria serving the circularity, Progress of circularity policy to execute right now	**Circularity policy Development**
• *The three demolished three and build 4 back, so it's very it's much better to keep the three, a big lecture hall and just add one* • *after the building has to be bigger but doesn't have to be completely demolished and make a bigger one as one disease known. You think you can use freedoms and at big one*	Keeping existent three rooms and adding new one room, Role of bigger size room implementation	**Renovation ideas**
• *But on the other hand, if you look at sustainability perspective or a circularity, then you should say OK, just keep this building as it is and try to use reuse it as much as possible* • *you're way too to make sure that sustainability aspect will also be met is to communicate up front that you have an ambition of sustainability on this project and not only within our department, but for all the university to really communicate. We have ambitions on this and if we don't meet them* • *Express that you're very sustainable, organizational, very sustainable faculty, and that gives a lot of opportunities with also with the building to express that will be an argument from our side to say, OK, if you're.*	Sharing sustainability ambition, Opportunity to raise the sustainability subject	**Renovation idea penetration**

• *The physical technical because people think, we cannot have a good building if we just renovate the old one* • *it's very well possible to maybe remain like 75% of the building* • *it just depends on how you calculate the façade. So that's has to be replaced because it's because of the energy demands we have, but like the structure we have and maybe a lot of materials who come from the facade, we can use again so. We maybe when you look at the square meters of the building, 75% should be possible to remain* • *A scenario, we have to add a square meter to the building, but if you do that on the right way and on the right places, then you can be that the 75% is the percentage of the building as it is right now. So not on the new building, but on the building now* • *You can also Like change the perspective of a renovated building. You going to say we have very sustainable building and we did not. Demolished because we are we care so much about our planet, it's, et cetera, right*	Recognition of renovation as an insufficient building, Possibility of remaining 75% of the building according to the square meters of the building, Needs for façade replacement for energy efficiency, Probability of reusability of many materials in the structure, Opportunity to change the perspective on renovated buildings	**Renovation probability**
• *it's for a lot of people. It's quite difficult to make an idea of what the building in the future can be like. If you look at the building now you see something, a lot of people think very bad or very ugly and they cannot imagine how it can be. Even though you keep the building and that's so we do go on trips with them to other projects where we can show OK here is how it's done so it can be done like this* • *the feeling of the users that they have a secondhand building. It's not new, but whether with a big renovation. everything is new except the construction. That's not an issue when you talk much to the users to convince them about that ideal. This new is just new* • *If the end users imagine that the end users feel they don't get a new building, they get a like a secondhand building*	Changes in perception of buildings by user, User discomfort with second-hand building	**End-user renovation perception**
• *Because also with it like for the faculties for the end users once in a lifetime experience and they look they sit here and this this happens to them once when they are working there and they have to go and they are feeling responsible also for the good housing of their faculties for the next 30 or 40 years. So, they think OK this happens to me to me now. So, I have to be very very keen on what kind of building do I get* • *For years, that's the opinion here. So, they think if I make a failure now of mistake now, then a lot of my next generations, they will face the consequences of that* • *they're very keen on having the goods, how getting the good housing and now not only for themselves, but also for the next generations to come* • *we got a secondhand building and they're not satisfied with that can happen here as well*	Responsibility for providing equality a place for the current end-users and next generations, Unsatisfaction of the end-users using a second-hand building	**End-user satisfaction**
• *There's one side and the other side is we do have a program director, sustainability on our campus. She's responsible for all of the sustainability policy we have as a university. And she probably will have an opinion on if we don't do it right, she will. I will hear her and saying for OK, I think it's not sustainable enough. But then again, that's one person* • *the sound of when you make you feel you're on the faculty side. we will notice immediately and when we do it wrong on sustainability side, that's we don't hear a lot of people arguing about that*	Lack of (diversity in expert) opinion on sustainability, Argument degree gap on requirements	**Need for diverse advice**
• *we can use it marketing wise. it's a good marketing point to choose renovation. because of the sustainability, what is high on the agenda of everyone and circularity is one of the issues because on campus we have about energy. I think we get the most things that are possible. We did already and now is it to work harder on the circularity as part of sustainability* • *she came in, and also, she has not enough knowledge about. She knows a lot about circularity, but not about how to do it in the to compare demolition and new building?*	Energy efficiency for the campus circularity, *Lack of expert opinion for comparing circularity in both options*	**Circularity comparison Performance**
• *as a faculty would like to be part of the better world and join in.* • *We all have a part to play in this and if we would all go for the for the for the at first scenario. We will always stay behind on our sustainability goals because then there is always another aspect that prevails or is more important. You have to you have to make sacrifices. In this discussion I mean that there's no doubt about it. There have to be sacrifices.*	Desire to be part of contributing to the better world, Favor of cost over sustainability aspects	**Sustainability perspective level of Faculty**
• *I want to support to the support base for at faculty. They at the end they must want a sustainable building as well as much as we do. Make the world a bit a little better, yeah* • *even earlier today I had a discussion with someone. I said, I understand that you have to really look into a, you know, that energy.*	Support for the faculty to achieve their sustainability aim	**Sustainability goals Support**

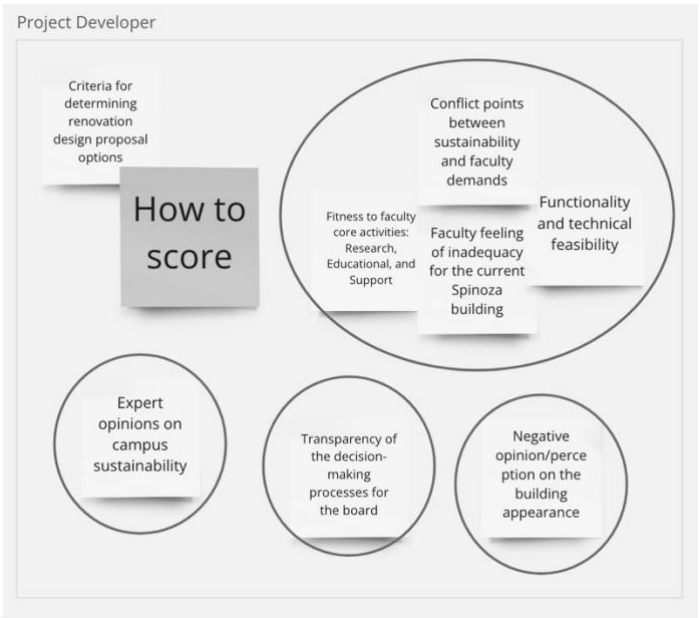
• *Yeah. I got myself for my working, if that's what they do. Interesting, isn't it? Because if it's, if it really touches that personal space. Then there are less convinced how sustainability is an issue of a new building. And that's true.* • *even earlier today I had a discussion with someone. I said, I understand that you have to really look into a, you know, that energy. A that you use in the space and the building materials that you have to use, but nevertheless you have to build a building where everybody fits in at any time. Let's say well, but nobody is there all the time every day. Yeah, but still imagines, he says to me. Imagine everybody wants to come on a Tuesday. Then everybody needs his own workspace.* • *Said yeah, that was you have a point. So even he was like changing. This position on this sustainability aspects of our yeah, I understand that he said that it's that you that you can actually save me building materials and save energy but he said but.*	Awareness of responsibility to have a part to play with sustainability issues, Gap between understanding of the importance and real practice	**Achievement level of Sustainability goals**
• *that would be really difficult you'll get all your requirements, but it's less sustainable. Or what? We turn it around. It's very system or, is it the other way around? It is very sustainable, but you don't get all your requirements and then now you're asking me what choice I would make, right? Well, that's a moral question here. maybe I should. I would choose for more sustainability and less requirements* • *it's hard for me to convince people that maybe the aspect of sustainability is maybe top priority and then come and then the other requirements come in and they feel it completely the different way they say it's it first our requirements and if it can be done in a sustainable way, OK.*	Low sustainability but meeting all requirements or High sustainability but non-obtainable of all the requirements, Challenge to convince people that sustainability is the top priority over all the requirements	**Sustainability perception level of EB (Executive board)**
• *Meets both uh requirements, so if we do that wrong then either our end users will be very disappointed because we get a very nice plan on the system suspended sustainability* • *if you, but not on the faculties and if we do the other side wrong, then we get a a a very nice building, but it's not sustainable enough* • *how about the sustainable what like who affected the sustainability* • *because you can hear the end users, if they're not satisfied, but you cannot hear, nature calling or the planets calling when you don't do it right? So that's our responsibility from our department*	Risk to fail for meeting both requirements, Effect of failure to meet only one-sided demand, Uncertainty of the effect of failure on sustainability requirements, Responsibility for bringing sustainability requirements	**Sustainability requirement fitness**
• *we have to explain to our end users to our faculties that they have to rely on the process, that's even though they do not get a completely new building, they still haven't a building that will meet all their requirements* • *needs to like to convince them like they're not. The demolish is not necessary or the not the best option. Or this way you can still be proud of the building or for those like changing their kind of like perspective look what the building* • *one of the big concerns of beggar's concerns then is can we during the whole process, convince our faculties like our end users that we can make a good building for them even though it's not completely demolished and built a new building? So, we did talk about that with the senior management of the faculties. We explained that and they are convinced that that we can make a beautiful, good building for them. Even if we do not demolish it completely*	Compromise of the end-user demands for realizing a completely new building, Persuasion of the end-user compromises in demolition option, Needs of positive end-user perspective on the exterior of the building	**Client compromise**

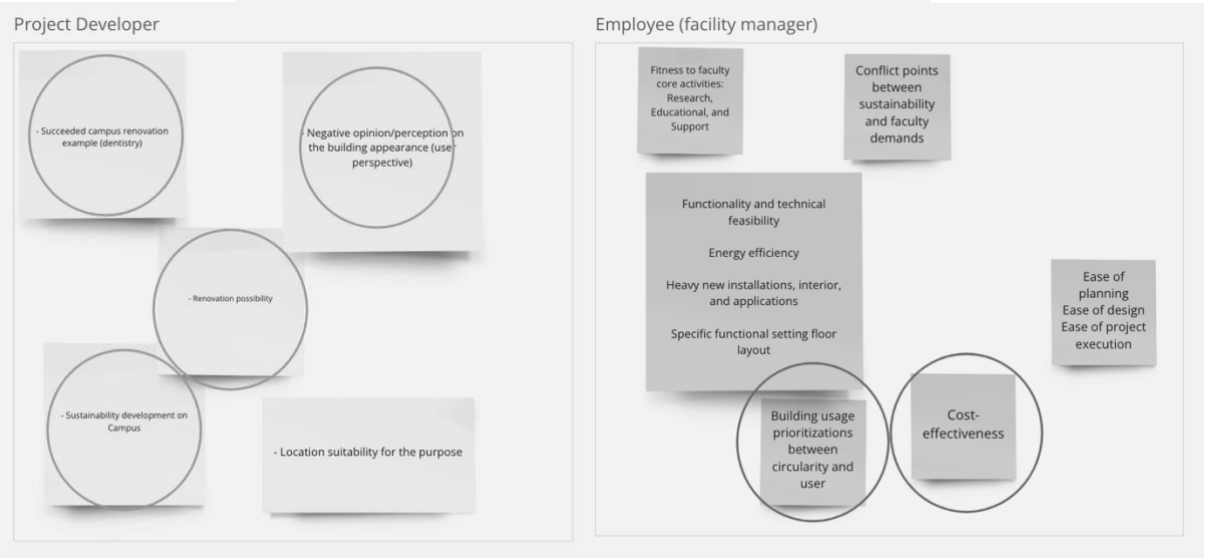
• *So that would really play for a complete demo demolition of the building and make something completely new. And you have more the best opportunities to get a building that suits the demands of our faculties* • *the climate installations in the building as it is now, they are terrible. So the climate there is terrible, very bad. So, there might be an ID that we cannot solve that if we don't demolish the building it can be done. We proved but it can be an issue. Or concern from people who think, if we keep this building, then we keep the climate problems within the building* • *Hight of the building floors is not so high maybe when we do the construction is not suitable the so. And maybe we are going to have new installations and new interior, etcetera. That is too heavy for the construction. That's maybe, about the technical problems we may deal with if we want to renovate it and that's a that's that can be a reason to demolish it* • *like the function is of course, if we already said but like if the demands of their faculties cannot be met in this building, then people want to demolish it. So, if we cannot convince them about that. that can be a reason for them to consider the demolition* • *if we present more uh like 5 plans from architects. Then they will say OK, did demolishing of the building isn't necessary to have a good plan?* • *there is a lot of knowledge about the building already know what the building can do and what the building and not can do for a new building. You have to learn a new building at you have to how the building reacts on some issues whether issues or something. So, it's some years old and we know that building for that time. And we know it how it works, how it reacts on some things*	Potential of demolition that creates the best opportunities to meet the demand of the end users, Climate installation issues, Lack of fulfillment for demanded function, Unnecessary in having a good plan to demolish the building, Adaptation for technical issues of a new building,	**Demolition probability**
• *there's a bit of attention already called like there we have two big demands on this project besides budget. But we have to 1st is the requirements of our end users like the faculties, what they want. This on one side and the other side is to be a sustainable as possible as a university and back to the building* • *You can make a mix of both. We don't know yet if it's possible or how it is possible, but I'm convinced that it is in some way possible to meet both demands* • *the more we rely on the on the system and sustainability aspects, the less options are there for the requirements of the faculties. So, it's a bit of a balance we need to find between those demands. you don't know yet what is the balance could be better but you want to go both* • *The one of the concerns is how we find the balance and in the committee that decides on what is the best balance can we use a method or a way to have both requirements* • *at the moment there is also with in the end user perspective, there's very important moment and it is the moment when we first see like design of an architect we first we talk a lot like now we talk a lot about what opportunities building has or a plan has whatever and then at the moment they first see it translated into design and they said OK, this is how your future building can look like. This is a very important moment*	Tension between two big demands on the project besides budget, Uncertainty in the feasibility of meeting both demands, Unknown of the best balance,	**Need for balanced requirements usage**
• *hope that renovating is cheaper. It's sometimes I think it's cheaper to demolish and build new one to start over but you don't have to make the construction, so it must be cheaper on som. But we'll see when we have the economics who calculated the few options* • *We did not get a task to build a new building which would be from a housing cost as perspective cheaper than what the way we are housed now. So, that is not part of the decision making yet. So, I believe that we try to get the housing calls on the same level as we have them now.*	lower cost option from the current housing	**Cost-effectiveness**

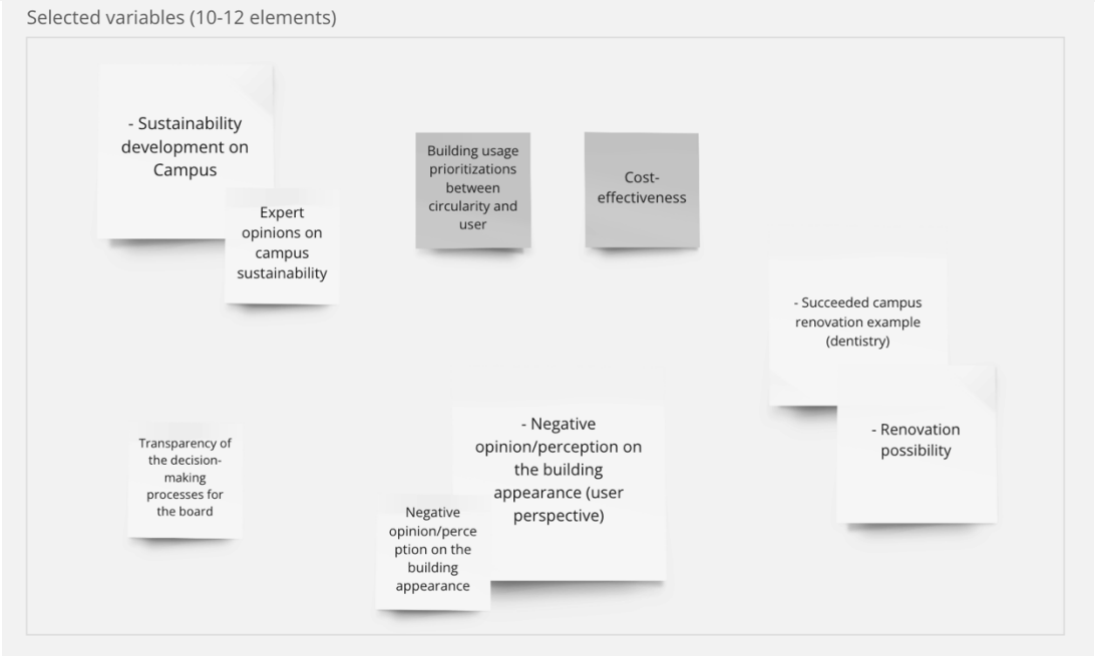
• *what we do is the architects, we ask for an architect and a lot of other engineers around him or her who will support all the aspects from building like the installations, the construction, the terrain, everything, to be honest* • *we as a department shouldn't search for that balance ourselves, but we need experts on that topics who can advise us on where the balance should be. So, our ID now is to ask different architects or engineers to make a plan and to make it like a competition on who can with this this plan. And then we decide on what plan gets the best balance between those two demands* • *So before whether we're goanna decide our own before putting that idea to the market like those architectural things. But so, when the idea in the process, but this is the only process before you make a decision, right? So to decide so then* • *And then we ask, uh, I think 5 architects or engineering companies to provide a plan, and we decide on one of those five plans* • *Also, the way that we will ask the architects to make a plan, I think they will all consider it's something in the combination of a partly remaining, the existing building, a partly adding new building as well. But we will see how many How many percentages will be demolished or what not*	Dependency on the architect for asking all aspects of building support, Advice from the experts for finding an ideal balance, Making competition on realizing a plan to choose the best-balanced one, Uncertainty number of the combined plan proposals	**Dependency on proposals**
• *Look at the plan and if we don't do that right up front, then we have a lot of problems. Afterwards, because we cannot change them during the competition* • *it's more like how we convince our end users or faculties that we if we have the option. The architects can have an option to really demolish it and make something new if they are convinced that our that your demands cannot be met in the in this building, then only then the architects can make a completely new building of they can make a plan for a new building so that* • *Is a reason for them to have more faith in the process of this selection of architects*	Impossibilities in changing the plan during the competition, Risk of persuasion from architects with their potential bias, Need thorough process of selecting architect	**Tender dependency risk**
• *Now what they have been doing is multicriteria. So, we think about the budget, we think about the functionality, we think about the circularity we think about. And so, there are 10 or more elements that take to into account* • *And if you don't have to take into account the skeleton, for example, then it's easier to make the rooms the sizes you want. It's easier to make it. And stalling the appearance you want the form is easier, so it's easier to demolish and make you. I think even it will be cheaper. But we want to be sustainable and. How much is it worth to us to be sustainable? That's the question.*	More than 10 elements of multicriteria to take into account for decision making, Unknown degree of worth building to be sustainable for us	**Need for Selection criteria**
• *At the end we are make the decision with more people and I think it's important that the decision makers they see the steps how to come to the decision* • *that's a matter also of trust and maybe for opinion or expert opinion on that. We have experience on this kind of transitions. But if you are like in our faculties are people who studying languages and Philosophy and that kind of thing. They don't used to deal with construction projects or building projects. So, it's very easy to have the like the image of the project changed*	Availability for the decision-makers to see steps of the decision-making process, Trust of the client in the expert opinion	**Need for transparency (of the progress)**
• *it's the difficulty with that is that we have to have the criteria how to. judge the designs because in the tender there will be 5 designs or and maybe some teams say well demolition and you is the best and other teams will say reuse skeleton is the best and how can we compare the two designs we have to make sense before we ask the market. How we are going to Judged* • *But I think the more we rely on the on the system and sustainability aspects, the less options are there for the requirements of the faculties. So, it's a bit of a balance we need to find. Between those demands. you don't know yet what is the balance could be better but you want to go both yes* • *The one of the concerns is how we find the balance and in the committee that decides on what is the best balance can we use a method or a way to have both requirements*	Challenge in decision making from design proposal options, Unknown in how to compare two designs to make sense, Unknown of the best balance, Ways of finding the best balancing that meets both requirements	**Best-balanced proposal selection probability**

Appendix C. Group session activity

The result of the Miro board used in the group discussion activity, mentioned in 3.4.3, is shown here. The selected variables by each stakeholder and the discussed variables as a group are presented.


Project Developer
Criteria for determining renovation design proposal options
How to score
Conflict points between sustainability and faculty demands
Fitness to faculty core activities: Research, Educational, and Support
Faculty feeling of inadequacy for the current Spinoza building
Functionality and technical feasibility
Expert opinions on campus sustainability
Transparency of the decision-making processes for the board
Negative opinion/perception on the building appearance


Project Developer
- Succeeded campus renovation example (dentistry)
- Negative opinion/perception on the building appearance (user perspective)
- Renovation possibility
- Sustainability development on Campus
- Location suitability for the purpose
Employee (facility manager)
Fitness to faculty core activities: Research, Educational, and Support
Conflict points between sustainability and faculty demands
Functionality and technical feasibility
Energy efficiency
Heavy new installations, interior, and applications
Specific functional setting floor layout
Ease of planning
Ease of design
Ease of project execution
Building usage prioritizations between circularity and user
Cost-effectiveness


Selected variables (10-12 elements)
- Sustainability development on Campus
Expert opinions on campus sustainability
Building usage prioritizations between circularity and user
Cost-effectiveness
- Succeeded campus renovation example (dentistry)
Transparency of the decision-making processes for the board
- Negative opinion/perception on the building appearance (user perspective)
Negative opinion/perception on the building appearance
- Renovation possibility

Appendix D. Text result of Power/Interest Grid analysis

Each stakeholder's interest and (potential) influence are explained below.

Executive Board: *High interest & High influence*

As the Executive Board was the stakeholder in making a decision for the project, they had the most substantial influence and interest in the decision-making process from Step 4 to 7. They expected to decide on the best-balanced solution for the CS building between the client's requirements and sustainability. They needed to choose possible proposals from the architects' presentation in tender, looking at both requirements. They required transparency in the decision-making process explained via the development executive as they were responsible for explaining the decision to the client. However, their decision needs to rely on advice as they are not experts in building and construction. For example, they were advised about functionality and feasibility by technical contractors through the project developer and sustainability by the sustainability consultant for circularity criteria.

Clients: *High interest & High influence*

They were the management representatives of two faculties developing the program requirements necessary to use the CS building. As project recipients, they were also the decision-makers and demanded to fulfill the requirements for all the essential activities: Education, Research, and Support. Therefore, their interest and influence were as high as the executive board in Steps 5 and 6 in Phase 3. However, they also aimed to contribute to sustainability as faculties that the project executive was supporting. There were dilemmas in the clients' expectations to what extent they must compromise these requirements to achieve their sustainable goal.

End-users: *High interest & High influence*

The end-users indicate students, researchers, and staff of the faculties. Securing their satisfaction with the CS building was considered essential to success in the project (the development executive, personal communication, May 16, 2022). As they were also the project recipients, their voices were collected to include in the decision. There were opposing opinions and perceptions regarding the current CS building's appearance and the alternative (renovation). It was a project barrier to extending the CS building life span.

Moreover, there were contradictions between awareness and priority—for instance, researchers' priority on owning one's workplace. Although researchers as the end-users are aware of the importance of sustainability, they do not want to sacrifice losing one's workspace ownership for sustainability. They understand the importance of sustainability but are unwilling to compromise on their priority. The faculties (the clients) are responsible for providing space for all users at any time. Thus, their interest was analyzed high that is influencing the entire decision-making process, and their influence can be directly significant in the decision-making, especially at Steps 5 and 6 in Phase 3.

Architects: *High interest & High influence*

In tender, at Step 5 in Phase 3 of the decision-making process, architects are required to propose to the executive board ideas that balance the requirements between sustainability and client/user. Therefore, interest and influence in the decision-making are high at this step because the result of the tender is directly to be this project's decision. Additionally, the presentation skill can often make a difference in the decision makers' minds regardless of the proposals' contents (the development executive, personal communication, May 16, 2022).

Sustainability consultant: *High interest & High influence*

The consultant was the only one in charge of developing the circularity policy. The policy is used to measure circularity during at Step 5 in Phase 3 of the decision-making process. The stakeholder can be particularly interested in how well a decision fits the policy. Thus, the influence can be substantial in terms of the sustainability perspective on the decision. Although the interest and effect can be directly linked to the decision, they are one-sided and partial. Therefore, both degrees were analyzed as high but slightly lower than the stakeholders mentioned above.

Employees: *Moderate interests & Moderate influence*

The employees here indicate campus staff. They are also a project recipient as they use the building for their work. Thus, their interest can be high in how their work at the CS building would be by the decision. However, those employees who manage campus facilities, for instance, had relatively low interest in the decision itself in this project phase. It is because of their primary responsibilities after the end of the project, namely in the use stage of the building life cycle. Although the employees need to provide their opinion about the project building for the decision-making, their opinions were not considered as high prioritization as the clients and end-users. On the other hand, there are campus supervisors who approve the decision. It means they can directly influence at Step 6 in Phase 3 before the final step to implement the decision in the decision-making process. Therefore, the interests and influence were analyzed as relatively high but lowest among the high interests and influence stakeholders.

Development executive: *High interest & Moderate influence*

As the stakeholder had the overall responsibility in the project start phase, the interest in the decision and its process was placed high. The project performance reflects the stakeholders' evaluation. The stakeholder also needs to address the impact of decisions, such as dissatisfaction with clients' decisions. The expectation in the decision was to meet both requirements in balance, like the executive board. The role needs to manage the decision-making process towards the board to make a decision. Therefore, the stakeholders' performance in the process can influence the decision. In addition, there was a concern that the end-user opinion may affect the board's mind to make a decision dominant in user demands over sustainability perspective.

Project developer: *High interest & Moderate influence*

The stakeholder also had high interest but moderate influence as the main task was to define the project towards the decision-making in the project start phase. The stakeholder focuses on technical feasibility for renovation and developing a detailed plan with advice from the specialized technical contractors. The renovation drawing was shared with the clients to discuss renovation options for their future buildings. The project development for demolition can start from zero and is usually easier than renovation. However, the effort of the stakeholder was made a lot to extend the CS building's life span as the CS building still had usable space and function. Therefore, the stakeholder's communication might influence the clients to consider renovation options/re-using the CS building at Step 5 in Phase 3.

Project executive: *High interest & Low Influence*

The stakeholder was analyzed as one of the high-interest stakeholders. Although the primary role is mainly to steer the project in the planning and implementation phase, the project executive needs to be active from the project start phase to ensure the agreement with the users for the decision: at Step 6 in Phase 3. Being a member of the executive board was also taken into account. Furthermore, the stakeholder was also supporting the clients' sustainability goals to realize as the background of this stakeholder was related to sustainability. Thus, the support might influence the sustainability aspects of the client's requirements. However, the result of the decision does not affect the nature of the role.

Municipality: *Low interest & High influence*

This stakeholder is the only external relevant stakeholder in the project who only comes in with permission for project plans. They need to judge whether a determined decision in this project can acquire authorization or not. Thus, their interest in the decision itself was placed relatively lower. Still, the influence is analyzed as high as the project must be approved to implement the decision at Step 7 in Phase 3.

Energy consultant: *Moderate interest & Moderate influence*

As the stakeholder is also an employee who manages and supplies energy on the campus, the degree of consultant's interest was placed as the same as the employees. The nature of the role is mainly procurement and managing energy in the building. Namely, it is after the building implementation, in the use stage of the building life cycle. However, the stakeholder provided advice to the requests from the project developer in the early start phase. The stakeholder emphasized the importance of considering energy circularity in this phase to build successful energy-neutral buildings.

Moreover, the stakeholder expected to be informed of the progress information to provide the right advice at the right time. It is because the stakeholder recognizes sharing the information among all stakeholders in the earlier phase of the decision-making process is key to realizing sustainable buildings. Therefore, including the advice from the energy consultant in the project start had a potential influence on considering the building circularity aspect effectively in the decision making.

Engineering contractors: *Moderate interest & Moderate influence*

The stakeholders are mainly technical consultants. They were asked to investigate material circularity and environmental impacts of renovating the CS building in the early project start phase. The result of the investigation was used for further investigation of renovation possibilities. Currently, the other technical consultants were asked to provide advice on both technical & functional feasibility. Thus, they can be relatively interested in the decision as it can be evaluated to reflect on their work performance. The earlier investigation already influenced the possibility of extending the CS's life span with alternatives as well as the in-depth results of the current contractors. Thus, both influence Step 2 in Phase 1. The results may not directly influence the decision-making but support technical aspects validation in alternatives to extend the building lifespan.

Project manager: *Low interest & Low influence*

The stakeholder is the leading actor in managing project planning and implementation tasks. Thus, the result of the decision does not affect as the primary responsibility starts the project planning and implementation phases. The stakeholder may prefer the decision for demolition as demolition is easier than renovation for the role (the project executive, personal communication, May 24, 2022). It is because planning from existing buildings often includes complexity. Therefore, the interest in the decision-making and this start phase was lower than the relevant actors in this project phase.

Design team and **Installation and construction contractors**: *Low interest & Low influence*

Likewise, these two stakeholders mainly act in the planning and implementation phases. Also, they may be interested in the decision for demolition as designing and constructing a new building are straightforward. Thus, interest and influence in decision-making at the project initiation stage were also the lowest among all stakeholders.

Appendix E. Steps to build a Casual Loop Diagram

These steps below were taken place to build the completed casual loop diagram (Figure 11, 4.3.2) after the group discussion mentioned in 3.4.3.

Create a connection circle: The relevant variables were further elaborated based on all the collected data. The 12 key variables were developed to create an interrelationship diagram; connection circle (CC). This visual tool is commonly used as a seed structure to build a causal loop diagram. The tool identified the following variables: Drivers and Outcomes. These two terms are described in Table E1: (i). The drivers and outcomes as variables built the CC on the Miro board (Figure E1). It presents: [O] the drivers and [I] the outcomes. See the descriptions in the table: (ii).

Identify relationships: Each variable was examined to explore potential relationships with the other. The relationships between pairs of variables were considered, and an 'influence' arrow was used to connect related variables. The arrows show the relationships between variables. The built CC then provides the following results: potential causes and potential key effects (see Table E1. iii).

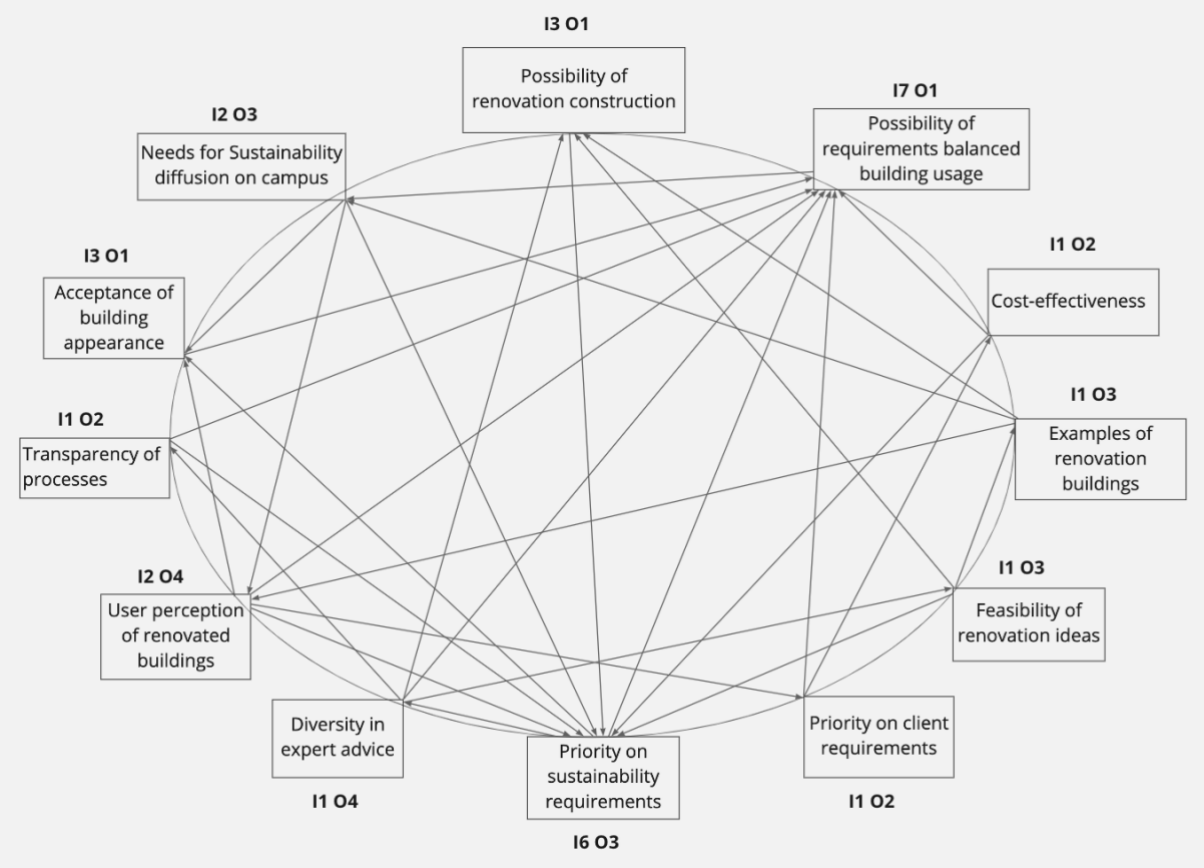
Table E1

Description of the terms

Term definitions					
i	**Drivers:** the fundamental elements of a system that drive the other parts	ii	**[O] the drivers:** the variables with more arrows going 'out' than in	iii	**Potential causes:** the variables with the most outgoing arrows
	Outcomes: the elements of the system that can be used to measure success		**[I] the outcomes:** the variables with more arrows coming 'in' than out.		**Potential key effects:** the variables with the most incoming arrows.

Figure E1

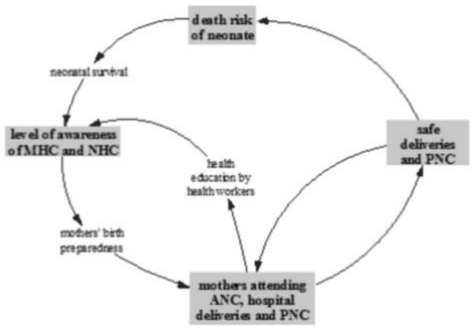
The created connection circle



Insert intermediate variables (I): The identified relationships in the CC were drawn with arrows using Vensim software in Figure E2. The software is primarily used for supporting continuous simulation and modeling. Intermediate variables were identified that help explain the system's situation from the collected data (Sapiri et al., 2017). They were added using the CC as a guide. It provided a better understanding of the relationships.

Figure E2

Example of CLD progress: (I)



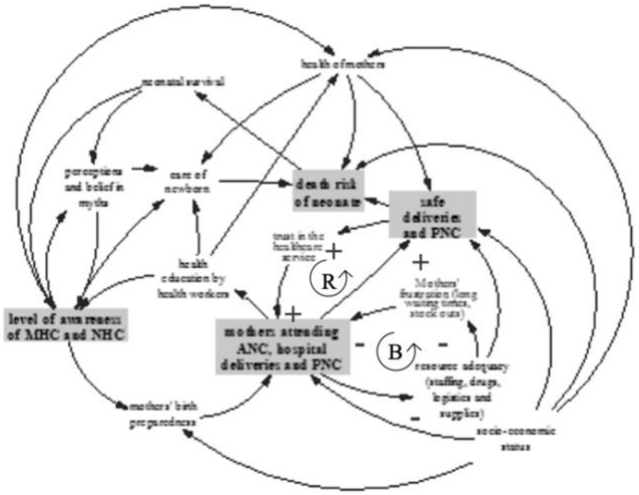
Identify linkages (II): The variables in the CC were examined to explore linkages between the variables and other potential variables in the project. The linkages among the other key variables in the system were identified by repeating them (see Figure E3). It allowed feedback loops in which the system outputs are circled back and used as inputs. These loops are shorthand descriptions of what was perceived as the current reality (Åström & Murray, 2007). It shows those aspects of the feedback structure which led to the observed pattern of system behavior (elements) in the situation (Pruyt, 2013).

Determine polarity (III): The polarity of all the relationships between variables was first determined to identify feedback loops in the system (Figure E3). The variables were assessed based on whether arrows between two variables indicate a change in the same or the opposite direction. Each arrow was labeled to indicate the direction of the effect. The '+' signs are the changes in the same direction, and the '-' signs are the changes in the opposite direction.

Identify feedback loops (IV): Once the polarity of every relationship in the CLD was established, feedback loops in the system were finally identified. Interactions between the variables in the CLD were identified by reinforcing and balancing loops (see table E2).

Figure E3

Example of CLD progress: (II), (III) & (IV)



The identified feedback loops in the system imply the elements of the sub-systems. It revealed how these feedback loops drive the dynamics of the system and its implications for interventions (Åström & Murray, 2007). The system's feedback structures were built in the CLD. The completed CLD visualizes the cause-effect relation in the situation.

Table E2

Explanation of reinforcing and balancing loops

Reinforcing loops	
What	A loop is one in which an action produces a result. The loop influences more of the same action. It results in growth or decline at an ever-increasing rate.
How	Feedback increases the impact of a change. Positive reinforcing loops produce virtuous cycles. Negative reinforcing loops produce vicious cycles.
Where	All the arrows in the loop are '+' or if there is an even number of '-' arrows.
Balancing loops	
What	A loop generates the forces of resistance. The loop eventually limits growth, maintains stability, and achieves equilibrium.
How	The loops reduce the impact of a change and are goal-seeking.
Where	An odd number of minus signs '-' in the loop.