CMO Opportunity-Identifying Framework for Complex Sustainable Construction Projects

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Summary

As climate change is negatively impacting the environment, action has to be taken to minimize future damage. The world has started working towards achieving sustainability goals, one of them being the net-zero goal. As the construction industry is responsible for 40% of the current carbon emissions, several construction companies are implementing sustainability practices in their projects. The implementation of these practices could bring several complexity elements at a technical, organizational, and environmental level in the front-end phase of the project, which can make it difficult for project teams to accomplish the project sustainability goals. However, the projects could also bring opportunities. This study investigates how complexity and opportunities could be interrelated and whether complexity could lead to opportunities. The main research question is formulated as:

"How could opportunities be generated from complexities by using management strategies in the front-end phase of sustainable construction projects?"

The research question aims to fill the two current knowledge gaps (the positive impact of complexity and the possibility of generating opportunities from complexities, which have not been sufficiently explored). To answer this research question, three qualitative research methods are used: literature review, case study analysis, and expert evaluation.

Chapter 3 describes the five main topics of interest for the study by means of literature review: sustainability, complexity, risk, opportunities, and management strategies. As the research is focused on sustainable construction projects, the term is defined as *"construction projects in which sustainability practices are implemented. Some of these practices can be sustainable design, the usage of sustainable building materials, managing the waste and its reduction by using suitable strategies, etc. Sustainable construction projects are managed by considering the economic, environmental, and social aspects.".* Regarding complexity, the literature was explored to find elements of complexity in general construction projects and sustainable construction projects. The overlapping elements were excluded from the study, and the elements specific to sustainable construction projects were divided into three main categories according to the TOE framework (technical, organizational, and environmental) and thirteen sub-categories. The opportunities that might arise in sustainable construction projects were identified as well and divided into three categories (environmental, social, economic) and sixteen sub-categories. Management strategies used to deal with complexity were explored in the literature and grouped into two main categories which express their level of control and interaction. Regarding complexity and opportunities, their relation was presented by their individual connection to risk. A conceptual framework illustrating this idea was built, which shows that management strategies could be means to generate opportunities from complexities.

In Chapter 4, a case study analysis is performed within Turner & Townsend (TT). According to its green purpose, the company currently offers services that help its clients achieve their sustainability and net-zero goals. The case study comprising of four cases which represent

sustainable construction fit-out projects was analysed in three branch offices of TT: Ireland, the UK, and the Netherlands, to explore the key elements of the study in practice (complexities, opportunities, and management strategies). Twelve semi-structured interviews were conducted with project members from the three countries. Compared to the academic literature selected for this study, additional complexities and opportunities were found in the interviews or internal documents that were reviewed. The management strategies applied or suggested by the project members were grouped into five main categories: communication and reporting, project planning, openness to change, team strategies, and external strategies, each of them allowing a certain amount of control and interaction.

The case study analysis is further performed in Chapter 5, which presents a comparison among the three branch offices regarding their net-zero and sustainability approaches, complexities encountered, management strategies applied or suggested, and opportunities identified. The main complexity elements encountered in the four case projects were fixed project schedule, project team's lack of expertise in implementing sustainability, difficulties in implementing sustainable project management, and stakeholders' lack of understanding of sustainability. Several management strategies were used to deal with the complexity elements (such as engaging the relevant stakeholders early upfront, analysing and suggesting different scenarios and methods, etc.), and unique strategies were captured from each branch office (for instance, optimizing the client's number of workshops, involving the supply chain in the design process, etc.). In the current study, the unique strategies are perceived as the management strategies mentioned by one branch office that were not mentioned by the other two. A few common opportunities were related to setting standards, end-users' lifestyle, training and education, and work process.

Based on the data gathered from the literature review and case study analysis, Chapter 6 presents the result of the study: the CMO (**C**omplexities, **M**anagement strategies, **O**pportunities) opportunity-identifying framework for complex sustainable construction projects (Figure 0.1). The framework presents how certain complexities could lead to opportunities by means of management strategies. It was developed based on the main findings of the study and the management strategies that are perceived as suitable for the most common complexities of the study. The opportunities were either common findings or own suggestions from the literature. The findings of the framework were evaluated by means of expert evaluation, and the framework was improved based on the discussion during a focus group session organized with experts from TT the Netherlands who work on sustainable construction projects. The findings of the literature review and case study analysis offer a variety of complexities, opportunities, and management strategies in sustainable construction projects that could add value to academia and practice. At a scientific level, the framework shows that complexities and opportunities are related to each other, and complexities could lead to opportunities. At a practical level, the framework illustrates the main research findings and represents a guide for industry experts to deal with complexity and generate opportunities.

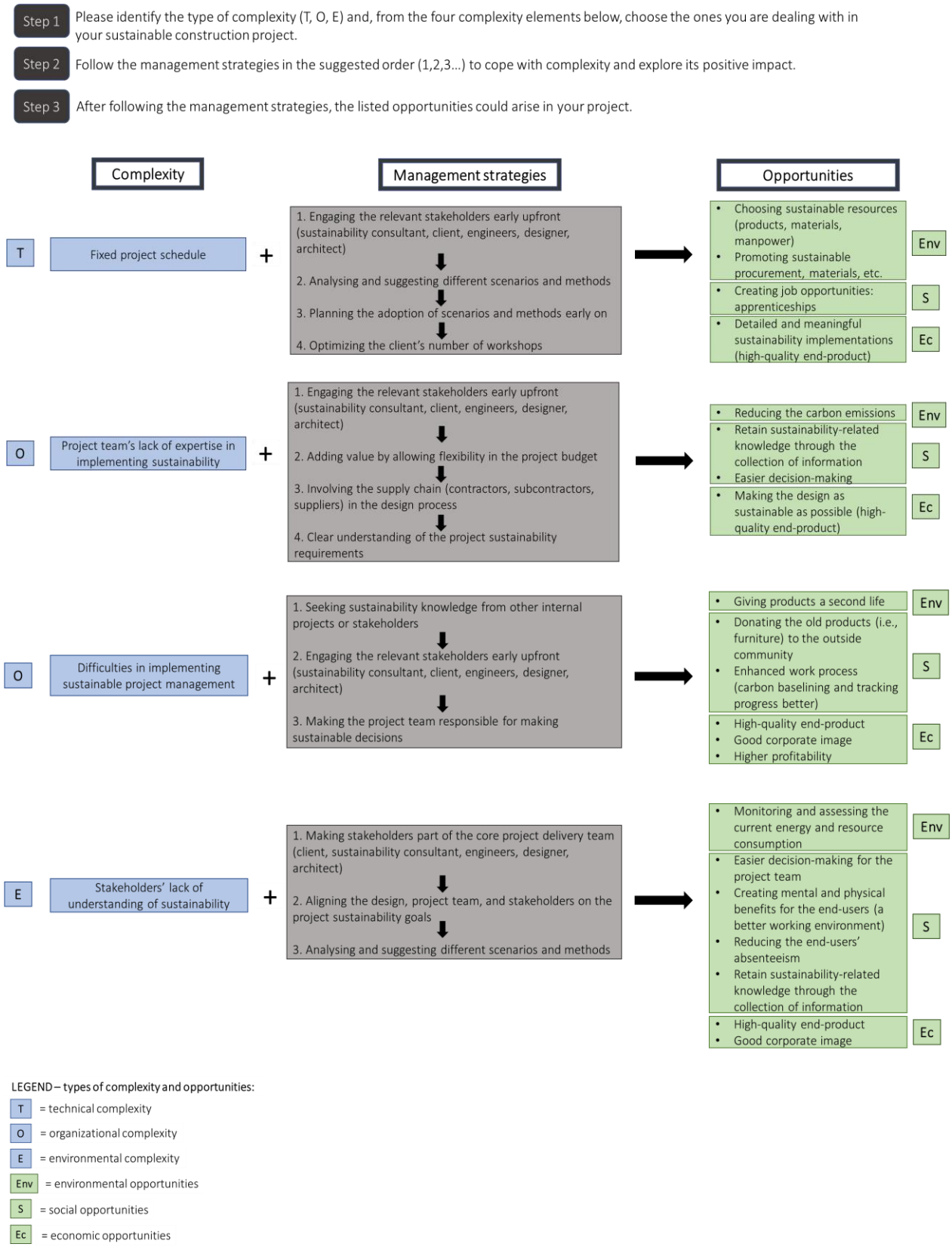

Figure 0.1. CMO opportunity-identifying framework for complex sustainable construction projects

Chapter 7 presents the limitations of the study. The case study analysis was limited to one project in Ireland, one in the UK, and one in the Netherlands, which does not allow building a pattern for all the project teams working in the three branch offices and countries. The semi-structured interviews were conducted with project members from TT (except for one sustainability consultant from another company) who have specific consultancy roles: project directors, project managers, cost managers, and sustainability consultants. Other roles might interpret the key elements differently. The evaluation of the framework was limited in the same manner. Lastly, the way the framework is used in projects might change the outcomes.

In Chapter 8, the conclusion shows that to generate opportunities from complexities, the management strategies that are used to deal with complexity are the means to achieve it (for instance, engaging the relevant stakeholders early upfront, analysing and suggesting different scenarios and methods, clear understanding of the project sustainability requirements, etc). To deal with the complexity elements encountered in sustainable construction projects, combinations of management strategies should be applied. Moreover, the order in which they could be applied is suggested. The strategies are based on a combination of control and interaction, as recommended in the literature. Depending on the project goals or the management strategies used, any opportunities from the environmental, social, and economic categories could be generated by following the suggested combinations of management strategies.

Several recommendations are made for practice and further research. For practice, recommendations for all the project members include being ready to deal with complexity and transform it into something positive, reflecting on their own work, actively identifying opportunities etc. The clients are advised to allow flexibility in the project budget or schedule, to provide a platform for all the project members for better data management, etc. A few recommendations such as hiring sustainability consultants and working with the cost-carbon calculator or NABERS certificate are made for the experts from TT NL. The unique strategies that were captured from each branch office are also recommended for all three of them (for example, seeking sustainability knowledge, reflecting on own work, data management, etc.). At a scientific level, further research could be carried out in other companies (different than TT), in the UK and Ireland (more in-depth), in the public sector, in different types of projects or project phases, and opportunities for stakeholders could be considered. Moreover, different interviewee roles could be involved in the research and the framework should be tested in practice to evaluate its effectiveness.

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1. Introduction

The current research is carried out in the context of climate change and contributes to delivering construction projects sustainably and successfully. The purpose of implementing sustainability in construction projects is to mitigate the environmental crisis (rising sea level, extreme temperatures, etc.). The following sections describe the research background (1.1), problem definition (1.2), knowledge gaps (1.3), research objective (**Research objective**1.4), research question and sub-questions (1.5), research scope (1.6), and case company description (1.7).

1.1. Background

Climate change has brought issues all over the world. It has been acknowledged worldwide that if action is not taken against the climate crisis, the increasing global temperatures will lead to an irreversible process towards destroying the ecology (Hitching-Hales, 2021). One of the most challenging tasks that companies currently have is achieving sustainability goals, considering the environmental, social, and economic aspects (Armenia et al., 2019). In the Netherlands, several governmental policies and guidelines are made to implement strategies such as circularity, energy efficiency, reducing the carbon footprint, etc., to tackle the climate crisis and achieve sustainability objectives (Ministry of Economic Affairs and Climate Policy, 2019).

In the construction industry, achieving major sustainability goals could be a very challenging task which could bring complexity to construction projects. Baccarini (1996) defines complexity as "consisting of many varied interrelated parts" and as being "complicated, involved, intricate". Complexity can be technical, organizational, as well as environmental, according to Bosch-Rekveldt et al.'s (2011) TOE framework. Several elements of complexity from all these three categories could be encountered in sustainable construction projects.

1.2. Problem definition

In the context of achieving sustainability goals in the construction sector, several academic papers focused on describing complexities encountered in sustainable construction projects. Some articles identify the complexity elements which have a negative impact on the project. The elements found in the academic literature can originate from the technical aspects (uncertainties in schedule, sustainability requirements, uncertainty in project scope, and complex and unique design – Cao et al., 2020), stakeholders' side (poor understanding of sustainability and interest in adopting principles of sustainable development – Maqbool & Amaechi, 2022), or the project manager's involvement in the construction project (unclear project scope, understanding of operational costs, risk management, and knowledge management application – Borg et al., 2020).

When looking at the positive side of sustainable construction projects, other authors looked at opportunities. For instance, on the financial side, sustainable projects bring lower costs for operating, maintaining, and developing (Saleh & Alalouch, 2015). Gan et al. (2015) identified the reduction of operating costs during the building service life, improved environmental performance, job creation, and enhanced corporate image as benefits arising from sustainable construction. Risk-wise, the contractors and owners are more risk-ready when implementing sustainable

practices, as they pay more attention to their operations (Shan et al., 2017), while other opportunities are promoting green construction technologies and positive social image.

Problem statement

Complexities and opportunities are two major topics in the current research and there are several articles in the literature which illustrate them. However, the connection between the two has not been sufficiently explored. Although complexity could have a negative impact on sustainable construction projects, it could also have a positive impact, potentially leading to opportunities.

1.3. Knowledge gaps

The two scientific gaps in the literature are the following:

- As the literature regarding complexity shows a focus on its negative impact (Dooley, 2002; Antoniadis et al., 2008; Vidal et al., 2010), the possibility of perceiving complexity as having a positive impact on projects is overlooked. Although complexity is neutral in its nature, it can have a negative or positive impact on projects at a technical, organizational, or environmental level. The idea of perceiving complexity as having a positive impact on the project can be addressed, to later find opportunities in sustainable construction projects.
- Although the negative impact of complexity is extensively addressed in the literature, the idea that opportunities could arise from complexities is insufficiently explored. Risks could bring either threats or opportunities (Ward & Chapman, 2003; Gunderman & Applegate, 2005; Hillson, 2002). The relation between complexities and opportunities could be made by showing that complexity is related to risk. If complexities can bring opportunities to make sustainable construction projects more valuable, project members should be able to identify these sustainability opportunities from complexities through means that are explored later in the research.

1.4. Research objective

The research objective is to show that complexity could generate opportunities in the context of sustainable construction projects. To achieve this, complexity elements, management strategies, and opportunities encountered in this type of projects are looked for in the literature and practice. The link between complexities and opportunities is explored, while the idea that management strategies could be means to find opportunities represents the starting point in developing a framework that illustrates how complexity could generate opportunities in sustainable construction projects.

1.5. Research question and sub-questions

The research question is formulated as follows:

"How could opportunities be generated from complexities by using management strategies in the front-end phase of sustainable construction projects?"

To be able to answer the main research question, four research sub-questions are formulated:

RSQ1) **"What are complexity and opportunity in the context of sustainable construction projects and what management strategies are used to deal with complexity?"** – The purpose of this question is to explore the literature related to complexity and opportunity in sustainable

construction projects, to find what complexity elements and what opportunities might be encountered in this type of projects. The link between complexity and opportunities is explored, as well as the management strategies used to deal with complexity.

RSQ2) **"What complexity elements, opportunities, and management strategies could be found in the front-end phase of sustainable construction projects in practice?"** – The aim of this question is to find the complexity elements and opportunities encountered by project members in practice in the sustainable construction projects which contribute to reaching the net-zero goal. Moreover, the management strategies used by project members to deal with complexity or generate opportunities are explored.

RSQ3) **"How can complexity elements, opportunities, and management strategies in the front-end phase of sustainable construction projects be compared in countries working towards achieving net zero?"** – The purpose of this question is to make a comparison between the results from three countries: Ireland, the UK, and the Netherlands, to identify the most common and the unique key elements of the study (complexities, opportunities, and management strategies used to deal with complexity or generate opportunities).

RSQ4) **"How could a framework help project members in identifying opportunities from complexities in the front-end phase of sustainable construction projects by using management strategies?"** – The aim of this question is to develop a framework by finding suitable combinations of management strategies. The framework will illustrate the strategies with steps that could help the project members who deal with complexity explore its positive impact and identify opportunities in their sustainable construction projects.

1.6. Research scope

The research is carried out on sustainable construction fit-out projects in the real estate sector within Turner & Townsend (TT). The company is commissioned to work on these projects by private clients. The focus of the research is on the front-end phase. Essential factors such as the project goals, scope, team, budget, schedule, and implementation of sustainability practices are considered by the project members from the beginning of the project (conceptualization) until the implementation phase. These elements could also bring complexity to the projects, which is the interest of the study. Therefore, the front-end phase is chosen to be analysed in the research. Regarding the sustainability goals, another specific factor included in the research of sustainable construction fit-out projects is that the analysed projects are part of the net-zero challenge in the Netherlands, Ireland, and the UK. The net-zero challenge is chosen as part of the research as it represents a major element of sustainability and is an important step for TT to achieve their and their clients' sustainability ambitions that contribute to reducing worldwide issues.

As a term, "sustainable project management" is defined as a combination of management strategies that are used considering the economic, social, and environmental aspects of the elements of a project (Silvius et al., 2017; Armenia et al., 2019). These elements can be the resources, supporting processes, etc. which are planned, monitored, and controlled to ensure a fair collaboration with the stakeholders (Silvius et al., 2017) and support project managers in the decision-making process (Armenia et al., 2019). In the current research, sustainable project

management in the context of TT is illustrated at three different levels. This means that the complexities and opportunities encountered by the project team can arise at the project level (related to the client's requirements), at the organizational level (related to TT as an organization and project team or stakeholders), and can have an impact on the environment, society, and economy (Figure 1.1).

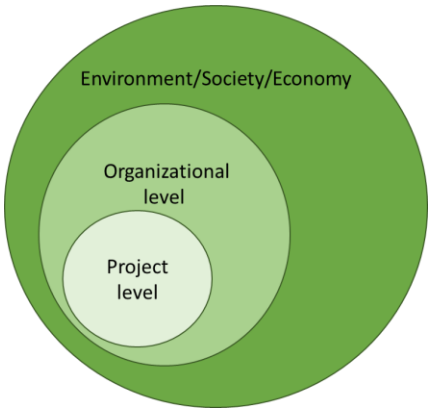

Figure 1.1. Focus levels for complexities and opportunities

1.7. Case company description and the net-zero challenge

TT is a multinational professional service company with the headquarters in the United Kingdom, in Leeds. The company is specialized in program management, project management, cost management, and consulting in the construction sector, more specifically in the real estate, infrastructure, and natural resources. The company has a total of 118 branch offices in 50 countries worldwide, and more than 9,400 employees in 2023, according to Turner & Townsend (n.d.). TT's parent company is CBRE Group. TT was chosen as a case company for the current research for several reasons, one of them being that TT is a global company with a good reputation for its high-quality delivery of services and prestigious clients. Moreover, TT is focused on two main services, which are project and cost management. This is in line with the author's professional goals and master's objectives (a research topic related to construction management). Lastly, from a previous internship experience at TT the Netherlands (TT NL), the author's overall impression was that the company's culture and working environment could positively contribute to high-quality research outcomes. Therefore, the research is carried out at TT NL. TT adds value to the research as it enables the analysis of the cases from three different countries and branch offices (Netherlands, Ireland, and the UK), as well as a variety of project members to interview.

Net zero is defined as reducing the emissions caused by greenhouse gas and at the same time balancing any released emissions by removing the existing gas from the atmosphere (Hitchings-Hales, 2021; University of Oxford, 2023; National Grid, 2023). Therefore, the overall net emissions become zero (The Economist, 2023). Further information related to the concept of net zero and how the Netherlands, the UK, and Ireland are working on achieving net zero at a national level can be found in Appendix A. These three specific countries were selected as they are neighbouring countries and are similar in terms of culture, climate, and religion. In fact, Ireland and the

Netherlands are the two most similar countries to the UK, according to Objective Lists (2022). TT is working on the net-zero challenge in all their branch offices globally. The net-zero and sustainability ambitions started in TT the UK (TT UK), which was the guiding team in Europe. Due to the changed regulations caused by the BREXIT, the European TT branches split into TT Europe and TT UK. In time, TT Ireland (TT EIR) became the leader in the net-zero challenge at a continental level. Therefore, a comparison amongst the three branch offices (TT UK, TT EIR, and TT NL) is relevant to the research.

The net-zero challenge involves two main goals: one of them is achieving net zero in their own branch offices which contributes to the global 2-degree Celsius goal, while the second goal involves helping their clients achieve their own sustainability goals, the main one being net zero (Turner & Townsend, n.d). The latter goal derives from the company's purpose of building a "green, inclusive, and productive world" (Turner & Townsend, n.d.). In the current study, only the second goal is of interest. Some of the sustainability practices that are currently used by TT NL and other offices are the following: sustainable procurement (green strategy), cost-carbon calculator (reporting and monitoring), and circular economy consulting. TT EIR and TT UK have already taken important steps towards achieving net zero and often organize knowledge-share or lessons-learnt sessions for TT NL in which they describe the barriers and opportunities which they have encountered in different projects on their way to achieving net zero. Within TT NL, it is known that the other two branch offices are more advanced, and they consider them a positive example from whom they can learn.

2. Methodology

The current research is carried out using qualitative research. According to Creswell (2013), qualitative research is a method which involves the exploration and analysis of how individuals perceive a certain issue. It requires gathering data and analysing it by interpreting it in a unique way. The current study uses this approach with the purpose of analysing how complexity is perceived in sustainable construction projects and the possibility of generating opportunities from those complexities.

The study uses a combination of deductive and inductive approaches. The deductive approach is used when analysing the elements of complexity found in the literature. The complexity elements are grouped into the three categories of the TOE framework (technical, organizational, and environmental), meaning that each element found is assigned to an existing category of complexities. In the same manner, the opportunities were grouped into three categories (environmental, social, and economic) and assigned to them. After the literature review stage, the inductive approach starts by gathering empirical data and is used in semi-structured interviews. Alongside the literature review findings, new data can be obtained (inductive approach), or existing data can be verified (deductive approach). New elements of complexity are found in the interviews. The study is open to finding new categories of opportunities, which are the environmental and social opportunities outside the net-zero goal. The complexity elements and opportunities already found in the literature are verified during the interviews and assigned to their categories. The research design is described in section 2.1, after which the research overview is illustrated in section 2.2.

2.1. Research design

Research design is the "blueprint of a scientific study" and includes the main elements of a research project, such as the problem definition, methodology, and research approaches used (Emeritus, 2022). For the current research project, three qualitative methods are used, namely the literature review (2.1.1), case study (including document review and semi-structured interviews – 2.1.2), and expert evaluation (2.1.3).

2.1.1. Literature review

The literature is reviewed regarding the key elements that are essential in contributing to the results of the study. First, the concepts of sustainability and sustainable construction projects are described. Second, a definition of complexity in construction projects is found from relevant articles, followed by identifying complexity elements in sustainable construction projects. Further, the concept of risk and the link between complexity and risk are explored. The concept of opportunity is described, along with identifying opportunities from academic papers which concern sustainable construction projects. Lastly, the management strategies used to deal with complexity are explored in the literature.

Several scientific papers were selected from two databases, namely Scopus and Google Scholar. Both databases include a very large variety of scientific papers and are trustful sources for the research. Scopus offers the possibility of searching papers according to certain criteria, as well as

generating a search log. The purpose of the search log is to make the literature review process clear, organized, and transparent, and to help future authors in reproducibility. Therefore, systematic review is conducted by means of the search log. Systematic review involves selecting and gathering the existing literature with the purpose of analysing the evidence found for a specific research question (University Libraries, 2023). The search log includes characteristics such as the authors, year of publication, number of pages, source, access, title, abstract, etc. Systematic review is conducted, and search logs are generated for two research topics (complexities and opportunities in sustainable construction projects), which can be found in Appendix B and Appendix D.

To find the relevant articles, certain key words that describe the concepts were used. The key words can be the concept itself or a synonym, as using both offers a larger variety of papers (Table 2.1).

Table 2.1. Key words and the corresponding search strings (Scopus database)

Key concept in sustainable construction projects	Key words	Generated search strings
Complexity	“complexit*” and “sustainable construction”	“(TITLE-ABS-KEY (complexit*) AND TITLE-ABS-KEY ("sustainable construction"))”
	"challeng*" and “sustainable construction projects”	“(TITLE-ABS-KEY (challeng*) AND TITLE-ABS-KEY ("sustainable construction projects"))”
Opportunity	“opportunit*” and “sustainable construction”	“(TITLE-ABS-KEY (opportunit*) AND TITLE-ABS-KEY ("sustainable construction"))”
	“opportunit*” and “sustainable construction project*”	“(TITLE-ABS-KEY (opportunit*) AND TITLE-ABS-KEY ("sustainable construction project*"))”

After finding the relevant academic literature, the articles were chosen based on a selection process which included several criteria (Figure 2.1):

- the accessibility of the papers and their availability in English, as only papers which provide full access, and an English version are chosen
- the papers should be articles and in their final publication stage, not conference papers, reviews, or published in the press
- the year of publication is no earlier than 2013 – when identifying complexities and opportunities in sustainable construction projects, articles no older than ten years were selected, as these elements might change in time, so recent papers could be more suitable. However, for defining the concepts, older papers were accepted in the study, as the definition and understanding of the concepts are unlikely to change
- the relevance of the title to the current research
- the relevance of the abstract to the current research
- the content of the papers and the relevance to the research questions

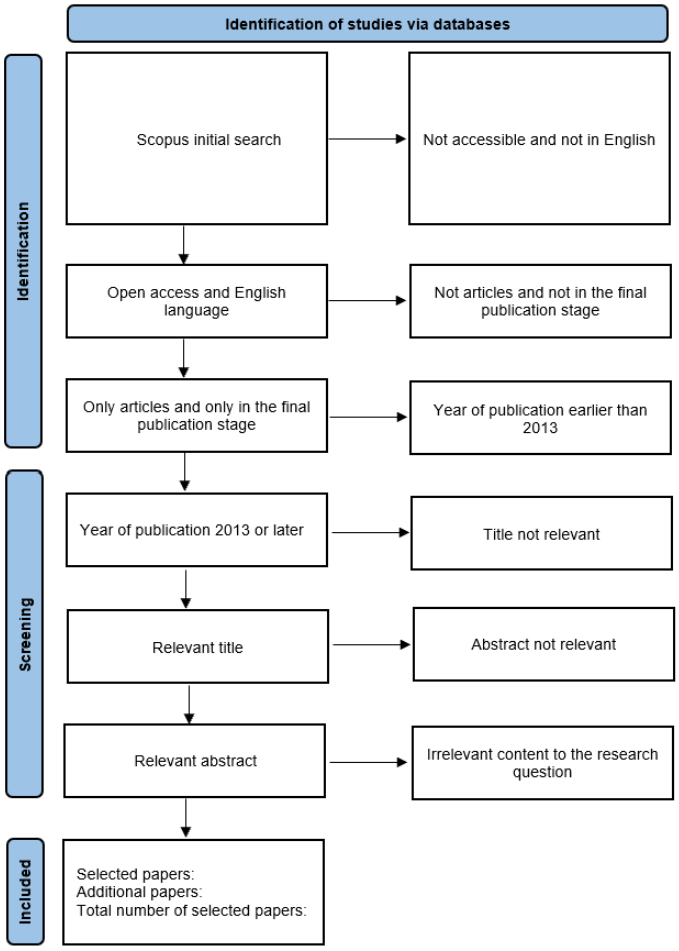

Figure 2.1. Papers selection process (University Libraries, 2020)

The paper selection processes can be found in Appendix C (complexities) and Appendix E (opportunities). To identify opportunities in the literature, the analysis of the selected articles was performed by using Atlas.ti, which is a software that helps in performing code analysis. The software illustrates where the opportunities are found in the text and how they are categorized by applying codes. Based on the codes, a code scheme was made. The code scheme for opportunities in sustainable construction projects is explained in detail and illustrated in sub-section 3.4.1. The review of the literature used in the current study is performed and described in Chapter 3.

Grey literature is also used in the study. This type of literature is represented by data that is found outside the usual publishing channels and includes newsletters, government documents, reports, etc. (McKenzie, 2022). Governmental websites are used as they provide data regarding the net zero goal, the current situation in the Netherlands, the UK, and Ireland related to climate change, and how the three countries are working on achieving net zero by 2030.

2.1.2. Case study

The case study analysis leads to an in-depth understanding of the selected cases and provides the research with valuable information (Creswell, 2013). The data gathered from TT EIR, TT UK, and TT NL is chosen as a source for the current study. Two cases are part of the study to gather data about

the projects in TT EIR and TT UK. One project for each of the two countries, alongside two other projects in TT NL are analysed to find out which elements of complexity and opportunities they found in their sustainable construction projects, as well as the management strategies used to cope with complexities. A comparison is made among the three branch offices, considering the similarities and differences among key elements of the study.

For the analysis of the case study, two methods were used: document review and semi-structured interviews. Grey literature is used for the document review. Company internal documents were chosen as they give in-depth information related to the cases that are analysed. As there is a need for detailed information related to the analysed projects to understand what they involve and how sustainability is implemented in TT NL, TT EIR, and TT UK, internal documents are useful. Moreover, the documents provide information regarding the services offered by TT in the three aforementioned countries to achieve their clients' net-zero goals.

To find new elements of complexity and opportunities in sustainable construction projects and to verify the findings of the literature review, semi-structured interviews were conducted (Rugg, 2010). According to Saunders et al. (2009), interviews are the most advantageous method to gather valuable information in conditions such as a large number of questions to be asked, and complex or open-ended questions. Another reason for choosing the interviews as a research method was to look for a pattern that would show that opportunities could be generated from complexities by using different management strategies. The semi-structured interviews were conducted as part of the case study and involved discussions with several project members from TT with the purpose of understanding the cases and analysing the key elements of the study. A total of eleven semi-structured interviews were conducted with project members from TT EIR, TT UK, and TT NL, and one interview with a project member from another company. The questions were predetermined, but there were also several unplanned questions, depending on the interviewees' responses and the detail in which they answered. The project members were asked questions related to the sustainable construction projects they worked on, the complexities and opportunities they encountered, and the management strategies used to deal with complexities and find opportunities. The interviews were conducted in person or online, on Microsoft Teams, if it was not possible to meet face to face. The case study analysis is described in Chapters 4 and 5.

2.1.3. Expert evaluation

After identifying the key elements from the sustainable construction projects in Ireland, the UK, and the Netherlands, a framework was built with the purpose of helping experts identify opportunities from complexities in sustainable construction projects. A framework represents a method that illustrates the research findings and helps in building theory (Waller, 2022). The method is suitable for the current study as, in qualitative research, frameworks are presented at the end of the studies to show the results that fill the scientific knowledge gaps (Waller, 2022).

Building the framework involved its evaluation, as it was essential to discuss its efficiency in practice and find areas of improvement (Maze, 2022). Moreover, it helped check the generalizability of the results of the study. The framework was therefore evaluated by organizing a focus group session with experts from TT NL who work on sustainable construction projects. As

it is suitable for qualitative research, the advantage of a focus group is that the author can confirm the findings of the study and learn more about them from industry experts (Physician, 2009). The focus group was organized to verify the pattern findings and improve the framework to be more suitable in practice. The participants were asked questions in this matter which led to more detailed discussions. The method was chosen over others (for instance, evaluation via email), as the discussion required the experts to express their viewpoints and complementing or challenging each other's ideas, which was preferred in comparison with individual discussions. The evaluation of the framework is described in Chapter 6.

2.2. Research overview

The research overview includes the chapters of the study, along with the corresponding methodology, and the research questions answered in each chapter (Figure 2.2).

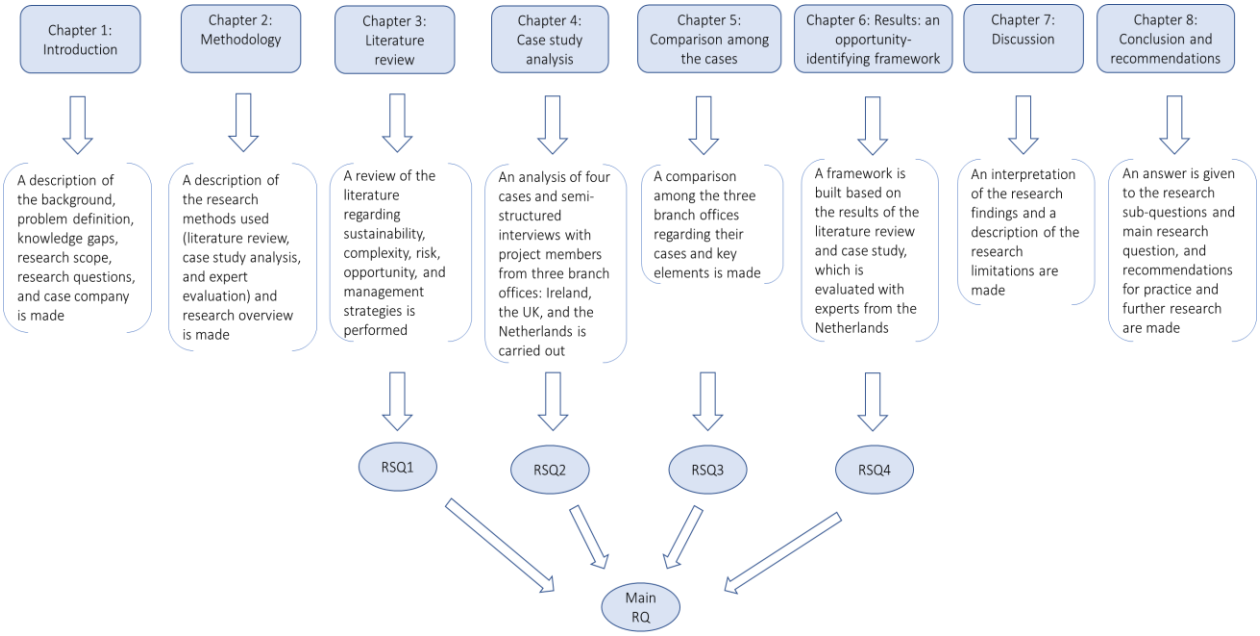

Figure 2.2. Research overview

3. Literature review

This chapter aims to answer the first research sub-question:

RSQ1: **"What are complexity and opportunity in the context of sustainable construction projects and what management strategies are used to deal with complexity?"**

To answer this research sub-question, the chapter reviews the literature to define the main topics addressed in the research and analyse them as broad concepts, and then zoom in on sustainable construction projects. The upcoming sections elaborate on the concepts of sustainability (3.1), complexity (3.2), risk (3.3), opportunity (3.4), management strategies (3.5), and present the results of the chapter, along with the next steps for the current research (3.6).

3.1. Sustainability and sustainable construction projects

Definition of sustainability

Elkington (1997) was the first author to propose the famous sustainability framework called "Triple Bottom Line". According to him, "society depends on the economy, and the economy depends on the global ecosystem whose health represents the ultimate bottom line" (environment). The triple bottom line includes three main concepts known as the 3Ps: Profit, People, Planet (EconPosts, 2020). Garren & Brinkmann (2018) defines sustainability as the ability of using a resource without permanently damaging it, or as using sustainable methods. However, benefits can also be created while ensuring that the environment and society are not impacted (Figge & Hahn, 2004). The value added by a company through different benefits, such as efficiency, is called Sustainable Value Added. The three pillars of sustainability are environmental, economic, and social "pillars" (Garren & Brinkmann, 2018; Primer, n.d). Environmental sustainability refers to protecting the natural resources by taking several measures. Economic sustainability is defined as the availability of economic resources, while social sustainability includes equal human rights and necessities for everyone (Primer, n.d.). The 3Ps are closely related to the three pillars of sustainability and are perceived as having the same meaning in the academic literature. Therefore, the profit is represented by the economy, people are represented by the society, and planet is represented by the environment (Figure 3.1).

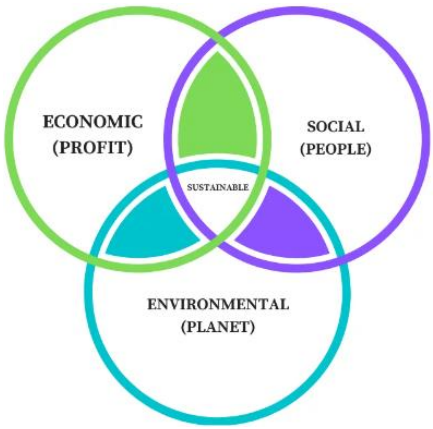

Figure 3.1. The Triple Bottom Line and 3Ps (EconPosts, 2020)

Sustainability in the construction industry

Several industries have started taking steps towards achieving net zero. The study further zooms in the construction industry. As the built environment produces 40% of the annual global carbon emissions (Architecture 2030, n.d.), the construction sector is responsible for making a change in this sense. Infrastructure projects have a high impact on the three main aspects of sustainability (economy, environment, and society). Beermann and Chen Austin (2021) also defined sustainable construction by encompassing these three main aspects. From an environmental perspective, sustainable construction requires suitable waste management strategies, renewable materials, and the use of strategies that protect the environment. From an economic point of view, the key is efficiency in using materials and sources. Lastly, sustainability is implemented in the social aspects by satisfying the needs of the people involved in construction processes (Figure 3.2).

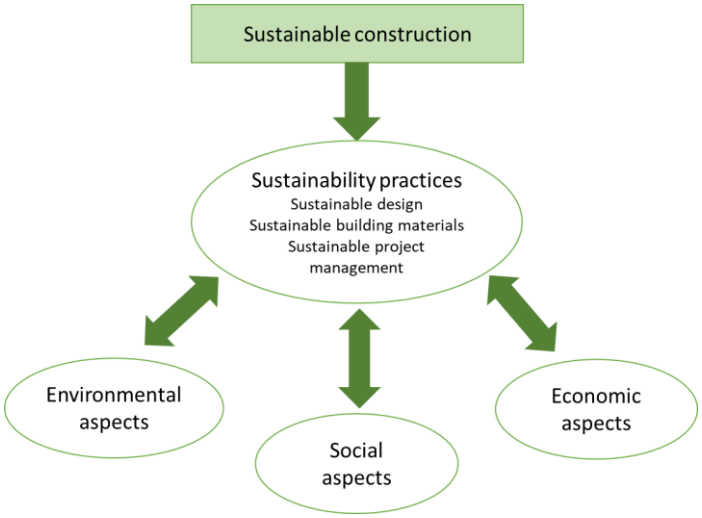

Figure 3.2. Definition of sustainable construction (illustration adapted from Beermann & Chen Austin, 2021)

Go Construct (2020) stated that sustainable construction involves "building with renewable and recyclable resources and materials". Another definition of the concept was built by the seven principles of sustainable construction, which are sustainable design, durability, indoor air quality, sustainable building materials, waste reduction, water conservation, and energy efficiency (Build Pass, 2021). Marcelino-Sadaba et al. (2015) also described sustainable construction as the construction projects which aim to develop the society and economy, while protecting the environment. Besides the definitions of sustainable construction, Beermann and Chen Austin (2021) found that sustainable practices should be implemented in all the stages of a construction project, from its beginning to its end.

Considering the definitions that are given above, the study describes the concept of sustainable construction projects by using a combination of these definitions. The following is the author's interpretation of the concept based on the findings of the literature:

*"**Sustainable construction projects** are construction projects in which sustainability practices are implemented. Some of these practices can be sustainable design, the usage of sustainable building materials, managing the waste and its reduction by using suitable strategies, etc. Sustainable*

construction projects are managed by considering the economic, environmental, and social aspects."

3.2. Complexity

Projects have become more and more complex, therefore more attention is paid to the concept of project complexity and the need for suitable strategies to cope with it (San Cristóbal et al., 2018). As Baccarini (1996) states, the construction industry is the most complex amongst all industries. Hence, the current study zooms in complexity in construction projects. Complexity influences construction projects as it impacts the time and budget estimates, procurement, and contracting. The literature shows that project complexity can be technical, organizational, and environmental (Baccarini, 1996; Antoniadis et al., 2008; Wood & Gidado, 2008; Wood & Ashton, 2009; Lebcir & Choudrie, 2011; Bosch-Rekveldt et al., 2011; Dao et al., 2016; Shernoff et al., 2016; Dooley, 2002). The definitions of technical, organizational, and external complexity are shown in Table 3.1.

Table 3.1. Definitions of technical, organizational, and environmental complexity

Term	Definition
Technical complexity	Originates from the technical aspects of the project (goals, tasks, tranformational processes, design, etc) and their interconnectivity, size, or interfaces between them (Baccarini, 1996; Bosch-Rekveldt, 2011; Lebcir & Choudrie, 2011; Dao et al., 2016)
Organizational complexity	It is the type of complexity which originates from elements that are part of the organization. The number of elements, as well as the variety, interrelatedness, and interdependencies between the team members contribute to organizational complexity (Dooley, 2002; Wood & Gidado, 2008)
Environmental complexity	It is the type of complexity created by external factors which could bring environmental challenge and support at the same time. The factors can be stakeholders, location, market conditions, risks, etc. (Bosch-Rekveldt, 2011; Shernoff et al., 2016)

Complexity – objective or subjective?

When looking at project complexity's objectivity or subjectivity, the literature illustrates both possibilities. Zolin et al. (2009) show that complexity can be objective, as it is perceived as "the characteristic of the structure or behavior of an organization". Complexity can also be subjective due to the uncertainty of recognizing a complex phenomenon, or the inaccuracy of comparing the complexity of several phenomena (Zolin et al., 2009). Complexity can be perceived differently depending on everyone's experience and skills, as well as external factors such as stakeholders and resources (Bosch-Rekveldt et al., 2011; Dao et al., 2016), therefore assessing project complexity is "a subjective process by nature" (Bosch-Rekveldt et al., 2011). This might impact the delivery of the project, leading to its success or failure (Bakhshi et al., 2016).

The study continues by perceiving project complexity as being subjective. Therefore, the project complexity is seen as being interpreted in a unique way by individual members of the organization or project team.

3.2.1. Complexity frameworks

Several project complexity frameworks were built to give a better understanding of the concept. The frameworks are selected as they include a large variety of complexity elements grouped in

different categories/dimensions. They were built to help industry experts identify the level of complexity of their project, as well as the factors which lead to complexity. One of the most popular complexity frameworks is TOE (Bosch-Rekveldt et al., 2011), which stands for Technical, Organizational, and Environmental complexity (Table F 1). The framework was built by using two main research methods, namely literature review and semi-structured interviews. It includes forty-seven elements of complexity divided into the three aforementioned categories. It further divides the categories into sub-categories, each of them comprising of elements of complexity. For instance, in the technical category, one sub-category is "tasks", and it includes complexities such as the variety of tasks or the interrelations between the technical processes. The framework also includes a column with questions that help the user understand what each element of complexity refers to.

Bakhshi et al. (2016) built an integrative systemic framework which helps understand the concept of project complexity by grouping several factors of complexity into the following dimensions: project context, connectivity, diversity, emergence, project size, autonomy, and belonging (Figure F 1). For instance, in the project context dimension, a few complexity factors are the geological condition and political issues. The framework was built based on findings in the academic literature (using literature review as a research method), and it includes thirty-six factors. Another complexity framework was built by de Rezende & Blackwell (2019) based on the Diamond framework, which includes four main dimensions with different complexity scales relating to the product of the project (for example, technology). Although it uses some of the scales of complexity from the Diamond framework, the new framework is more general and includes more complexity dimensions (Figure F 2). The dimensions found by de Rezende & Blackwell (2019) are the following: interdependence, uncertainty, speed, criticality, novelty, dynamic, political, social, institutional, and size/variety. Each of these dimensions has four levels of complexity. For instance, the speed dimension has the following levels of complexity: slow, regular, fast, and time critical. The framework could be used by experts when analysing several aspects of the project, such as goals, stakeholders, and budget. The three complexity frameworks are illustrated in Appendix F.

3.2.2. Complexity in sustainable construction projects

More and more companies have started to implement sustainability practices in their construction projects. It was noticed that complexity is increasing in sustainable construction projects and their requirements (Borg et al., 2020). In addition, there are several challenges which constitute a barrier in implementing sustainable project management in construction projects (Ershadi et al., 2021). This sub-section reviews the literature related to complexities in sustainable construction projects by following the selection process described in sub-section 2.1.1. Table G 1 in Appendix G includes an overview of all the complexity elements encountered in sustainable construction projects, found in the literature. The elements were selected at an organizational level and not broader (People-Planet-Profit) due to research time constraints. They were grouped into three main categories, in the same way that the TOE framework was built, in the technical, organizational, and environmental categories. Although the study was open to finding new categories of complexities, the categorization finally resumed to TOE. Therefore, twenty complexities were identified in the

literature specialized to sustainable construction projects and grouped in the category “technical” complexities, twenty-six elements were grouped into the “organizational” category, and fourteen in the “environmental” category.

It is noticed that there is an overlap of elements in the complexity frameworks illustrating complexity in general construction projects and the articles including complexities in sustainable construction projects. Some elements of complexity are suitable for both the general and the sustainable construction projects, such as the variety of project tasks, interfaces between professionals, and project location. However, certain elements might be encountered specifically when working on sustainable construction projects. For instance, elements such as sustainability requirements, lack of supporting processes to implement sustainability practices, lack of the sustainability concept knowledge from the project team’s or the project manager’s side, and interest/support in adopting principles of sustainable development are specific to sustainable projects. Table G 1 also includes a column illustrating a total of twenty-eight overlapping elements of complexity between general and sustainable construction projects. The unique elements are highlighted in the table. The study continues to focus on the complexity elements which are encountered only in sustainable construction projects. The unique elements were selected and listed in Table 3.2.

The specific elements are clustered into sub-categories. A few sub-categories were adopted from the TOE framework but adapted to be suitable for sustainable construction projects (for instance, project sustainability goals, requirements, scope, market influence). Each of them includes elements that are related to the same topics (goals, scope, etc.). Other sub-categories were created for complexities that are specific to sustainable construction projects (for example, project team’s expertise in implementing sustainability, stakeholders’ understanding of sustainability, etc.). The elements of complexity that arise related to the same aspects (project team, stakeholders) were clustered into sub-categories.

The technical category includes five sub-categories of elements of complexity:

- project sustainability goals – complexity arising from setting the project goals related to sustainability and their level of clarity
- project scope – complexity arising from defining the scope of the project and its level of clarity
- project sustainability requirements – complexity arising from setting the project requirements related to sustainability and their level of clarity
- project technical processes – complexity arising from the technical processes involved in the project
- project sustainable design – complexity arising from designing the project in a sustainable way

The organizational category includes four sub-categories:

- sustainable project management implementation – complexity arising from the implementation of sustainable project management by the team in the project
- project team's expertise in implementing sustainability – complexity arising from the project team's level of knowledge or expertise in implementing sustainability
- project team's interest in implementing sustainability – complexity arising from the project team's level/lack of interest in implementing sustainability in the project
- conflicts amongst the project team members – complexity arising from the conflicts amongst the project team members regarding the sustainability aspects of the project (practices, resources, compliance with requirements, etc.)

Lastly, the environmental category includes four sub-categories:

- stakeholders' understanding of sustainability – complexity arising from the way the stakeholders understand and apply the concept of sustainability in the project
- sustainability codes and standards – complexity arising from the codes and standards made for sustainability and complying with them
- market influence – complexity arising from the influence that the market has on the project (considering the project sustainability requirements and goals)
- conflicts between the project team and stakeholders – complexity arising from conflicts between the parties involved in the project regarding the sustainability aspects of the project (practices, resources, compliance with requirements, etc.)

Table 3.2. Complexity elements specific to sustainable construction projects (Literature review)

Element no.	Category	Sub-category	Complexity elements in sustainable construction projects	Author(s)
1	Technical	Project sustainability goals	Too ambitious sustainability goals	Mikaelsson & Jonasson (2021)
2		Project scope	Unclear project scope	Othman et al. (2014); Borg et al. (2021)
3		Project sustainability requirements	Unclear project sustainability requirements	Cao et al. (2020); Alves et al. (2021); Wu et al. (2018); Zhang et al. (2022); Scherz et al. (2022)
4		Project technical processes	Lack of supporting processes for the sustainability requirements	Gorecki et al. (2022); Maqbool & Amaechi (2022); Lindblad (2020); Alves et al. (2021); Wu et al. (2018); Borg et al. (2021); Chen et al. (2022)
5			Ambiguity in technical processes	Chen et al. (2022)
6		Project sustainable design	Complex and unique (sustainable) design	Cao et al. (2020); Wu et al. (2018); Othman et al. (2014); Frost et al. (2022); Chen et al. (2022); Marcelino-Sadaba et al. (2015)
7			Inadaptability and modularity of design solutions	Gorecki et al. (2022); Alves et al. (2021); Chen et al. (2022)
8			Inappropriate BIM & integrated design	Gorecki et al. (2022); Maqbool & Amaechi (2022); Chen et al. (2022)
9	Organizational	Sustainable project management implementation	Lack of sustainable resources	Maqbool & Amaechi (2022); Marcelino-Sadaba et al. (2015); Othman et al. (2014); Gorecki et al. (2022); Cao et al. (2020); Mikaelsson & Jonasson (2021)

Continued…

10	Organizational	Sustainable project management implementation	Lack of suitable management strategies	Scherz & Vafadarnikjoo (2019); Scherz et al. (2022); Chen et al. (2022); Marcelino-Sadaba et al. (2015); Zhang et al. (2022); Gorecki et al. (2022); Othman et al. (2014)
11			Complex decision-making process	Borg et al. (2021); Sarpin et al. (2021); Othman et al. (2014)
12			Lack of open communication	Sarpin et al. (2021); Zhang et al. (2022); Othman et al. (2014)
13			Difficulties in adopting sustainability practices	Sarpin et al. (2021); Ershadi et al. (2021); Maqbool & Amaechi (2022); Alves et al. (2021)
14			Inadequate sustainable project management collaboration	Ershadi et al. (2021); Maqbool & Amaechi (2022); Mikaelsson & Jonasson (2021); Wu et al. (2018)
15			Inappropriate risk management	Cao et al. (2020); Borg et al. (2021); Frost et al. (2022)
16			Inadequate training/delivering of information of sustainable project management principles	Sarpin et al. (2021); Ershadi et al. (2021); Zhang et al. (2022)
17			Policy implementation efforts	Maqbool & Amaechi (2022); Wu et al. (2018)
18			Inappropriate project organization structure	Maqbool & Amaechi (2022)
19		Project team's expertise in implementing sustainability	Improper cost management and control	Sarpin et al. (2021); Cao et al. (2020); Gorecki et al. (2022); Ershadi et al. (2021); Alves et al. (2021); Mikaelsson & Jonasson (2021); Borg et al. (2021); Othman et al. (2014)
20			Under-skilled project manager/project team	Sarpin et al. (2021); Gorecki et al. (2022); Maqbool & Amaechi (2022); Alves et al. (2021); Mazhar & Arain (2015); Othman et al. (2014)
21			Lack of sustainability concept knowledge of PM/project team	Sarpin et al. (2021); Gorecki et al. (2022); Alves et al. (2021); Wu et al. (2018); Mazhar & Arain (2015); Borg et al. (2021)
22			Lack of experience of the owner staff resources	Cao et al. (2020); Gorecki et al. (2022)
23			Lack of economic expertise	Gorecki et al. (2022)
24		Project team's interest in implementing sustainability	Lack of commitment of the project team (to the project)	Gorecki et al. (2022); Ershadi et al. (2021); Maqbool & Amaechi (2022); Wu et al. (2018); Rosales-Carreon & Garcia-Diaz (2015)
25			Lack of sensitivity to ecological issues	Gorecki et al. (2022)
26			Lack of respect for nature	Gorecki et al. (2022)
27		Conflicts amongst the project team members	Conflicts between professionals	Othman et al. (2014); Chen et al. (2022)
28	Environmental	Stakeholders' understanding of sustainability	Stakeholers' poor understanding of sustainability (financial, environmental, and social benefits, innovation in sustainability)	Maqbool & Amaechi (2022); Mikaelsson & Jonasson (2021); Borg et al. (2021)
29		Sustainability codes and standards	Lack of specialized codes and standards (for sustainability requirements)	Chen et al. (2022)
30		Market influence	Issues in market supply and demand	Wu et al. (2018); Rosales-Carreon & Garcia-Diaz (2015)
31			Issues in logistics	Gorecki et al. (2022); Zhang et al. (2022); Borg et al. (2021); Othman et al. (2014); Chen et al. (2022)
32		Conflicts between the project team and stakeholders	User/owner's lack of satisfaction (related to the project sustainability aspects)	Wu et al. (2018); Guo et al. (2019)

3.3. Risk

Alongside complexity, risk is another essential part of the current study. The concepts of complexity and risk might be related to each other and might influence each other during the project lifetime. Therefore, this section focuses on defining risk and project risk in sub-section 3.3.1, followed by finding a link between complexity and risk, in sub-section 3.3.2.

3.3.1. Definition of risk

The literature offers a variety of definitions of risk. Risk is defined as an event that can have numerous outcomes which can be "more or less favourable than the most likely outcome", each of them having a probability of occurrence (Smith et al., 2014). "Project risk" is perceived as the combination of these risks. Another similar opinion was shared by Zou et al. (2007), who defined project risk as the "combination of the probability or frequency of occurrence of a defined threat or opportunity" and the result of the occurrence. Williams (1996) defined risk as the probability and the impact of the risk. The dual side of risk is also described in the literature, which shows that risks can be perceived as an event that can have either a positive or negative impact on the project (Zou et al., 2007; Ward & Chapman, 2003). In line with this definition, Ward & Chapman (2003) stated that both threats and opportunities should be considered when managing the project risk. Gunderman & Applegate (2005) presented the need to balance the negative effects of risks with the potential benefits. The idea of perceiving risk as a threat or opportunity is also addressed by Hillson (2002), who considers risk as an "umbrella term". Hillson (2002) also defines uncertainty as threat or opportunity.

Considering the findings in the literature, the study uses the following definition of risk:

*"**Risk** represents an event that might happen which has a probability of occurrence and an impact. The impact can be either negative, called threat, or positive, called opportunity."* (Figure 3.3)

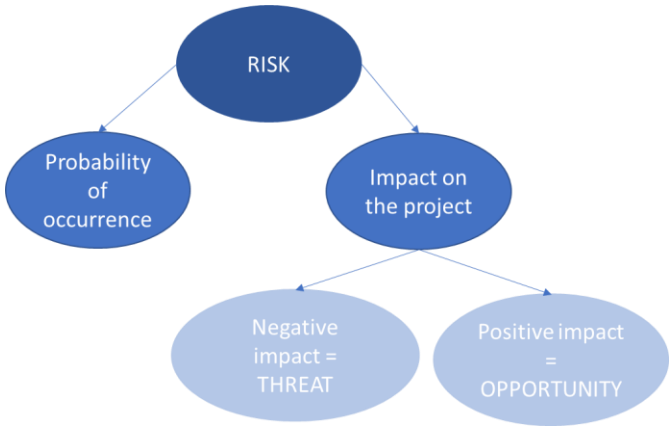

Figure 3.3. Definition of risk

3.3.2. Link between complexity and risk

Bosch-Rekveldt et al. (2011) stated that risk can contribute to project complexity because of its probability, impact, and total number of risks in a project. Risk is perceived as an element of complexity that can be part of the TOE framework as technical risks, organizational risks, and

environmental risks, thus leading to the same types of complexity and the overall project complexity. However, the academic literature shows that project complexity can lead to risks as well (Bosch-Rekveldt et al., 2011; University of Minnesota Libraries, 2016). For instance, the high level of technological complexity caused by unknown errors might lead to high risks in budget, schedule, and quality (University of Minnesota Libraries, 2016).

Regarding the relation between complexity and risk in a project, the current study considers both possibilities that are expressed above. Table G 1 shows that risk management is one element of complexity that can be encountered in sustainable construction projects, hence risk is seen as an element which contributes to the project complexity. However, the literature presents the opposite view as well. Therefore, the study shows that (project) complexity and (project) risk are interrelated, can influence each other, or result from each other (Figure 3.4).

Figure 3.4. The interrelatedness between project complexity and project risk

3.4. Opportunities in construction projects

As sub-section 3.3.1 described threat and opportunity as the two sides of risk, the study further dives into the positive side of risk, which is opportunity. Therefore, it is first important to understand the concept of opportunity. According to Cambridge Dictionary (2023), an opportunity is defined "as an occasion or situation that makes it possible to do something that you want to do or have to do or the possibility of doing something". Opportunity is also perceived as "an appropriate or favorable time or occasion" (Dictionary, 2023).

Zooming into opportunity in the context of construction projects, it has been noticed that in general, project managers might not be aware of the potential opportunities that might arise in a project because they focus on their experience with risks (Denney & Powell, 2020). Moreover, experts tend to focus on the negative side of risk and overlook the positive aspects (Hillson, 2004). This section analyses the literature related to opportunities. In sub-section 3.4.1, opportunities in sustainable construction projects are identified from several academic articles.

3.4.1. Opportunities in sustainable construction projects

This sub-section reviews the literature related to opportunities in sustainable construction projects by following the selection process described in sub-section 2.1.1. Twenty academic articles were analysed using the Atlas.ti software, with the purpose of identifying potential opportunities that can arise in sustainable construction projects at the project and organizational levels. Opportunities at a broader level were not looked at due to research time constraints. By using Atlas.ti, every time an opportunity was found in an article, a code was associated with it. The codes represent several categories and sub-categories of opportunities, which were built after identifying opportunities of the same type. The code scheme imported from Atlas.ti, which illustrates the categorization and sub-categorization of opportunities is visualized in Figure 3.5. By using Atlas.ti, eighty-six opportunities were found. In general, the opportunities found in sustainable

construction projects arise from various sources, such as the choice of building materials, sustainable buildings, policies, business models, value management, or numerous technologies (such as Building Information Modeling and Artificial Intelligence). For instance, by making a building sustainable, opportunities such as the well-being and comfort of the end-users can arise.

The opportunities were categorized according to the three main levels of sustainability: environmental, social, and economic opportunities. The definitions of the three levels were adapted to describe the environmental, social, and economic opportunities (Table 3.3).

Table 3.3. Definitions of environmental, social, and economic opportunities (adapted from Primer, n.d.)

Term	Definition
Environmental opportunities	Enable the environmental protection and balanced use of resources through applying sustainability practices such as resource management, waste management, quality requirements, and assessing and monitoring the impact on the environment.
Social opportunities	Represent equal human rights and necessities for everyone, such as health, safety, a balanced lifestyle, availability of jobs, education, and accessible housing.
Economic opportunities	Are defined as the availability of economic resources across generations (for instance, salaries, loans, etc.).

For a better understanding and clear organization of all the opportunities found, they were grouped into sub-categories. Once all the opportunities were listed, it was noticed that some were related to the same elements. For instance, all the opportunities related to resources were sub-categorized into "resources", while all the ones linked to managing and implementing sustainability were grouped into "sustainability management". The other elements were grouped in the same manner, while some were different from the rest (for instance, setting standards). Separate sub-categories were created for them.

In the environmental category, five sub-categories were created:

- quality – opportunities related to the environmental quality assurance
- setting standards – opportunities related to pushing the market (contractors, subcontractors, suppliers) to be more sustainable through several practices, materials, and other factors
- resources – opportunities related to the sustainable usage of resources
- sustainability management – opportunities arising from managing the projects in a sustainable way by using different sustainability practices
- waste management – opportunities originating from the way the waste is managed

In the social category, the following four sub-categories were created:

- health & safety – opportunities related to the employees' health and safety on the site or at the office, at any given point during the project lifetime; it can also refer to the end-users' health and safety after the project is delivered
- jobs – opportunities related to the employees' jobs, such as the creation of jobs
- lifestyle – opportunities related to the employees' lifestyle and experience while working; it can also refer to the end-users' lifestyle after the project is delivered

- training and education – opportunities for training and education for employees or end-users

Lastly, the economic category includes seven sub-categories:

- collaboration – opportunities for collaboration with other professionals in the future (for the organization)
- competition – opportunities in the competition amongst organizations or client companies
- costs – opportunities for lower project costs for the organization or client
- image – opportunities for a good image for the organization
- processes – opportunities to use specialized and suitable processes to comply with the sustainability requirements
- quality – opportunities for a high-quality end-product
- resources – opportunities related to materials, technologies, and employees' work

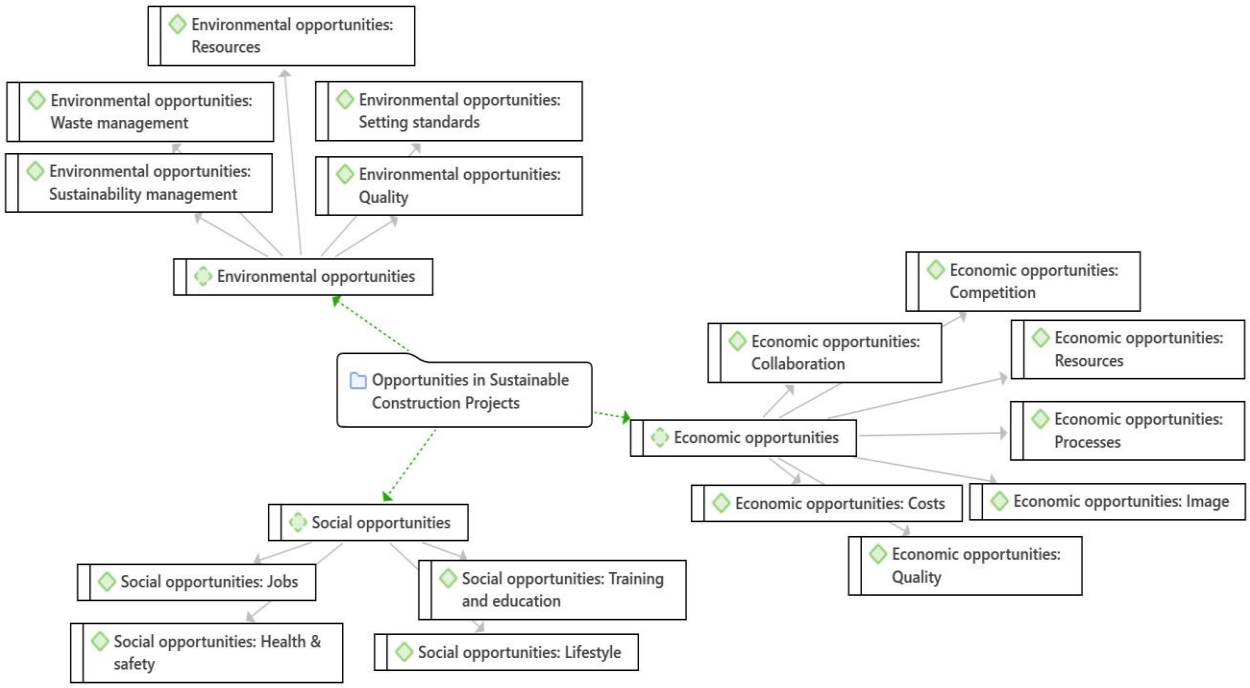

Figure 3.5. Code scheme illustrating the categories and sub-categories of opportunities from the academic literature (Atlas.ti)

Table 3.4 illustrates an overview of the opportunities found in the literature, grouped into the three categories and the sixteen sub-categories observed in Figure 3.5.

Table 3.4. Opportunities in sustainable construction projects (Literature review)

Element no.	Category	Sub-category	Opportunities in sustainable construction projects	Author(s)
1	Environmental opportunities	Quality	Radioactivity and impurities neutralization	Sonebi et al. (2022)
2			Improved air quality	Emmanuel Eze et al. (2020); de Almeida Barbosa Franco et al. (2022)
3			Carbon storage (ecological quality)	Lahtinen et al. (2019)
4		Setting standards	Setting standards for future development	Marsh et al. (2022)
5		Resources	Optimization of resources	de Almeida Barbosa Franco et al. (2022)
6			Reduce resource scarcity	de Almeida Barbosa Franco et al. (2022)
7			Improve and assess energy performance	de Almeida Barbosa Franco et al. (2022)
8			Improve resource efficiency	de Almeida Barbosa Franco et al. (2022); Emmanuel Eze et al. (2020); Riala & Ilola (2014)
9			Assess resource efficiency	de Almeida Barbosa Franco et al. (2022)
10			Reduce resource consumption	Emmanuel Eze et al. (2020); de Almeida Barbosa Franco et al. (2022); Lahtinen et al. (2019); Tafazzoli et al. (2020)
11			Reduce resource demand	Piderit et al. (2019)
12			Promote resource conservation	Marsh et al. (2022)
13		Sustainability management	Predict the impact on the environment	de Almeida Barbosa Franco et al. (2022)
14			Manage the impact on the environment	de Almeida Barbosa Franco et al. (2022)
15			Monitor the impact on the environment	de Almeida Barbosa Franco et al. (2022)
16			Promote recycling of raw materials	Zu Castell-Rudenhausen et al. (2021)
17			Promote reusage of raw materials	Zu Castell-Rudenhausen et al. (2021)
18			Manage sustainability issues	Yu et al. (2018)
19			Sustainable tendering (such as environmental scoring criteria)	Yu et al. (2018)
20			The reduction in CO2 emissions	de Almeida Barbosa Franco et al. (2022); Emmanuel Eze et al. (2020); Karlsson et al. (2020); Piderit et al. (2019)
21		Waste management	Waste minimization	de Almeida Barbosa Franco et al. (2022); Emmanuel Eze et al. (2020); Marsh et al. (2022); Tafazzoli et al. (2020); Torgautov et al. (2021); Yu et al. (2018)
22			Waste recycling	de Almeida Barbosa Franco et al. (2022); Yu et al. (2018); Emmanuel Eze et al. (2020)
23			Waste reusage	Yu et al. (2018)
24			Assess waste management	de Almeida Barbosa Franco et al. (2022); Yu et al. (2018); Zu Castell-Rudenhausen et al. (2021)
25			Improve waste management	de Almeida Barbosa Franco et al. (2022); Yu et al. (2018)
26	Social opportunities	Health & safety	Avoid physical stress and injuries	de Almeida Barbosa Franco et al. (2022)
27			Improve health & safety	de Almeida Barbosa Franco et al. (2022); Dlamini & Yessoufu (2022); Emmanuel Eze et al. (2020); Marsh et al. (2022); Tafazzoli et al. (2020)
28			Reduction in work accidents	de Almeida Barbosa Franco et al. (2022)
29			Alerting of potential accidents	de Almeida Barbosa Franco et al. (2022)
30		Jobs	Job opportunities	Emmanuel Eze et al. (2020); Marsh et al. (2022); Gan et al. (2015)
31			High salaries for employees	Murtagh et al. (2016)
32			Reduced vacant spaces	Emmanuel Eze et al. (2020)

Continued…

33	Social opportunities	Lifestyle	Modern lifestyle	Booth et al. (2021)
34			Aesthetics of the buildings	Booth et al. (2021)
35			Facilities management	de Almeida Barbosa Franco et al. (2022); Murtagh et al. (2016); Torgautov et al. (2021)
36			Noise voidance and reduction	Emmanuel Eze et al. (2020)
37			Improved quality of life	Emmanuel Eze et al. (2020); Marsh et al. (2022); Piderit et al. (2019)
38			Self-identity	Murtagh et al. (2016)
39			Enjoyment	Murtagh et al. (2016)
40			Improvement of customer satisfaction	Tafazzoli et al. (2020)
41		Training and education	Educational programs for professionals	Araya et al. (2022)
42			Promote training plans	Araya et al. (2022)
43			Retain sustainability-related knowledge through collection of data/information from completed projects	de Almeida Barbosa Franco et al. (2022)
44			Training of workers related to sustainability	de Almeida Barbosa Franco et al. (2022); Yu et al. (2018)
45			Professionals' specialization	Emmanuel Eze et al. (2020)
46			Sustainability guidance for practitioners	Yu et al. (2018)
47	Economic opportunities	Collaboration	Increased collaboration and transparency among stakeholders	de Almeida Barbosa Franco et al. (2022)
48			Efficient experience sharing scheme	Emmanuel Eze et al. (2020)
49			Partnerships for knowledge	Emmanuel Eze et al. (2020)
50			Collaboration between professionals	Marsh et al. (2022)
51			Promoting the client's interest in sustainability	Yu et al. (2018)
52		Competition	Competitive advantage	Marsh et al. (2022)
53			Improved project outcomes	Emmanuel Eze et al. (2020)
54		Costs	Low-cost resources (such as materials, systems)	Sonebi et al. (2022); Booth et al. (2021); de Almeida Barbosa Franco et al. (2022); Lahtinen et al. (2019)
55			Eliminate energy bills	Booth et al. (2021)
56			Avoid redesign costs	de Almeida Barbosa Franco et al. (2022)
57			Improved/reduced costs	de Almeida Barbosa Franco et al. (2022); Tafazzoli et al. (2020); Zu Castell-Rudenhausen et al. (2021); Dlamini & Yessoufu (2022)
58			Optimization of costs	de Almeida Barbosa Franco et al. (2022); Riala & Ilola (2014)
59			Facilitate cost estimations	de Almeida Barbosa Franco et al. (2022)
60			Lower operational costs	Dlamini & Yessoufu (2022); Emmanuel Eze et al. (2020); Gan et al. (2015); Saleh & Alalouch (2015)
61			Lower development costs	Saleh & Alalouch (2015)
62			Lower maintenance costs	Dlamini & Yessoufu (2022); Emmanuel Eze et al. (2020); Saleh & Alalouch (2015)
63			Higher profit and return on investment	Emmanuel Eze et al. (2020)
64			Lower life-cycle costs	Emmanuel Eze et al. (2020); Marsh et al. (2022)
65			Less financial risks	Shan et al. (2017)
66			Cost-effective alternatives	Lahtinen et al. (2019)
67			Longer payback time for owners	Gan et al. (2015)

Continued…

68	Economic opportunities	Image	Good corporate image	Marsh et al. (2022); Shan et al. (2017); Gan et al. (2015); Emmanuel Eze et al. (2020)
69			Shows an organization's commitment to social responsibility	Marsh et al. (2022)
70		Processes	Appropriate project management	de Almeida Barbosa Franco et al. (2022)
71			Productivity and efficiency of operations and processes	de Almeida Barbosa Franco et al. (2022)
72			Integration of technology	Emmanuel Eze et al. (2020); Marsh et al. (2022)
73			Better technical solutions	Riala & Ilola (2014)
74			Promote green construction technologies	Shan et al. (2017)
75		Quality	Better quality of materials (such as strength, durability, workability, appearance, and molding)	de Almeida Barbosa Franco et al. (2022)
76			High-quality building techniques	Lahtinen et al. (2019)
77			Quality in design	Murtagh et al. (2016)
78		Resources	Obtaining of raw materials	Araya et al. (2022)
79			Usage of locally sourced materials	Booth et al. (2021)
80			Structure construction, mapping, monitoring	de Almeida Barbosa Franco et al. (2022)
81			Provide interaction with the project	de Almeida Barbosa Franco et al. (2022)
82			Provide collection and connection of information	de Almeida Barbosa Franco et al. (2022)
83			Integration of projects and experts	de Almeida Barbosa Franco et al. (2022)
84			Saving the natural resources	de Almeida Barbosa Franco et al. (2022)
85			Increase in employees' productivity and reduction in absenteeism	Emmanuel Eze et al. (2020); Marsh et al. (2022)
86			Investments into the advancement of technologies	Lazauskas et al. (2015)

As observed in Table 3.4, some of the opportunities were mentioned more often than others in the academic literature, which shows that they are common in sustainable construction projects. A few examples of common opportunities are the reduction in resource consumption (environmental), waste minimization (environmental), improvement of health & safety (social), improved/reduced costs (economic), and low operational costs (economic).

3.5. Management strategies

To explore the possibility of generating opportunities from complexity elements by using different management strategies, the current section reviews the literature related to management strategies used to deal with complexity.

3.5.1. Competing management approaches

As complexity impacts construction projects and could lead to budget overruns or delays in the project schedule, Koppenjan et al. (2011) express the need for management approaches in large engineering projects that would help industry experts manage the project and its complexity. In their paper, two main management approaches are described, which are seen as "competing" (Koppenjan et al., 2011). These are Predict-and-control or Type 1 approach and Prepare-and-commit or Type 2 approach.

The two management approaches are described and compared in terms of the key elements of the project and how the project team manages them. Predict-and-control is perceived as being traditional and systematic, while Prepare-and-commit is mostly based on considering all the elements of a project when dealing with complexity. Type 1 expresses the need to control the

project and prepare for unexpected situations from the first stages of the project by clearly defining the project scope and activities carried out by each of the project members. On the opposite end, Type 2 is less focused on the front-end and accepts that the project scope is not fixed, depending on the changes that might occur, while the project members' responsibilities are shared during the project lifetime. In Type 1, the construction stage is controlled by keeping a fixed schedule and budget, and incentivizing the contractors based on the execution of their tasks, while the opposite approach expresses the need for functional roles for the project members, which are advised to work closely with each other. The contractors are incentivized to functionally execute the project tasks in Type 2. Change is perceived as a negative factor in the Type 1 approach and avoided as much as possible through hierarchical team management with limited information exchange, while Type 2 is open to change, as it is perceived as inevitable. The management of the project team is similar to a network and involves a lot of information exchange. Lastly, the project interfaces are managed by a single project manager in Type 1, and by the entire project team in Type 2 (Koppenjan et al., 2011).

Predict-and-control and Prepare-and-commit are perceived as two opposite management approaches which express the need for control and flexibility, respectively. The conclusion of Koppenjan et al. (2011) is that the key elements of a project (scope, time, and budget) require a combination of the two approaches, as they cannot be managed properly if only one approach is implemented. The same applies to the other elements of the project. To compensate for the downsides of each approach, the combination of the two management strategies is recommended to be used in engineering projects.

3.5.2. Strategies focused on control and interaction

A similar viewpoint is expressed by Hertogh & Westerveld (2010), who describe the need for using a combination of different management strategies when dealing with complexity. Therefore, both control and interaction are recommended to be used when managing complex projects. On a scale of detail and dynamic complexity, four management approaches are suggested depending on the level of the two. Detail complexity refers to the type of complexity which includes several variables, while dynamic complexity is known as the type of complexity whose cause and effect are not obvious from the beginning, but become more visible with time, according to Senge (1997). The four management approaches are: Internal and Content Management, Systems Management, Interactive Management, and Dynamic Management and are described according to Hertogh & Westerveld (2010):

- Internal and Content Management – is a management approach which consists of finding a solution to the problem which occurred in the project without considering the level of control or interaction that might be required; the approach does not consider the stakeholders' requirements and is simply focused on solving issues
- Systems Management – is a management approach suitable for detail complexity and is focused on control; similarly to Predict-and-control, the strategy consists of strict management of the key elements of a project: scope, time, and budget; the purpose of

controlling these elements is to avoid unpleasant events, therefore the team should work to minimize the chances of such events

- Interactive Management – opposite to Systems Management, Interactive Management is suitable for dynamic complexity and is based on satisfying the stakeholders' needs and requirements; the approach is based on allowing flexibility and accepting that change is inevitable; it involves that the project members are aligned regarding the project scope, the problem can be rediscussed and redefined by considering all the team members' thoughts and solutions, and the predictability of different events is not long-term
- Dynamic Management – is a management approach suitable for a project with a high dynamic and detail complexity; it is based on two main elements: the combination of control and flexibility, and going the extra mile to manage the project in the best way possible; the latter element refers to having the right skills, effective cooperation with the stakeholders, new and innovative management solutions, being the project champion, and transforming threats into opportunities

The four management approaches are illustrated in Figure 3.6.

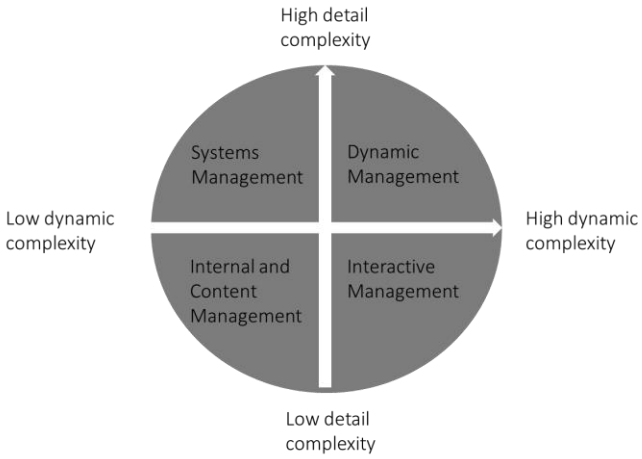

Figure 3.6. Strategies focused on control and interaction (adapted from Hertogh & Westerveld, 2010)

3.6. Conclusion

The previous sections show that both complexity and opportunities are an essential part of sustainable construction projects and are defined by the elements listed in Table 3.2 and Table 3.4. Sub-categories of elements of complexity were created, and it was noticed that complexity is different from general construction projects and requires specific goals, knowledge, commitment, technical processes, project team, and management methods. In terms of opportunities, three categories of opportunities were created, namely environmental, social, and economic, which were divided into sub-categories.

3.6.1. Complexities and opportunities in sustainable construction projects – way forward

In the upcoming stages, the study focuses only on the sub-categories of complexities and opportunities found in the literature – Table 3.2 and Table 3.4, respectively. As the next step is to

capture the complexities and opportunities encountered in sustainable construction projects in practice, new elements might be found depending on the data gathered from the document review and semi-structured interviews with the project members from TT UK, TT EIR, and TT NL. As the projects contribute to the net-zero and other sustainability goals, the complexities and opportunities are looked at and interpreted from a sustainability perspective and are perceived as arising from implementing the sustainability practices to make the projects sustainable (Figure 3.7).

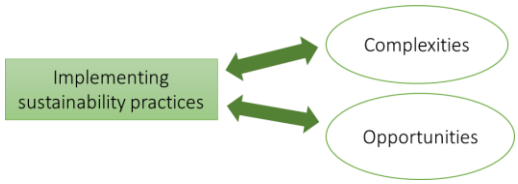

Figure 3.7. Complexities and opportunities perspective

The opportunities arising in the cases are interpreted from two different viewpoints. One perspective is the net zero goal, which refers to the environmental, social, and economic opportunities which impact the project/client (i.e., energy savings, air quality improvements) or the organization/TT (i.e., good reputation) (Figure 1.1). Other opportunities are considered outside the net-zero goal, as they directly impact the People-Planet-Profit level (i.e., positively contributing to the wider community, improving the effects of climate change).

3.6.2. Link between complexity, opportunity, and management strategies – way forward

The focus of the current sub-section is to build a conceptual framework that expresses the relation between project complexity and opportunities. The academic literature shows little research into the positive impact that complexity can bring, or the relationship with opportunities. The positive impact of complexity through opportunities and benefits is addressed (Vidal & Marle, 2008; Morcov, 2021; San Cristóbal et al., 2018). The connection between the two concepts was also explored in the context of infrastructure projects through uncertainty: "the uncertainty that emerges from complexity can lead to opportunities" (Massaad, 2021).

Previously, it was shown that complexity can lead to risks and risks can bring threats or opportunities in projects. The relationship between complexity and risk shows that complexity can actually lead to threats or opportunities. However, in the current study, threats are not explored, as the focus is on opportunities. Therefore, as the main connector, risk brings together complexity and opportunities and demonstrates that the two concepts are related, and that opportunities can arise from complexity. Having demonstrated this hypothesis, the next step is to find the means to obtain opportunities in the context of sustainable construction projects. To do this, the study suggests that the management strategies used to deal with complexity could be the means to generate opportunities in sustainable construction projects. The conceptual framework that expresses the relationship between project complexity and project risk, and management strategies as a potential way to generate opportunities is illustrated in Figure 3.8.

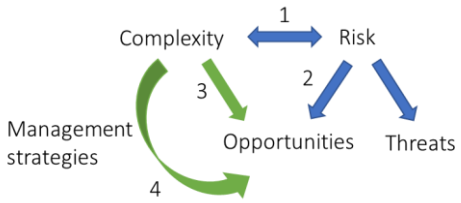

Figure 3.8. Conceptual framework expressing that complexity can generate opportunities

The upcoming chapter aims to find suitable management strategies that could confirm the conceptual framework. In section 3.5, it was noticed that the strategies Predict-and-control and Systems Management are based on control, while Prepare-and-commit and Interactive Management involve interaction. The current study continues by combining the characteristics of each of these two pairs of similar management strategies and refers to them as Control and Interaction, respectively (Table 3.5). This could help in correctly identifying and categorizing the management strategies found in the interviews.

Table 3.5. Characteristics of Control and Interaction (adapted from Koppenjan et al., 2011; Hertogh & Westerveld, 2010)

Control	Interaction
Predict-and-control & Systems Management	Prepare-and-commit & Interactive Management
Traditional and systematic	Considers all the elements of a project
Focused on the front-end	Not focused on the front-end
Control the project	Allows flexibility
Prepare for the unexpected	Changes might occur
Clear definition of the project scope	Project scope is not fixed
Clear definition of the project team's activities	Shared responsibilities
Keep a fixed scheduled and budget	Functional roles for the project members; advised to work closely with each other
Contractors are incentivized based on the task execution	Contractors are incentivized to functionally execute the project tasks
Change is avoided	Change is inevitable
Hierarchical team management	Network team management
Limited information exchange	Information exchange is supported
Project interfaces are managed by a single project manager	Project interfaces are managed by the entire project team
Suitable for detail complexity	Suitable for dynamic complexity
Strict management of scope, time, and budget	Satisfying the stakeholders' needs and requirements
Minimize the chances of unpleasant events	Project members are aligned on the project scope
	The problems are rediscussed and redefined considering all the team members
	Short-term predictability of events

4. Case study

The purpose of this chapter is to answer the second research sub-question:

"What complexity elements, opportunities, and management strategies could be found in the front-end phase of sustainable construction projects in practice?"

Section 4.1 presents the case study preparation, while section 4.2 describes how the data was collected from the cases. Further, in section 4.3, the data is analysed and interpreted related to complexities, opportunities, and management strategies. Lastly, the conclusion from the analysis of the cases is presented in section 4.4, along with the next step in the current research.

4.1. Case study preparation

This section presents the preparation for performing the analysis of the cases.

4.1.1. Selection of the cases

The cases are chosen based on the following four criteria:

Similarity of the countries: A first criterion is related to the three countries chosen for the study. Ireland and the UK are neighbouring countries for the Netherlands, so they have a similar culture and similar strategies for managing sustainable construction projects. Moreover, their branch offices are working on helping their clients reach the net-zero goal, which might mean that all three have similar ambitions. The analysis of cases from these three countries is relevant for the research as Ireland and the UK are more advanced in terms of how they manage the projects that are part of the net-zero goal, and a comparison among the three offices can be made.

Project scope: Another criterion is the scope of the project, which is to make offices or office buildings sustainable by means of fit-out works. Working on making offices as sustainable as possible and driving the projects in a sustainable way are two major goals that help TT advance on the way to net zero.

Completed front-end phase: The third criterion is that the projects should have completed the front-end phase. As the study zooms into this specific project phase, the conclusions related to the complexities and opportunities which arose in the front-end phase could be drawn by the project members only if the phase is completed.

Recommendation from a company Director: Before selecting the four cases, Directors from the three countries were contacted for recommendations of sustainable construction projects that could be suitable for the current study.

Based on these criteria, four cases were selected.

4.1.2. Description of the cases

Project A – TT EIR: It is a corporate occupier-type of project. The scope is to develop the interior of six floors of an office building according to the client's requirements. As hybrid work is preferred these days, only four of the floors will be occupied by the client's employees, while the remaining two floors will be rented out to other companies. The building is LEED* and BREEAM** certified,

and its design is WELL*** approved. However, the client has higher ambitions related to sustainability and requires a suitable design in this sense and the use of unique technologies in the building. The goal is to adapt the office to obtain LEED version 4.1. Gold, which is the latest version of the certificate. To achieve this, a team composed of architects, engineers, project and cost managers, sustainability consultants, and engineers specialized in smart and enhanced building systems are working on the project. Among their strategies, they are assessing the project on a cost-carbon basis.

**LEED (Leadership in Energy and Environmental Design) is a certificate which stands for healthy, energy and cost-efficient green buildings (U.S. Green Building Council, 2022)*

***BREEAM (Building Research Establishment Environmental Assessment Method) is an internationally accredited badge that proves the compliance of a building with its requirements (performance, quality, sustainability), according to BRE Group (2022); buildings are assessed in terms of energy consumption, pollution, water usage, waste, transport, health, materials, management, and land use and ecology (Oldenburger Fritom, n.d.)*

****WELL is an international certificate that promotes a healthy and active lifestyle, natural light, and air quality (AECOM, 2016)*

Project B – TT UK: The type of project is corporate occupier, with the scope of making a Grade 2 listed**** building as sustainable as possible by upgrading its internal fabric. The purpose is to make the office fit-for-purpose in line with the latest requirements. The client's main goal is to analyse the financial viability of transforming the interior of the 18-floor building into a more sustainable version. Another goal is to reduce the carbon emissions of the building, in line with the client's net-zero goal. The project's current position is BREEAM excellent, and the team are working on upgrading it to BREEAM outstanding and keeping the WELL Gold certificate. A team composed of architects, engineers, designers, and project and cost managers are working on changing and updating the previous design of the building, which was made pre-COVID, by using NABERS UK***** as a guide for assessing and measuring the carbon emissions of the building.

*****Grade 2 listed - a status that shows that the building must be preserved as it is of high interest (Bidwells, 2018)*

*****NABERS UK (National Australian Built Environment Rating System) is an adapted version of the original NABERS Australian certificate; it is a rating system that measures a building's energy efficiency by comparing it to specific measures which were developed using information related to the performance of several buildings; the rating is done using a scale from 0 to 6 stars (Australian Government, n.d.);*

Project C – TT NL: It is a corporate occupier-type of project. The scope of the project represents the transformation of a single-tenant building occupied by the client of the project, into a multi-tenant building. As COVID-19 impacted the employees' traditional ways of working, one of the project goals is to reduce the initial space by 50%. This implies that half of the building will be occupied by the client and the new tenants, while the other half is meant to be used for laboratory works as part of the client's company. As the client is opening the doors for new tenants, the other main project goal is to bring their partners closer to manage the energy transition in a collaborative way and achieve their net-zero goal together. The transformation of the building involves making all its office floors sustainable without impacting the existing partitions. As the building is already LEED Gold certified, the main implementations are choosing sustainable furniture and improving the look-and-feel for the employees with the help of TT's cost-carbon calculator, and a team composed of architects, project and cost managers, and engineers.

Project D – TT NL: The project is a corporate occupier-type, commissioned by a client company which is planning to expand through a higher number of employees in the next 4-6 years. The client decided to change the office location to a new building, occupying two floors of it. The office comprises a living area on one of the floors, and an office area on the other floor. The scope of the project consists of making the new office sustainable by means of fit-out works. As the building is BREEAM outstanding and WELL certified, the project goals will be achieved in accordance with the Green Lease* rules. The client's main goal is to create an office that is as sustainable as possible within the desired time and budget, following the LEED and WELL guidelines. A team composed of architects, project and cost managers, and engineers are working on achieving the client's goal without using the cost-carbon calculator.

**Green Lease is a lease agreement which ensures that the occupied space is used responsibly from a sustainability point of view; it requires attention to the energy and water consumption, and other factors while constructing and using commercial spaces (*Aquicore, n.d.)

4.2. Data collection

This section is divided into two sub-sections describing the sources for data collection.

4.2.1. Document review

Prior to conducting the interviews, the experts provided relevant documents related to their projects. The documents include data regarding the scope of the project, milestones (project execution plan, contractor requirements, returnable schedule – sustainability approach, sustainability delivery plan) and several certifications which show the sustainability targets of the project (WELL, LEED, BREEAM). The relevance of the document review in the current study is to help understand the projects and offer the opportunity to ask specific questions during the interviews. Moreover, the documents provide information related to the opportunities that the project members from TT are looking at in their projects, which are connected to the net-zero goal. Table 4.1 provides a list of the documents reviewed for each case.

Table 4.1. Documents reviewed for each case

Project	Documents reviewed
Project A	LEED initial assessment report
	LEED social impact checklist
	LEED & WELL client kick-off
	WELL human resources guidance
	LEED scorecard
	WELL checklist
	WELL scorecard
	WELL introduction
	Project execution plan
Project B	Sustainability delivery plan
Project C	Project sustainability opportunity guidance
	Project execution plan
Project D	Carbon case studies
	Additional sustainability services proposal
	BREEAM NL GreenLease support proposal

4.2.2. Semi-structured interviews

Selection of the interviewees

The interviewees are selected based on the following three criteria:

Part of the project team: The experts who participated in the study are currently working on the sustainable construction fit-out projects described in sub-section 4.1.2. As they are dealing with the sustainability targets required by their clients, they are directly contributing to achieving their clients' net zero and sustainability goals. Therefore, they could describe their experience in this type of project regarding the complexities and opportunities they encounter, and the management strategies used.

Role in the project: Another criterion is the project members' role, so the influence that they have on it. Although most interviewees are project managers, the following roles are relevant in the study as well: project director, sustainability consultant, and cost manager. The project manager is essential in the study as it is the role with "the widest view of elements contributing to project complexity" (Bosch-Rekveldt et al., 2011). Moreover, project managers must make sure the projects comply with all the sustainability requirements and plan everything accordingly. One senior and one junior project manager were selected for projects A, C, and D, as the different age and experience can lead to a different interpretation of the project complexity and opportunities. The project directors have an overview of the complexities and opportunities that can arise in all aspects of the projects, while the sustainability consultants and cost managers could identify these key elements from a sustainability and cost management point of view, respectively. Overall, the complexities and opportunities could be identified from various perspectives.

Recommendation from a company director: Directors from the three countries were contacted for recommendations of experts working on sustainable construction projects in their branch offices. Therefore, after mentioning the preferred roles for the current research (project managers and sustainability consultants), the directors recommended the experts who could participate in the research.

Interviewee profile

Table 4.2. Interviewee profile

Interviewee ID	Role	Company	Industry experience (years)
PM1.A	Associate Director - Project Management	TT	25
PM2.A	Assistant Project Manager	TT	6
CM.A	Associate Director - Cost Management	TT	8
SC.A	Director - Sustainability	Other	10
PM.B	Associate Director - Project Management	TT	11
SC1.B	Associate Director - Sustainability	TT	14
SC2.B	Principal Consultant - Retrofit & Housing	TT	18
PD.C	Director - Project Management	TT	22
PM.C	Project Manager	TT	8
SC.C	Senior Consultant - Sustainability	TT	4
PM1.D	Project Manager	TT	8
PM2.D	Junior Consultant - Project Management	TT	6
CM.D	Senior Cost Manager	TT	13

Twelve semi-structured interviews were conducted with the project members listed in Table 4.2. Ten experts were interviewed separately, while one interview included two experts (PM1.A and PM2.A), as they work closely within the project and could complement each other's answers. Moreover, eleven experts were chosen from the TT organization, while one expert (SC.A) was chosen from outside TT. As in project A there was no sustainability consultant from TT, SC.A was recommended by the Director from TT EIR and was still selected as the expert contributes to managing the project in a sustainable way and is aware of the complexities and opportunities encountered in the project. Moreover, SC.A's contribution to the project leads to achieving the net-zero target. The reason for interviewing only one project member from outside TT is that the rest of the teams either had their internal sustainability consultant (projects B and C) or did not have one at all and another member was recommended (project D). Lastly, the same project manager was selected for both cases in the Netherlands (PM.C, PM1.D), as the cases are very different from each other in terms of their scope, requirements, and project teams. Therefore, the results from the two interviews with the project manager were different, but in line with the other project members' viewpoints from project C or D.

Interview protocol

The majority of the questions that were asked during the interviews were predetermined. However, depending on the answers provided by the experts, new questions could be asked. According to Mashuri et al. (2022), semi-structured interviews are advantageous in qualitative research as they offer the interviewer the opportunity to dive into details depending on the interviewees' answers. Moreover, it gives the interviewer the chance to follow their research storyline while adapting or changing their questions in accordance with the clarity and comprehensiveness of the answers. Semi-structured interviews help focus on the desired topic while exploring the participants' thoughts in depth (Lai Yee, 2022). To make sure that the interview would be conducted without any misinterpretations, certain terms were defined beforehand (front-end phase, opportunities).

Another method was checking the clarity of the questions and terms for the project members by having an interview trial with the company supervisor. The supervisor's feedback led to improving the questions or giving additional explanations. While the term "opportunities" was explained in the same manner for everyone, the definition of "front-end phase" was adapted according to the terms used in each of the three counties. Regarding "complexity" as a term, in a previous research project carried out by the author of this study at TT, its meaning was unclear. Therefore, the term "complexity" was not used in the interviews, and it was replaced by the word "challenge". The connection between the two terms can be made as, usually, experts perceive complexity as a factor that would challenge them and impact their projects positively or negatively. The interview protocol can be found in Appendix H.

4.3. Results

This section presents the data gathered from the document review and the twelve semi-structured interviews. The documents gave an overview of the opportunities that the project members involved in the four cases look at, while during the semi-structured interviews, complexities, as

well as opportunities and management strategies could be identified from the discussions with the experts. In project C, the opportunities were identified directly in the Sustainability Opportunity Tracker, which included all the opportunities that the project members consider in their project. Although in projects A, B, and D, the elements were not specifically named "opportunities" in the documents, they were identified due to the similarity with the opportunities found in the literature.

Sub-sections 4.3.1, 4.3.2, 4.3.3, and 4.3.4 include the above-mentioned key elements listed in different tables for projects A, B, C, and D, respectively. The tables also include their categorization and the interviews or documents where they are mentioned. Compared to the elements previously found in the literature specialized for sustainable construction projects, in the interviews and documents, new key elements were found. To analyze the documents and transcripts from the interviews, Atlas.ti was used for code analysis. Every time a complexity element, opportunity, or management strategy was found, a code was assigned to them, after which the elements could be categorized and sub-categorized. The code schemes for complexities (Figure I 1), opportunities (Figure I 2), and management strategies (Figure I 3) can be found in Appendix I.

4.3.1. Project A

In project A, the **complexity** which arose in the front-end phase of the project originated from the client's requirement to comply with the latest version of the LEED certificate for the office fit-out. On the technical side, the new certificate impacted the clarity of the project sustainability requirements and goals and brought changes to the design, as well as schedule delays ("from a time point of view, there is some loss of efficiencies" – CM.A). On the organizational side, in the beginning, the project team did not have the expertise to comply with the new requirements ("I did not understand what was out there and how to get it" – PM2.A) and had difficulties to communicate the sustainability benefits to the client and to consider the sustainability consultant's opinion.

Although the client's goal was certain (a sustainable office that complies with the latest version of LEED), environmentally, the project complexity arose from the client's lack of understanding of the need to achieve this goal. The compliance with the codes and standards (LEED) also brought complexity to the project because the chosen version required more attention from the project team ("the biggest challenge was the energy model" – SC.A). Lastly, the communication between the client and the project team brought complexity as the client did not have the resources (time and experts) to dedicate to discussing all the aspects of the LEED certificate. The complexity elements are listed in Table 4.3. In comparison with the complexity elements selected after the literature review, the new elements of complexity are highlighted in the table.

Table 4.3. Complexity elements found in interviews (Project A)

Complexities			
Category	Element	Description	Mentioned in interviews
Technical	Project sustainability goals	Unclear sustainability goals	CM.A
	Project sustainability requirements	Unclear sustainability requirements	PM1.A; CM.A
	Project sustainable design	Design changes to improve the building's efficiency	PM1.A
	Project schedule	Schedule delays (fixed schedule)	PM1.A; CM.A
Organizational	Project team's expertise in implementing sustainability	Lack of sustainability knowledge and implementation	PM1.A; PM2.A
	Sustainable project management implementation	Considering stakeholders' opinions; issues with proving the sustainability advantages to the client	PM1.A; SC.A
Environmental	Stakeholders' understanding of sustainability	Client's lack of understanding of sustainability	PM1.A; PM2.A; CM.A; SC.A
	Sustainability codes and standards	Challenges to comply with the newest LEED version	SC.A
	Stakeholders' resource management	Difficulties in engaging with the client; client's lack of resources to communicate	PM2.A

Table J 1 in Appendix J lists the **opportunities** found in the documents which illustrate the compliance of the project with the LEED and WELL certificates. Table 4.4 presents the opportunities mentioned in interviews by the experts working on the project. At an environmental level, there are several opportunities which arose in the front-end phase of the project. These are related to setting standards as the project team challenged the stakeholders to find sustainable solutions ("you could set up a threshold saying OK, this is the baseline" – SC.A). Another opportunity originated from the reduced use of resources (water, energy) and sustainability management by monitoring the impact on the project life cycle. Alongside these opportunities, environmentally, the documents also illustrated a reduced carbon footprint and the management of the waste produced by construction and demolition.

The social opportunities are related to the end-users' health and safety by ensuring a working environment that would contribute to their mental and physical health and a good lifestyle by offering several facilities and a social environment. Other opportunities are related to training and education for end-users (in this case, the children who visit the building) and project members, and an enhanced work process (as a sustainability-advanced office building was chosen for the project, "we are starting off on a good foot" – PM1.A; "we are a step ahead in terms of their policies" – PM2.A). The documents showed that the end-users (employees) are also educated regarding mental health. The economic opportunities are related to the costs, quality, image ("it's a very distinguishable, so recognizable, prominent building, so it is a good one to add to our portfolio of projects" – PM1.A), new project acquisitions and reductions in resource consumption. The documents showed a new opportunity, which is social equity. The project also brought one environmental opportunity which is not related to the net-zero goal.

In addition to the opportunities found in the literature selected for this study, the opportunities found in interviews or documents are highlighted in the tables.

Table 4.4. Opportunities found in interviews (Project A)

Opportunities				
Category	Element	Description	Opportunities for	Mentioned in interviews
Environmental	Setting standards	Challenging suppliers, designers, and engineers to offer sustainable solutions; setting up thresholds for stakeholders	Client	CM.A; SC.A
	Resources	Reduced energy consumption, water efficiency (after the project is delivered)	Client	SC.A
	Sustainability management	Monitoring the current impact on the project life cycle	Client	CM.A
Social	Health & safety	Ensuring good daylight ratio, air circulation, and the end-users' mental and physical health	Client	PM2.A; CM.A
	Lifestyle	End-users' engagement with each other; facilities (bus stops, showers, lockers, thermal comfort); enjoyment of work place	Client	PM2.A; CM.A; SC.A
	Training and education	Educating children with the displays inside the building (project level); getting knowledge and applying it in future projects; upskilling (TT level)	Client and TT	PM1.A; PM2.A; CM.A; SC.A
	Work process	Enhanced work process: the TT team is a step ahead in terms of policies and work process because the client chose a suitable building and had the required information	TT	PM1.A; PM2.A
Economic	Costs	Lower product costs, good return on investment, profitability	Client	CM.A; SC.A
	Image	Being a positive example for choosing the newest version of LEED; gaining people's trust; good reputation	TT	PM1.A; PM2.A; CM.A; SC.A
	New project acquisitions	Working on project A brings a "good business opportunity" as the project has several sub-projects	TT	PM1.A
	Quality	End result: high-quality sustainable fit-out	Client	CM.A; SC.A
	Resources	Reduced energy consumption, improved efficiency of the building (after the project is delivered)	Client	PM1.A; SC.A
Environmental outside TT's net-zero goal	Helping in solving the world's most complex problems	Positively impacting the built environment; being a positive example for the market	Environment	CM.A

During the interviews, the project members were asked about the **management strategies** used to deal with complexity or find opportunities, or the lessons learnt that they would apply in future sustainable fit-out projects. The experts gave several examples of management strategies which are listed in Table 4.5 and clustered into five categories.

- **communication and reporting** – includes strategies such as the clear understanding of the project requirements, early communication and recommendations, regular meetings with the clients, guiding the client in the decision-making process, regular reporting, tracking progress, making a communication plan, governance and reporting
- **project planning** – includes strategies such as early planning, prioritizing and planning the sustainability requirements, setting up goals and targets and ways of approaching them, implementing and establishing the cost-carbon relation, mapping the supply chain, identifying opportunities, narrowing down the available options, and set boundaries for the project goals

- openness to change – includes strategies such as adding value to the project by allowing flexibility in the time or budget, analysing, suggesting or adopting different scenarios and methods which are suitable for the sustainability goals and requirements, and setting a mindset to always be on top and prepared for what will come

Table 4.5. Management strategies found in interviews (Project A)

Management strategies				
Category	Strategy		Observed dominant strategy	Mentioned in interviews
	Applied	Suggested/Ideal		
Communication and reporting	Clear understanding of the project sustainability requirements		Control	PM2.A
	Early communication and recommendations for stakeholders		Interaction	CM.A; SC.A
	Clear and regular communication and reporting		Control	PM1.A; PM2.A; CM.A; SC.A
	Making a communication, reporting, and risk management plan		Control	PM1.A; CM.A; SC.A
	Contributing to the client's workshops and guiding the client in the decision-making process	Contributing to the client's workshops and guiding the client in the decision-making process	Interaction	PM1.A; PM2.A; SC.A
	Tracking and measuring the progress of the project		Control	CM.A
Project planning	Planning early on (sustainability requirements, adoption of scenarios and methods, etc.)		Control	CM.A
	Planning and prioritizing the sustainability requirements		Control	CM.A
	Setting up targets/goals and strategies		Control	CM.A; SC.A
	Approaching targets/goals in a program or sequence		Control	PM1.A; CM.A
	Implementing and establishing the cost-carbon relation		Control	CM.A
	Supply chain mapping		Control	CM.A
	Identifying opportunities		Interaction	CM.A
Openness to change		Adding value by allowing flexibility in the time/budget	Interaction	SC.A
	Analysing, suggesting, or adopting different scenarios and methods		Interaction	CM.A; SC.A
Team strategies	Engaging the relevant stakeholders early upfront	Engaging the relevant stakeholders early upfront	Interaction	PM1.A; CM.A
	Aligning the design, project team, and stakeholders on the project sustainability goals		Interaction	CM.A
		Making stakeholders part of the core project delivery team	Control	CM.A
		Booking the client's time in advance	Control	PM1.A
		Optimizing the client's number of workshops	Control	PM1.A
External strategies	Challenging the supply chain to be more sustainable		Control	CM.A
	Problem escalation		Control	PM1.A

- team strategies – refers to the decisions made by the internal project team (project and cost managers) and includes strategies such as engaging all the relevant stakeholders up front, choosing a local project team or sustainability experts, aligning the team on the

sustainability goals, making stakeholders' part of the core project delivery team, scheduling meetings with the client in advance

- external strategies – includes strategies such as challenging the supply chain regarding sustainability, escalating issues encountered at the project level to experts of a higher grade in the company, seeking sustainability knowledge, managing the project data, reflecting on own work, and capturing lessons learnt

The strategies were divided into applied and suggested/ideal strategies. The applied strategies are the ones that the project members already used in their projects, while the suggested/ideal represent the strategies mentioned as lessons learnt that they would apply in a future sustainable project. To make the connection between the Control and Interaction strategies found in the literature, and the management strategies found in interviews, the latter were analysed in terms of how much control and interaction they involve. A separate column in Table 4.5 ("observed dominant strategy") expresses if the management strategies mentioned by the project members involve more control or interaction, and this is retrieved from the answers given in interviews.

The interviewees were also asked about the strategies they use to transform the negative impact from the complexities (challenges) into opportunities. In project A, they mentioned a large number of strategies but, in general, they did not describe how they transformed one specific challenge into an opportunity. However, CM.A gave a few specific examples of how management strategies could lead to opportunities. The examples were linked to potential complexity elements:

- if the project sustainability requirements are not clear (technical complexity), by working on understanding them clearly (communication and reporting strategy), the work process is going to be easier (social opportunity) or the quality of the project higher (economic opportunity): the project members "are more empowered to make sustainable decisions, and if they understand that, the brief is going to be that much clearer, which will allow the consultants to provide the information to make the decisions a lot easier, a lot clearer than trying to figure out the goals along the way"
- if the sustainable project management implementation is complex (organizational complexity), by making the stakeholders part of the core project delivery team (team strategy), the quality of the project will be very high: "the output of the engagements of the wider consultants […] is that the end product for the client is going to be a really, really high-quality sustainable fit-out with good credentials"
- if the sustainable project management implementation is complex (organizational complexity), by engaging the relevant parties early upfront (team strategy), tracking, measuring progress, and reporting (communication and reporting strategy), opportunities such as good reputation, share price, and profitability might arise
- if the project sustainability requirements are unclear (technical complexity) or if the sustainable project management implementation is complex (organizational complexity), by making the stakeholders part of the core project delivery team, "all the targets can be laid out and addressed immediately", which can lead to several opportunities, such as a high-quality project (economic) or easy work process (social)

4.3.2. Project B

Project B brought all three categories of **complexities** into the front-end phase of the project. Technically, the previous design of the building was listed as a Grade 2 building, which brought difficulties to the project scope and limited the project members' possibilities to make the building sustainable. The project schedule and budget were fixed, which brought more complexity ("the project had planning constraints – PM.B). The organizational complexity originated from the project team's lack of sustainability knowledge and difficulties to implement the sustainability practices ("challenges around internal skills within the project team knowledge about sustainability and net zero interventions and how those could be applied" – SC2.B). Environmentally, the client's lack of understanding of sustainability and net zero brought complexity to the project. Moreover, there were some difficulties to obtain information about manufacturing processes from the suppliers. Lastly, the client's lack of interest in implementing sustainability (as sustainability did not have priority in the project) was an element of complexity. The complexity elements are listed in Table 4.6. In comparison with the ones found in the literature and in project A, the new elements of complexity are highlighted in the table.

Table 4.6. Complexity elements found in interviews (Project B)

Complexities			
Category	Element	Description	Mentioned in interviews
Technical	Project scope	The scope was limited because of the design; the team were limited in terms of the changes they could implement to make the office sustainable	SC1.B
	Project sustainable design	Old building and design received a status that limited the upgrade of the office	PM.B; SC1.B; SC2.B
	Project schedule	Fixed project schedule; rapid program	PM.B; SC2.B
	Project budget	Fixed project budget	PM.B; SC2.B
Organizational	Project team's expertise in implementing sustainability	Lack of sustainability knowledge and implementation	SC2.B
	Sustainable project management implementation	Difficulties in convincing the stakeholders regarding the advantages of choosing suppliers who are not local; difficulties in the net zero interventions	PM.B; SC1.B; SC2.B
Environmental	Stakeholders' understanding of sustainability	Client's lack of understanding of sustainability and net zero (at a structural and project level)	PM.B; SC2.B
	Market influence	Difficulties in getting the required information from the suppliers	SC1.B
	Stakeholders' interest in implementing sustainability	Client's lack of interest in prioritizing sustainability	SC1.B

In the front-end phase of project B, Table J 2 in Appendix J lists the **opportunities** found in the sustainability report of the project. Table 4.7 presents the opportunities mentioned in interviews, which, at an environmental level, are related to the quality of the air, setting standards by challenging suppliers to be more sustainable and socially responsible, monitoring and saving energy and other resources, sustainability management through carbon reduction, use of more sustainable materials ("transitioning of materials like steel to copper pipework" – SC2.B), working

on circularity and climate resilience for the office building, and managing different waste pieces. The document also shows the use of recycled aggregates on site (sustainability management) and a 95% reuse, recycling, or recovery of demolition waste (waste management).

Table 4.7. Opportunities found in interviews (Project B)

Opportunities				
Category	Element	Description	Opportunities for	Mentioned in interviews
Environmental	Quality	Improved air quality	Client	SC1.B
	Setting standards	Challenging suppliers to be more sustainable; pushing suppliers to be socially responsible	Client	SC1.B; SC2.B
	Resources	Monitoring the energy and resource consumption; assessing the energy performance; energy savings (after the project is delivered)	Client	SC1.B
	Sustainability management	Carbon improvements/reduction; choosing more sustainable materials (copper instead of steel); working on circularity and climate resilience for the end-product	Client	SC1.B; SC2.B
	Waste management	Looking at how the waste pieces can be managed	Client	SC2.B
Social	Jobs	Job creation: 15 new apprenticeships; 20 work experience placements across the supply chain	Client	PM.B; SC1.B; SC2.B
	Lifestyle	Ventilation, lighting, and air quality improvements for the end-users	Client	SC2.B
	Training and education	15 construction careers information advice and guidance sessions for young people from other priority groups in the community (project level); develop the project team's internal skills; the project becomes case study material (TT level)	Client and TT	SC1.B; SC2.B
	Work process	Encouraging the project team and stakeholders to participate in the decision-making process	TT and stakeholders	SC1.B
	Social equity	Compliance with the client's accessibility best practice guidance (ensuring that the end-users with different disabilities are included)	Client	SC1.B
Economic	Collaboration	Gaining stakeholders' trust; getting new clients (TT level); application of law school social value; involving wide stakeholder groups into economic development discussions (project level)	Client and TT	PM.B; SC1.B; SC2.B
	Costs	Good value for the price (reducing carbon and costs); lower costs due to the use of less material; financial reduction for embodied carbon	Client	SC1.B; SC2.B
	Image	Credibility for clients	TT	SC2.B
	Quality	Detailed and meaningful sustainability changes; delivering a high performance sustainable office	Client and TT	SC1.B
	Resources	Use of local tradespeople and trading companies	Client	SC2.B

Socially, the opportunities which arose are job creation (“fifteen new apprenticeships and twenty work experience placements across the supply chain, so across the contractor and various

installers" – SC1.B), ensuring a better lifestyle for the end-users through air quality, ventilation, and lighting improvements in the building, and training and education at a project level (career fares) and TT level (upskilling). Other social opportunities were the enhancement of the work process and social equity. The document shows an opportunity related to the end-users' health and safety as well (improved specification for sanitaryware). Economically, there were opportunities for collaboration, as TT benefitted from gaining the stakeholders' trust and obtaining new clients, while the opportunity for stakeholders was that they were engaged in economic development discussions (PM.B). Regarding finances, there were lower costs in the project due to the use of less material and reducing both carbon and costs. Although the project scope was limited, there was an opportunity for both the client and TT to deliver a high-quality sustainable project by implementing "detailed, meaningful changes, rather than trying […] a little bit here and there" (SC1.B), which helped TT gain credibility for their clients (good image). Lastly, in terms of resources, there was an opportunity to use local tradespeople and companies. The interviews and document related to project B show that there are no additional opportunities which arose in comparison to the literature.

The **management strategies** identified in project B are listed in Table 4.8. SC1.B and SC2.B gave specific examples of how the right **management strategies could lead to opportunities**, and the examples were linked to potential complexity elements:

- if the project scope is limited (technical complexity), communicating all the relevant aspects at the same time (communication and reporting strategy) "helped change the agenda" (SC1.B) and led to detailed and significant changes to make the building more sustainable
- if there are difficulties in the sustainable design (technical complexity), making the project team responsible for making sustainable decisions (team strategy) "can get some very small benefits without any impact or thought. If you get small benefits everywhere, it cumulates" – SC1.B
- if there are difficulties to implement sustainable project management (organizational complexity), by involving the supply chain in the design process (team strategy) and analyzing and suggesting different scenarios and methods (openness to change strategy), opportunities for carbon reduction (environmental – sustainability management) and cost savings (economic – costs) arise: "we worked with the design team and supply chain to come up with alternative solutions […], we had some really good opportunities in terms of – we changed steel pipework to copper and there is a small financial cost to that but good carbon savings as well" – SC1.B
- if the project team lack expertise in implementing sustainability (organizational complexity), by capturing lessons learnt (external strategy), there is an opportunity for delivering a high-quality sustainable project (economic – quality): "taking the experience from the project, learning from it, integrating those learnings into all their future projects, which ultimately helps them deliver better outcomes for all their clients […] and it enables them to talk to their clients from a more educated perspective" – SC2.B

Table 4.8. Management strategies found in interviews (Project B)

Management strategies				
Category	Strategy		Observed dominant strategy	Mentioned in interviews
	Applied	Suggested/Ideal		
Communication and reporting	Clear understanding of the project sustainability requirements		Control	PM.B
	Early communication and recommendations for stakeholders		Interaction	SC1.B
	Clear and regular communication and reporting		Control	PM.B; SC2.B
	Making a communication, reporting, and risk management plan		Control	SC2.B
	Communicating all the relevant aspects at the same time		Interaction	SC1.B
		Governance and reporting	Control	PM.B
Project planning	Planning and prioritizing the sustainability requirements	Planning and prioritizing the sustainability requirements	Control	PM.B; SC1.B; SC2.B
	Setting up targets/goals and strategies		Control	PM.B
	Implementing and establishing the cost-carbon relation		Control	SC2.B
	Narrowing down the available options		Control	SC1.B
	Setting boundaries for the project goals		Control	SC1.B
	Identifying opportunities		Interaction	PM.B; SC2.B
Openness to change	Adding value by allowing flexibility in the time/budget		Interaction	SC1.B
	Analysing, suggesting, or adopting different scenarios and methods		Interaction	PM.B; SC1.B; SC2.B
	Setting a mindset to always be on top and prepared for what will come		Control	PM.B
Team strategies		Engaging the relevant stakeholders early upfront	Interaction	SC1.B; SC2.B
		Aligning the design, project team, and stakeholders on the project sustainability goals	Interaction	PM.B
	Making the project team responsible for making sustainable decisions		Control	PM.B; SC1.B
		Building a team of experts with complementary skills	Interaction	SC1.B
		Involving the supply chain in the design process (contractors, sub-contractors)	Interaction	SC1.B
	Making decisions based on the strict sustainability requirements		Control	SC1.B
External strategies	Capturing lessons learnt		Control	SC2.B
	Challenging the supply chain to be more sustainable		Control	SC1.B

4.3.3. Project C

In project C, all three categories of elements of **complexity** arose in the front-end phase of the project. As the stakeholders (architects) were from Spain, environmentally, there was a lack of local Dutch sustainability knowledge and local codes from their side, as well as difficulties in complying with the local codes. The complexity arose from elements such as the sustainability solutions

offered by the stakeholders ("they have the knowledge, but it is more related to Spain, not to the local markets" – PM.C), conflicts, unaligned implementation of the sustainability practices, lack of trust between the project team and stakeholders ("negative atmosphere, trust is gone" – PM.C), issues with logistics (delivery of materials), and few site inspections due to the stakeholders' geographical location. Other stakeholders contributed to the environmental complexity because of elements such as the lack of understanding of sustainability, lack of resources and "data challenges" (SC.C) and the stakeholders' inappropriate delivery of information to the sustainability consultant. Technically, there were changes in the design and difficulties in demonstrating how the design is sustainable, which led to schedule delays, high costs, as well as difficulties in following the technical processes (Table 4.9).

Table 4.9. Complexity elements found in interviews (Project C)

Complexities			
Category	Element	Description	Mentioned in interviews
Technical	Project sustainable design	Changes in the design; difficulties in proving that the design is sustainable	PD.C; PM.C
	Project (sustainability) technical processes	Difficulties in following the technical process (implementing changes, submitting drawings)	PM.C
	Project schedule	Schedule delays (fixed schedule)	PM.C; SC.C
	Project budget	High costs	PM.C
Organizational	Project team's expertise in implementing sustainability	Project team's lack of sustainability concept knowledge	SC.C
	Sustainable project management implementation	Difficulties in adopting sustainability practices; inappropriate project organization structure; inadequate sustainable project management collaboration; lack of suitable management strategies; lack of open communication; lack of sustainable resources (experts and programs)	PD.C; PM.C; SC.C
Environmental	Stakeholders' understanding of sustainability	Architect's lack of local knowledge; lack of understanding of sustainability (environmental and economic benefits)	PD.C; PM.C; SC.C
	Sustainability codes and standards	Lack of knowledge of the local codes; difficulties in complying with the local codes	PD.C; PM.C
	Market influence	Logistics	PD.C
	Alignment of sustainability methods between the project team and stakeholders	Unalignment of the sustainability solutions with the local conditions	PM.C
	Conflicts between the project team and stakeholders	Disagreements; unaligned collaboration and implementation of sustainability practices	PD.C; PM.C
	Stakeholders' resource management	Inappropriate resource management (people and data)	SC.C
	Stakeholders' collaboration	Stakeholders' inappropriate delivering of information	SC.C
	Trust in stakeholders	Lack of trust in stakeholders	PM.C
	Stakeholders' geographical location	Unalignment between stakeholders' location and project location; difficulties in site inspections	PD.C; PM.C

Organizationally, the project team did not have the knowledge to manage the project in a sustainable way. They had issues with implementing sustainability in the project as the project organization structure was inappropriate (sustainability was "rarely represented" in the front-end phase – SC.C). Moreover, the team had to convince the architects to find more sustainable

solutions and had to solve the design issues previously created by them (inadequate collaboration, lack of suitable management strategies). Other elements of complexity were the lack of open communication and sustainable resources, as other stakeholders involved in the project did not communicate all the necessary aspects to the sustainability consultant and did not have a suitable approach for their tasks ("limited tracking and reporting that happens for sustainability" – SC.C). In comparison with the complexity elements found in the literature, the new elements of complexity are highlighted in the table.

Looking at the opportunities which arose in the front-end phase of project C, environmentally, the opportunities are related to setting standards ("the market cannot give, so how do we get them there?" – SC.C). Opportunities also arose related to the efficiency of resources, climate change resilience, and carbon optimization (as mentioned in the project internal documents as well). In terms of sustainability management, the carbon emissions are reduced, and sustainable procurement is implemented, as found in the documents, while the interviewees said that more sustainable materials are chosen ("cork is in, and everybody really likes it" – PD.C) and they focus on reusing materials. The project team also looked at how to reduce waste (waste management), circular economy, and how to prevent pollution (quality). The social opportunities are mentioned in the interviews and documents: health and safety and a good lifestyle, by offering facilities such as transport and travel and sit-stand desks for the employees, and training and education ("get more knowledge about sustainability when you have a client that has a sustainable way forward" – PD.C).

Economically, the costs are reduced due to the reuse of materials and energy optimization, good corporate image, and resources (reduced water consumption). The project also brought environmental and social opportunities outside the net-zero goal. Environmentally, the urban impact was considered by having assets that contribute to the wider community, as mentioned in documents. Socially, the project team's work process was easier due to the technical programs used and the sustainability consultant. Another opportunity was reusing the furniture by donating it to schools or football clubs (charity). The opportunities found in the interviews are listed in Table 4.10, while the ones found in documents are in Table J 3 (Appendix J). In addition to the opportunities found in the literature, the opportunities found in the interviews or documents in project C are highlighted in the tables.

Table 4.10. Opportunities found in interviews (Project C)

Opportunities				
Category	Element	Description	Opportunities for	Mentioned in interviews
Environmental	Quality	Pollution prevention (through assets that do not harm or cause nuisance to the end-users); enhancement of the assets sustainability in use	Client	SC.C
	Setting standards	Finding solutions which challenge the market to develop in a sustainable way; research for the organization and beyond	Client	SC.C
	Resources	Enhanced biodiversity; climate change resilience for the assets; energy and carbon optimization; positive urban impact; optimized water use	Client	SC.C
	Sustainability management	Reducing the CO2 emissions; use of sustainable building materials; energy and carbon optimization; green infrastructure (reducing the use of steel and concrete based facilities; using natural elements with the same functionality); positive urban impact; sustainable procurement (project materials, services, and equipment are purchased based on specific sustainability criteria); enhancement of the assets sustainability in use	Client	PD.C; PM.C
	Waste management	Implementing end of life and circular economy (minimization of waste at the end of the project)	Client	SC.C
Social	Health & safety	Enhanced end-users and stakeholders' health and wellbeing; pollution prevention; encourage sustainable transport and travel (supporting walking, cycling, and public transport; discouraging use of engine/petrol cars)	Client and stakeholders	PD.C; SC.C
	Lifestyle	Pollution prevention; encourage sustainable transport and travel	Client	SC.C
	Training and education	Learning; professionals' specialization (TT level); innovation; research for the advancement of knowledge and technologies related to sustainability (project level)	Client and TT	PD.C; SC.C
	Work process	Carbon baselining and tracking the progress better; dedicated resource who can understand the sustainability requirements	TT	PM.C; SC.C
Economic	Costs	Reuse materials; energy and carbon optimization after the project is delivered; green infrastructure (lower fuel costs as the energy is derived from bio waste)	Client	PM.C
	Image	Good corporate image	TT	PM.C
	Resources	Optimized water use	Client	SC.C
Environmental outside TT's net-zero goal	Urban impact	Assets making a positive contribution to the wider community (long-term adaptability of the assets, maximization of open green space, reuse of land that was previously occupied)	Environment	SC.C
Social outside TT's net-zero	Charity	Mental benefits; making donations of used items to other communities (footbal clubs, schools)	Society	PM.C; SC.C

The **management strategies** identified in project C are listed in Table 4.11.

Table 4.11. Management strategies found in interviews (Project C)

Management strategies				
Category	Strategy		Observed dominant strategy	Mentioned in interviews
	Applied	Suggested/Ideal		
Communication and reporting		Clear understanding of the project sustainability requirements	Control	PM.C; SC.C
		Early communication and recommendations for stakeholders	Interaction	PM.C; SC.C
	Clear and regular communication and reporting		Control	PD.C; SC.C
	Making a communication, reporting, and risk management plan		Control	SC.C
	Contributing to the client's workshops and guiding the client in the decision-making process		Interaction	SC.C
	Governance and reporting		Control	SC.C
	Tracking and measuring the progress of the project		Control	SC.C
Project planning		Planning and prioritizing the sustainability requirements	Control	PM.C; SC.C
	Approaching targets/goals in a program or sequence		Control	SC.C
		Implementing and establishing the cost-carbon relation	Control	PM.C
Openness to change	Adding value by allowing flexibility in the time/budget		Interaction	PM.C; SC.C
	Analysing, suggesting, or adopting different scenarios and methods	Analysing, suggesting, or adopting different scenarios and methods	Interaction	PD.C; PM.C; SC.C
Team strategies	Engaging the relevant stakeholders early upfront	Engaging the relevant stakeholders early upfront	Interaction	PD.C; PM.C; SC.C
	Making the project team responsible to make sustainable decisions	Making the project team responsible to make sustainable decisions	Control	PM.C
		Getting the local team/sustainability knowledge	Control	PD.C
External strategies	Capturing lessons learnt		Control	PM.C; SC.C
		Seeking sustainability knowledge from other projects or experts	Control	PM.C; SC.C
		Reflecting on own work	Control	PM.C
		Data management	Interaction	SC.C

PM.C and SC.C gave specific examples of how the right management strategies could lead to opportunities, and the examples were linked to potential complexity elements:

- if the sustainable project management implementation is complex (organizational complexity), by suggesting different scenarios and methods (openness to change strategy), environmental and social opportunities can arise: “are the furniture pieces not going to be reused? Give them a second life. We are working with a partner from the furniture supplier. They will take back the old furniture and they will make sure the parts will be given a second life or the entire piece will go to school or charity” – PM.C
- if the stakeholders lack understanding of sustainability (environmental opportunity), by seeking sustainability knowledge (external strategy), the result will meet the client’s expectations (economic opportunity – quality): “we have internal training so that we have the basic knowledge on what to look out for, what you need to do. So, if something will

come up, you could tackle it straight away, while now […] we are reliant on the architect. If the architect is going to fail […], the result will not be as the client is expecting" – PM.C

- if the sustainable project management implementation is complex (organizational complexity) by allowing a higher project budget for better technical processes, such as the cost-carbon calculator (openness to change strategy), the project members can "start carbon baselining and tracking the progress better" (SC.C), which helps in their work process (social opportunity)

4.3.4. Project D

In project D, **complexity** originated from the client's decision to proceed with a design which is as sustainable as possible in line with the LEED and WELL certificates within a fixed schedule and budget. Technically, the complexity originated from the project sustainability requirements, which were unclear in the front-end phase, as well as the goals, and the number of sustainability tasks was high in a short period. This brought complexity in the schedule and time pressure ("the design phase would have been extended by a month, which we could not afford in the schedule" – PM1.D), as well as high and unclear costs (Table 4.12).

Table 4.12. Complexity elements found in interviews (Project D)

Complexities			
Category	Element	Description	Mentioned in interviews
Technical	Project sustainability requirements	Unclear sustainability requirements	PM1.D; PM2.D
	Project (sustainability) tasks	High number of sustainability tasks	PM1.D
	Project schedule	Schedule delays; fixed schedule	PM1.D; PM2.D
	Project budget	Unclear costs; high costs; fixed budget	PM1.D; PM2.D; CM.D
Organizational	Project team's expertise in implementing sustainability	Project team's lack of sustainability concept knowledge; under-skilled project team	PM2.D; CM.D
	Sustainable project management implementation	Complex decision-making process; lack of sustainable resources (programs, experts, and data); inappropriate project organization structure; difficulties in adopting sustainability practices	PM1.D; PM2.D; CM.D
Environmental	Stakeholders' understanding of sustainability	Client's lack of understanding of sustainability	PM2.D
	Sustainability codes and standards	High number of codes/certificates; difficulties in complying with the codes	PM1.D; PM2.D; CM.D
	Market influence	Market supply and demand	PM2.D; CM.D

Organizationally, the team did not have the required knowledge related to sustainability and had difficulties in adopting the sustainability practices as they did not have the suitable management strategies to manage the project in terms of sustainability ("for me, it was a new process and also for the client and for the local team, so that is a challenge that we are facing together to come up with a solution and approach how to tackle it" – PM1.A). The project had an inappropriate organizational structure as the team did not include a sustainability consultant in the front-end phase. Moreover, the project team did not have the necessary resources that would help them offer the client sustainable solutions. Environmentally, the stakeholders did not understand what

sustainability includes, while the two certificates the team had to comply with brought difficulties. Lastly, there was a lack of sustainable resources which had high prices that did not match with the fixed budget. In comparison with the complexity elements found in the literature, the new complexity element is highlighted in the table.

Looking at the **opportunities** that arose in the front-end phase of project D, Table 4.13 lists the ones found in interviews, while Table J 4 (Appendix J) lists the opportunities found in documents. Environmentally, they are related to setting standards ("it gives the general contractor a little bit more pressure because they need to fulfill this" – PM2.D) and sustainability management ("they are trying to reduce the carbon footprint" – PM1.D, "we are trying to use sustainable and reusable materials" – CM.D). Additionally, the documents illustrated opportunities related to the resources (smarter and more efficient resources – energy, water) and waste management (efficiency in waste and space usage). Socially, the interviewees described opportunities related to the employees' lifestyle ("the people would probably go to the office quite more than they previously did because it is nice to be in the office" – PM2.D, good air quality and light) and training and education due to retaining sustainability-related knowledge from the project ("looking around for the same people has to deal with the same projects, same requests from the clients", "it is a great benchmark project for all the other projects across Europe" – PM2.D, "the project really forces us to look into it" – PM1.D).

Table 4.13. Opportunities found in interviews (Project D)

Opportunities				
Category	Element	Description	Opportunities for	Mentioned in interviews
Environmental	Setting standards	Setting standards for the market/contractors/suppliers	Client	PM2.D
	Sustainability management	Reducing the carbon emissions; choosing sustainable resources; reusing resources; promote sustainability practices	Client	PM1.D; PM2.D; CM.D
Social	Lifestyle	Improved air and light quality for the end-users; enjoyment of the work place (project level); self-identity from working on the project (TT level)	Client and TT	PM2.D
	Training and education	Learning; retain sustainability-related knowledge through collection of information; sustainability guidance for practitioners	TT	PM1.D; PM2.D
	Work process	Better understanding of the requirements and better quality of work	TT	PM2.D
Economic	Image	Good corporate image	TT	PM1.D; PM2.D; CM.D
	Quality	Making the design as sustainable as possible	Client	PM1.D
	Resources	Reduction in the end-users' absenteeism; usage of local resources (products and experts)	Client	PM2.D; CM.D

Economically, opportunities arose regarding the company's image ("we have complied and it is a very sustainable project, something that we can be proud of and we can show it" – PM1.D), quality

("the architect was really forced to design as sustainable as possible" – PM1.D), and resources ("the direct approach is to make use of local products and local people" – CM.D), while the documents showed an opportunity in costs as well, as the reuse of resources is less costly. Compared to the opportunities found in the literature, there are not any new opportunities in the interviews or documents in project D.

The **management strategies** identified in project D are listed in Table 4.14.

Table 4.14. Management strategies found in interviews (Project D)

Management strategies				
Category	Strategy		Observed dominant strategy	Mentioned in interviews
	Applied	Suggested		
Communication and reporting	Clear understanding of the project sustainability requirements	Clear understanding of the project sustainability requirements	Control	PM1.D; PM2.D
	Clear and regular communication and reporting		Control	PM2.D
		Contributing to the client's workshops and guiding the client in the decision-making process	Interaction	CM.D
Project planning		Planning early on (sustainability requirements, adoption of scenarios and methods, etc.)	Control	PM1.D; PM2.D
	Planning and prioritizing the sustainability requirements	Planning and prioritizing the sustainability requirements	Control	PM1.D; PM2.D; CM.D
Openness to change	Adding value by allowing flexibility in the time/budget		Interaction	CM.D
	Analysing, suggesting, or adopting different scenarios and methods		Interaction	PM1.D; PM2.D; CM.D
Team strategies	Engaging the relevant stakeholders early upfront	Engaging the relevant stakeholders early upfront	Interaction	PM1.D; PM2.D; CM.D
	Aligning the design, project team, and stakeholders on the project sustainability goals		Interaction	PM2.D
	Making stakeholders part of the core project delivery team		Control	PM1.D
External strategies	Capturing lessons learnt		Control	PM2.D
	Seeking sustainability knowledge from other projects or experts		Control	PM2.D

Although the interviewees from project D did not give specific examples of how they transformed the complexity elements into opportunities, from the discussion with PM2.D, it was retrieved that the unclear project sustainability requirements (technical complexity) were transformed into an opportunity to add value to the project by making it more sustainable (economic opportunity – quality) by seeking sustainability knowledge (external strategy).

4.4. Conclusion and way forward

Compared to the findings of the literature, in terms of the complexity and opportunities encountered in sustainable construction projects in the four cases, it was noticed that most of the complexity elements and opportunities are found in practice as well. Technically, in all the four projects, complexity arose mainly from the project sustainable design, project schedule, and project budget. At an organizational level, the only two elements of complexity were related to the project team's sustainability knowledge and implementation of sustainable project management.

Lastly, at an environmental level, complexity arose from the way that the concept of sustainability is understood by the stakeholders, compliance with the sustainability codes and standards, and the influence the market has on the project. Alongside the common elements between the literature and practice, new complexity elements were found in the four cases, from the semi-structured interviews and internal documents from TT. The new complexities were part of the technical and environmental categories, while the organizational category did not bring any additional elements. In terms of opportunities, the common ones originated from all the three categories. Environmentally, the project team set standards on the market, while other opportunities were related to sustainability management and the use of resources and are leading in sustainable construction projects. Socially, opportunities regarding the end-users' lifestyle, training and education for the end-users or the project team, and enhanced work process for the project team are predominant. Economically, the opportunities arose related to costs, image, quality, and resources. Compared to the literature, the practice also brought new elements from the social and economic categories. Moreover, a few opportunities were identified outside the net-zero goal at an environmental and social level (People-Planet).

Regarding the link between the complexity elements and opportunities in sustainable construction projects, several management strategies were identified from the discussions with the project members. The strategies were clustered into the same five categories for all the three projects: communication and reporting, project planning, openness to change, team strategies, and external strategies. In the current study, the management strategies are perceived as a mean that could transform complexities into opportunities. During the semi-structured interviews, a few examples were described for each of the four cases, which show how specific management strategies can lead to opportunities. These examples were linked to potential complexity elements. It was also noticed that, by using different management strategies for the same complexity elements, different opportunities could arise. The management strategies were analyzed in terms of how much control or interaction they include. It was noticed that from a total of thirty-six management strategies, in twenty-five of them control was predominant, while in the remaining eleven, interaction led. In the next chapter, a comparison will be made amongst the three branch offices (TT EIR, TT UK, and TT NL), with the purpose of comparing the complexities faced, opportunities found, and management strategies used to cope with complexity and grasp opportunities in the four sustainable construction projects, which ultimately helps build the opportunity-identifying framework.

5. Comparison among the cases

The purpose of this chapter is to answer the third research sub-question:

"How can complexity elements, opportunities, and management strategies in the front-end phase of sustainable construction projects be compared in countries working towards achieving net zero?"

Section 5.1 compares the three branch offices (TT EIR, TT UK, and TT NL) in terms of the cases analysed in Chapter 4, while section 5.2 presents the conclusion and next steps in the study.

5.1. Comparison among the three branch offices (Turner & Townsend Ireland, the UK, and the Netherlands)

The three project teams (Irish, British, and Dutch) are first compared based on their approach regarding net zero and what technical tools they use (5.1.1). The complexity elements (5.1.2), management strategies (5.1.3), and opportunities (5.1.4) are other elements of comparison for the three branch offices, finding the most common and unique ones.

5.1.1. Net-zero approach and technical tools

From a net-zero perspective, all three project teams are working on office fit-out projects, trying to make them as sustainable as possible by implementing several sustainability strategies. Moreover, their priority is to reduce the carbon footprint of the offices or buildings. In terms of the approaches and tools used to achieve their clients' goals, all the project teams are managing their projects by complying with several specialized sustainability certificates. However, the project members from TT EIR are taking the next step by managing the project in accordance with the latest version of the LEED Gold certificate (v4.1). As mentioned in the interviews, LEED Gold v4.1 has not been used in many other companies, which is why the Irish team try to push the market in a better and more advanced direction.

Regarding measuring the carbon footprint, the Dutch and Irish teams use the cost-carbon calculator. For the Irish team, the tool is essential to start with in their projects as they can advise the clients based on it. In the Netherlands, the cost-carbon calculator is used in some of their projects, such as project C, but it was not implemented in the front-end phase. In project D, the tool was not used. The UK is the first European country to work with the NABERS rating system, which is a valuable Australian certificate that rates the energy of a building. The team from the UK use it as an alternative method to the cost-carbon calculator to improve the energy performance and consumption of a building. The Irish team included a sustainability consultant from a collaborating company from the beginning of the project, the British team had two sustainability consultants in their team, while the Dutch team included one consultant in the second half of the front-end phase (project C) or did not include them at all (project D). While the team from the UK did not have any issues in the collaboration with the sustainability consultants, the Irish team found it difficult to consider the sustainability expert's opinion and implement it in their management strategies, while the Dutch team did not consider the expert's opinion in all the decisions they made (did not include the expert in all the client workshops).

5.1.2. Complexity elements

Based on the project goals, requirements, and sustainability approach used by each project team, different elements of complexity were encountered in the front-end phase. In TT EIR, the project complexity originated from two elements: choosing the latest version of the LEED Gold certificate, as the team did not know what it required and how to approach it, and the collaboration with the sustainability consultant and with the client. In the UK, complexity arose mostly from the status of the building (Grade 2), so the old design, which limited the scope of the project, while the project schedule and budget were fixed. These technical complexities brought complexity at an organizational level as well. In TT NL, the projects were complex because of the following elements: the collaboration with an architect from another country, late use of the cost-carbon calculator in the project, not involving the sustainability consultant actively in the decision-making process (project C); making the office as sustainable as possible without using specific certifications, the lack of a tool/program that would evaluate the building in terms of sustainability, and the lack of a sustainability consultant who would have helped in making decisions (project D).

Looking at the complexities encountered in all four cases, the most common elements from the technical, organizational, and environmental categories were identified and highlighted in Table 5.1. The lack of sustainability knowledge for the three branch offices and having difficulties in implementing the sustainability practices were common organizational complexity elements. At an environmental level, the stakeholders' lack of sustainability knowledge (architect, clients, suppliers) was encountered while, at a technical level, the fixed project schedule brought complexity to all the four cases.

Table 5.1. Comparison of the complexity elements across the cases

Complexities		
Category	Element	Mentioned in cases
Technical	Project sustainability goals	A
	Project sustainability requirements	A; D
	Project scope	B
	Project (sustainability) tasks	D
	Project sustainable design	A; B; C
	Project (sustainability) technical processes	C
	Project schedule	A; B; C; D
	Project budget	B; C; D
Organizational	Project team's expertise in implementing sustainability	A; B; C; D
	Sustainable project management implementation	A; B; C; D
Environmental	Stakeholders' understanding of sustainability	A; B; C; D
	Stakeholders' interest in implementing sustainability	B
	Sustainability codes and standards	A; C; D
	Market influence	B; C; D
	Alignment of sustainability methods between the project team and stakeholders	C
	Conflicts between the project team and stakeholders	C
	Stakeholders' resource management	A; C
	Stakeholders' collaboration	C
	Trust in stakeholders	C
	Stakeholders' geographical location	C

5.1.3. Management strategies

In terms of the management strategies used by the project teams to cope with complexity or obtain opportunities, the same categories of management strategies were used by all three teams and a high number of strategies were common. The Irish and Dutch teams manage their project complexity with more control than interaction, while in the UK, control and interaction are more balanced.

Control and Interaction in the management strategies

All the strategies are explained below in terms of the balance between the two approaches: control and interaction. A dominant approach is chosen based on how the project members described the strategies during the interviews:

1. Clear understanding of the project sustainability requirements – the method involves a clear definition of the project scope, and a hierarchical team management, as the project team follow the exact requirements given by the client and wait until the client decides what needs to be achieved → Control
2. Early communication and recommendations for stakeholders – involves a clear definition of the project scope with a lot of information exchange among the team members and stakeholders, who work closely with each other → Control < Interaction
3. Clear and regular communication and reporting → involves hierarchical team management as the project team reports regularly to the client; the project members make sure that the project scope is clearly defined, which also involves a lot of information exchange → Control > Interaction
4. Making a communication, reporting, and risk management plan → the project team's tasks are very well defined and reported to the client (hierarchy), and a risk management plan is built to avoid unpleasant events → Control
5. Contributing to the client's workshops and guiding the client in the decision-making process → involves network team management and a lot of information exchange to satisfy the client's needs and requirements → Interaction
6. Tracking and measuring the progress of the project → strict management of scope and time; control of the project → Control
7. Communicating all the relevant aspects at the same time → strict management of the project scope, with a lot of information exchange involving all the team members; change is accepted, and all the project members are aligned on the scope → Control < Interaction
8. Governance and reporting → hierarchical management → Control
9. Planning early on (the project requirements, adoption of scenarios and methods, etc.) → involves a clear definition and management of the project scope → Control
10. Planning and prioritizing the sustainability requirements → involves a clear definition and management of the project requirements → Control
11. Setting up targets/goals and strategies → involves a clear definition and management of the project scope with a lot of information exchange among the team members → Control > Interaction

12. Approaching targets/goals in a program or a sequence → involves a clear definition of the project team's activities with a lot of information exchange; deals with details → Control > Interaction
13. Implementing and establishing the cost-carbon relation → involves controlling the budget from the front-end phase of the project → Control
14. Supply chain mapping → involves controlling the project by clearly establishing the supply chain and scoring the suppliers → Control
15. Identifying opportunities → involves allowing flexibility and accepting that changes might occur; discussions that involve both the project managers and designers → Interaction
16. Narrowing down the available options → involves a clear definition of the project team's tasks and controlling the project scope → Control
17. Setting boundaries for the project goals → involves clearly defining and strictly managing the scope of the project → Control
18. Adding value by allowing flexibility in the time/budget → involves allowing flexibility and accepting changes → Interaction
19. Analyzing, suggesting, or adopting different scenarios and methods → involves allowing flexibility and redefining the scope → Interaction
20. Setting a mindset to always be on top and prepared for what will come → involves preparing for the unexpected, aligning all the project members on the scope, and some hierarchy → Control > Interaction
21. Engaging the relevant stakeholders early upfront → involves network team management with some hierarchical steering, aligning the project members on the scope and working closely with each other → Control < Interaction
22. Aligning the design, project team, and stakeholders on the sustainability goals → involves aligning all the project members on the scope, while still trying to control the scope → Control < Interaction
23. Making stakeholders part of the core project delivery team → aligning all the project members on the scope with the purpose of strictly managing the scope → Control > Interaction
24. Booking the client's time in advance → strictly managing the time and prepare for the unexpected → Control
25. Optimizing the client's number of workshops → strictly managing the time, while still allowing time for discussions amongst all the team members → Control > Interaction
26. Making the project team responsible to make sustainable decisions → involves a hierarchical approach (reporting) and strict management of the scope, while ensuring information exchange → Control > Interaction
27. Building a team of experts with complementary skills → involves that the project members work closely with each other and share responsibilities, while still trying to control the scope → Control < Interaction

28. Involving the supply chain in the design process (contractors, subcontractors) → involves aligning all the project members on the goals and working closely with each other to improve the design and prepare for the unexpected → Control < Interaction
29. Making decisions based on the strict sustainability requirements → involves strictly managing the scope of the project → Control
30. Getting the local team/sustainability knowledge → involves minimizing the chances of unpleasant events by exchanging information with local experts → Control > Interaction
31. Challenging the supply chain to be more sustainable → involves the strict management of the project scope while ensuring information exchange → Control > Interaction
32. Problem escalation → involves a hierarchical approach → Control
33. Capturing lessons learnt → involves information exchange among the team members with the purpose of learning from mistakes to avoid unpleasant events in the future → Control > Interaction
34. Seeking sustainability knowledge from other internal projects or stakeholders → involves have a clear understanding of the project scope and the strategies that could be used to be prepared for what will come; involves information exchange → Control > Interaction
35. Reflecting on own work → the strategy aims to capture lessons to be prepared for what could arise in the current/future projects → Control
36. Data management → involves aligning all the project members on the project scope → Interaction

Each category of management strategies includes unique strategies from at least one branch office. As each team can learn from the other, in the current study, the strategies used by one project team that are not used by the other two could help the project members transform the complexity elements into opportunities in their projects. The unique strategies from each project team are listed in Table 5.2 and elaborated on in Appendix K.

Table 5.2. Unique management strategies in each of the three project teams

Unique management strategies			
Category	EIR	UK	NL
Communcation and reporting		Communicating all the relevant aspects at the same time	
Project planning	Supply chain mapping	Narrowing down the available options	
		Setting boundaries for the project goals	
Openness to change		Setting a mindset to always be on top and prepared for what will come	
Team strategies	Booking the client's time in advance	Building a team of experts with complementary skills	Getting the local team or sustainabililty knowledge
	Optimizing the client's number of workshops	Involving the supply chain in the design process (contractors, subcontractors)	
		Making decisions based on strict sustainability requirements	
External strategies	Escalating problems		Seeking sustainability knowledge from other internal projects or stakeholders
			Reflecting on own work
			Data management

In general, the purpose of identifying the unique management strategies during the semi-structured interviews is to be conveyed as recommendations for project members to deal with complexity in their projects and identify opportunities. However, they also contribute to the development of the opportunity-identifying framework.

5.1.4. Opportunities resulted from the top complexity elements

Regarding the opportunities which arose in the front-end phase of the projects, the majority of them were common for all four cases: to set standards in the market through the decisions they made (such as choosing more sustainable solutions), to reduce the carbon footprint, or related to the end-users' lifestyle (i.e., facilities), training and education for the end-users (i.e., learning about mental health) and project team (i.e., upskilling), good corporate image, resources, quality, and work processes. The differences between the cases are the opportunities outside the net zero goal. The Irish team are trying to help solve the world's most complex problems (being at the top of the industry and positively impacting the built environment through their services), while the Dutch team are working on assets that have a positive impact on the wider community and socially contribute by making donations from the items that will not be used anymore in their project. The British team did not mention any opportunities outside the net-zero goal.

5.2. Conclusion and way forward

The comparison among TT EIR, TT UK, and TT NL shows that TT EIR and TT UK are closer to achieving net zero than TT NL (as mentioned in the beginning of the study). The conclusion is based on the involvement of the sustainability consultants early in the project (EIR and UK), the latest certificates followed by the project members (EIR) and making decisions based on the cost-carbon calculator (EIR) or the NABERS certificate (UK). The third research sub-question can be answered by the most common complexities and opportunities encountered in the four cases, as well as the common or unique management strategies used by each project team (TT EIR, TT UK, and TT NL). Figure 5.1 illustrates the main key elements retrieved from the comparison among the three branch offices. The unique strategy is highlighted in a different colour.

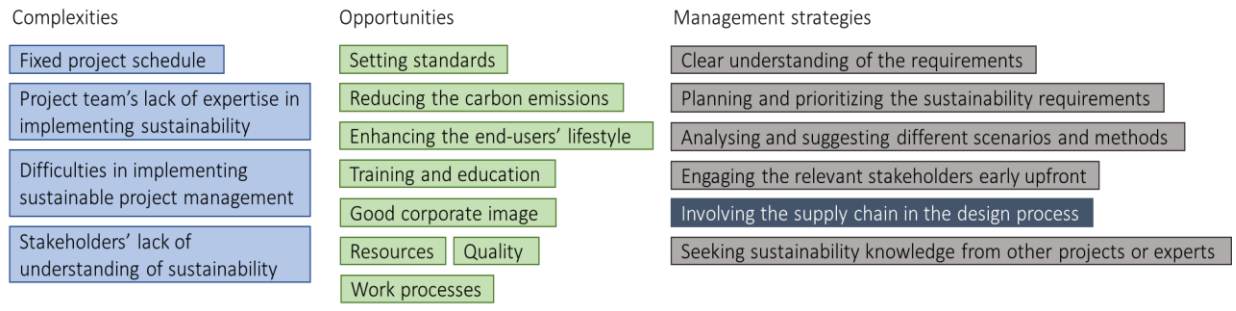

Figure 5.1. Main findings of the four cases

Based on the results from the literature review and case study analysis, in the following chapter, an opportunity-identifying framework is developed, which illustrates how specific complexity elements lead to several opportunities by means of management strategies in sustainable construction projects.

6. Results: an opportunity-identifying framework

The purpose of this chapter is to answer the fourth research sub-question:

"How could a framework help project members in identifying opportunities from complexities in the front-end phase of sustainable construction projects by using management strategies?"

To answer this research sub-question, the current chapter describes the preliminary version of the framework (6.1), the expert evaluation (6.2), the development of the final framework (6.3), and the conclusion of the chapter (6.4).

6.1. Preliminary framework

The preliminary version of the framework was developed considering the theoretical background presented in the literature review (Chapter 3) and the case study analysed (Chapter 4), which is related to complexities and opportunities in sustainable construction projects, and management strategies used to deal with complexities and generate opportunities. The developed framework shows how specific examples of complexity elements can lead to opportunities by means of management strategies in sustainable construction projects. The purpose of building an opportunity-identifying framework for complex sustainable construction projects is to illustrate all the research findings, fill the knowledge gaps initially presented in this study, and guide industry experts in dealing with complexity by using certain management strategies to generate opportunities.

The CMO (**C**omplexities, **M**anagement strategies, **O**pportunities) opportunity-identifying framework includes three main steps. The first step is the identification of the categories of complexity (technical, organizational, and environmental) and complexity elements encountered in the experts' projects from the four complexity elements included in the framework. The second step is to use the listed management strategies in the recommended order to cope with complexity and explore its positive impact, followed by the third step, which involves generating the suggested opportunities from three categories (environmental, social, and economic).

The framework is based on the conceptual framework built in sub-section 3.6.2, which shows that complexity and opportunities are linked through risks and opportunities can be generated from complexities by using management strategies. The majority of the complexities and opportunities found in the academic literature (the sub-categories of elements from Table 3.2 and Table 3.4) were confirmed by the ones found in the case study, therefore all validated elements were initially considered to be illustrated in the framework. Regarding complexities, a decision was made to illustrate only the ones that were most often encountered in the four cases (Figure 5.1), while the opportunities that were selected for the framework are either the most common findings (Figure 5.1), or less common based on the author's recommendations. The purpose of illustrating the less

common opportunities in the framework is to show that any could arise from the selected complexities.

The management strategies that are recommended to deal with the four complexity elements were chosen based on a few aspects. One of them is the project members' experience and suggestions, meaning that the framework recommends a combination of applied and suggested management strategies from the four cases. The management strategies were also chosen based on the recommendation of the literature of combining control and interaction when dealing with complexity. Therefore, the combinations of management strategies include both control and interaction. Another aspect that was considered in developing the framework is that the strategies were used in at least three of the four cases (for instance, "engaging the relevant stakeholders early upfront" was mentioned in all the four cases, while "aligning the design, project team, and stakeholders on the sustainability goals" was mentioned in three cases, which means that both strategies are preferred when dealing with complexity).

Apart from the aspects considered in forming the combinations, in general, as all the management strategies were suggested by the project members to cope with complexity or generate opportunities, many combinations of strategies could have been made from them. Alongside the preferred strategies (mentioned in at least three cases), other strategies that were mentioned fewer times by the project members were also considered suitable for dealing with complexity and included in the framework. For instance, planning the adoption of scenarios and methods is considered a suitable strategy to manage the fixed project schedule as it helps organize the project better. Seeking sustainability knowledge and making the project team responsible for making sustainable decisions are strategies that help deal when having difficulties to implement sustainable project management, as knowledge is gained from other projects or stakeholders and the project members are more motivated to adopt sustainability practices. Lastly, making stakeholders part of the core project delivery team helps the stakeholders have a better understanding of what sustainability includes. Two unique strategies were also selected as they are considered suitable to deal with complexity: optimizing the client's number of workshops might help keep the fixed project schedule in control, while involving the supply chain in the design process might compensate the project team's lack of expertise and help them implement sustainability. Therefore, in terms of management strategies, the framework is based on the findings of the literature review and case study, as well as the author's own suggestions of a suitable combination and order of management strategies to achieve the main research goal (generating opportunities from complexities). By using the suggested management strategies, the project members could benefit from the listed opportunities.

The CMO opportunity-identifying framework also includes a legend which illustrates the categories of complexities and opportunities (Figure 6.1). The way that industry experts could use the framework in their sustainable construction projects is described in the next section, after the framework was evaluated with experts.

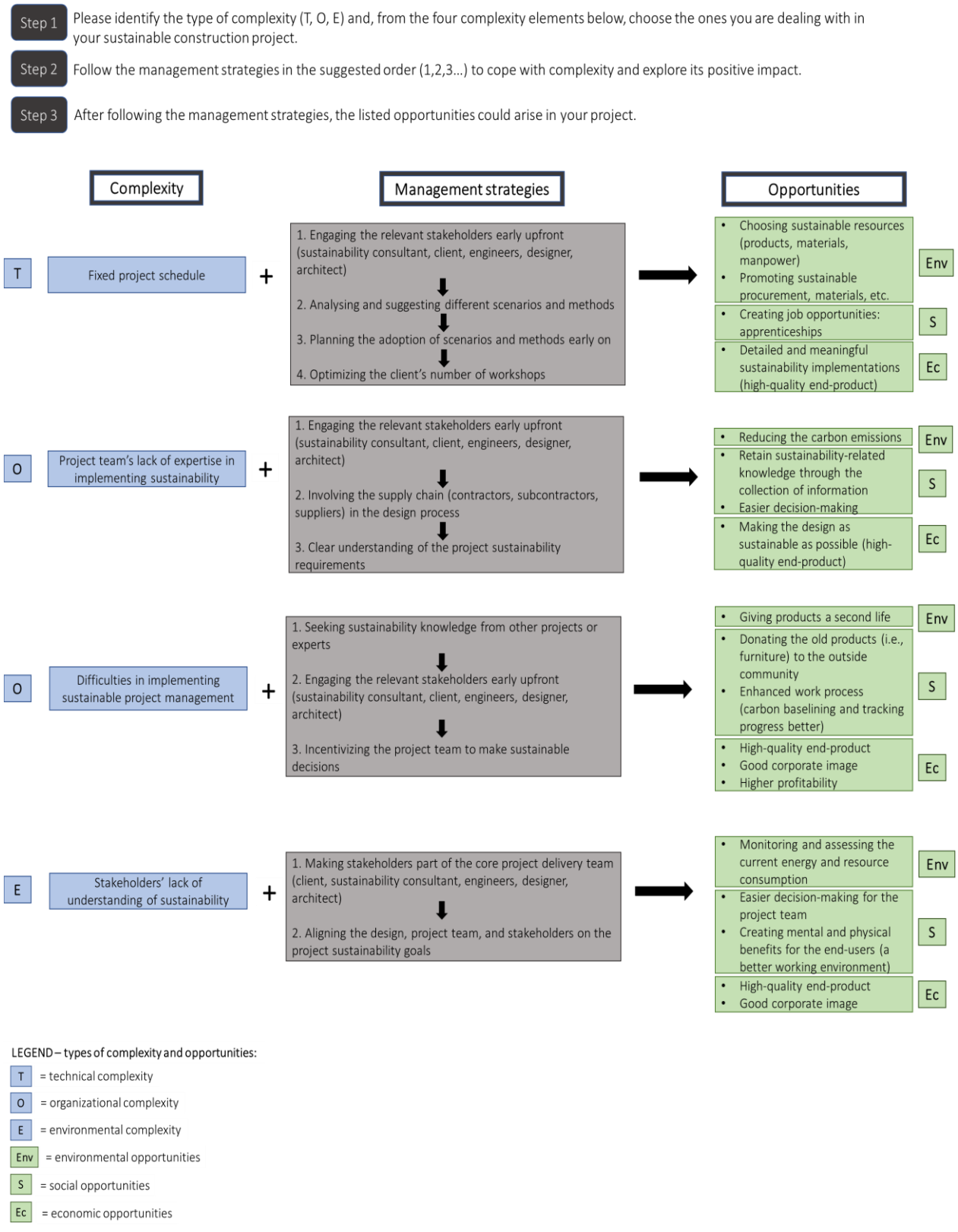

Figure 6.1. Preliminary CMO opportunity-identifying framework

6.2. Expert evaluation

This section presents the expert evaluation session, for which a focus group meeting was organized. The goal of the session, the selection process for the experts who participated, their profile, the set-up of the expert evaluation, and implemented changes are described.

Goal of the session

The focus group session was organized to achieve two main goals: the evaluation and improvement of the preliminary version of the framework. The evaluation could be achieved by checking if the key elements included in the framework are commonly encountered in practice, and if the combinations of management strategies and suggested opportunities are suitable for the selected complexity elements. The preliminary framework could be improved by discussing together with the experts how the framework could be used in practice.

Selection of the experts and their profile

Four experts were part of the focus group and have the following roles in the company: Director Real Estate Public Sector and Program Manager Net Zero BENELUX, Associate Director Project Management, Associate Director Cost Management, and Project Manager who is part of the Dutch Net Zero Team. The experts were selected based on the two following criteria:

- working for TT NL – as the research is carried out at TT NL, it was more efficient to gather experts from the office and organize the focus group session in person
- experience with sustainable construction projects – all the selected experts are currently working on sustainable construction projects and have experience in this sense, which proves their suitability for the session

Table 6.1 lists the focus group experts' roles, company, and years of industry experience.

Table 6.1. Focus group expert profile

Role	Company	Industry experience (years)
Director - Real Estate (Public Sector)	TT	25
Associate Director - Project Management	TT	10
Associate Director - Cost Management	TT	10
Project Manager (Net Zero Team)	TT	5

Set-up of the expert evaluation and implemented changes

The experts were asked questions that helped achieve the goals of the session. The questions were related to whether the selected complexity elements are common in sustainable construction projects, the suitability of the suggested management strategies and opportunities, ways to improve the framework, and the applicability of the framework in practice. The summary of the focus group session can be found in Appendix L.

By asking the experts several questions, the findings of the framework could be validated. For instance, the four elements of complexity illustrated in the framework were confirmed as being common elements in general in sustainable construction projects. The management strategies were perceived as suitable for dealing with the selected complexity elements, as well as the

opportunities arising from them. However, the experts made a few suggestions that helped improve the framework and make it comprehensive and complete. In general, the experts' suggestions were implemented either by reaching consensus in the group, by at least another expert's confirmation, or by the findings of the case study interviews. The suggestions made only by one expert which was not confirmed by others or by the interview findings were not added or changed in the framework, as each suggestion should be validated by at least one more interviewee/expert in the focus group.

One recommendation was related to the strategy "incentivizing the project team to make sustainable decisions", which was suggested to be changed to "making the project team responsible for making sustainable decisions", as "incentivizing" was associated with economic aspects. The recommendation was confirmed by the other focus group experts. When discussing the involvement of the supply chain in the design, another suggestion was to allow flexibility in the budget, which was added to the framework as it was confirmed by the other attendees and interview results. The last management strategy that was added to the framework is "analysing and suggesting different scenarios and methods" after the project team are aligned on the project goals. Regarding opportunities, a few were suggested: reduced absenteeism, gaining knowledge, and competitive advantage. The first two were added to the framework, while the last one was not implemented as it was not confirmed by other experts or interviewees. The implemented changes are highlighted in Figure 6.2.

6.3. Final framework

This section describes the development of the final framework. The context in which the framework can be used is any sustainable construction project and, as the study recommends, from the very beginning of projects. It can be implemented as part of the documents which describe the approaches used by the project team to manage the project. Moreover, as suggested by the experts who participated in the focus group session, to use the framework, all the project members should first understand the concept of sustainability. After implementing the feedback from the focus group discussion, the elements of the final framework (Figure 6.2) can be described:

T: Fixed project schedule

Four management strategies were selected to deal with this complexity element and generate opportunities. The way to cope with a fixed project schedule is balanced by choosing two management strategies that are focused on interaction, and two for which control is required. As a first step, the framework recommends engaging the relevant stakeholders early upfront as it is important to get all the important stakeholders on board from a very early stage. This will help the project team stay aligned regarding the project goals and will enhance the decision-making process. Their roles and responsibilities in the project should be clear as well, and the sustainability consultant should not be absent in the project, as their opinion regarding the sustainability aspects brings high value. After all the stakeholders are engaged, discussions regarding different scenarios and methods of how sustainability could be implemented in the project can take place (second step). The feasibility of the scenarios and methods should be discussed in terms of the value they bring to the project and the budget and time required. Based on these aspects, the project

members can decide which scenario is better that also keeps the project schedule in control. Depending on the project sustainability goals, opportunities such as choosing to work with sustainable resources (materials, products, etc.) or promoting sustainable procurement and materials could arise. The third step is to plan the adoption of the chosen scenarios and methods according to the fixed project schedule. This requires a clear and fixed planning that should be understood by all the stakeholders. If the planning is clear, there might be an opportunity for job creation, as a fixed schedule might require more members to work on the project. They can be either other industry experts or apprentices. Lastly, it is suggested to optimize the client's number of workshops (during which initial discussions about the project scope and design take place between the project team and client) to ensure that the project members keep their focus over the entire duration of the project. A fixed schedule might limit the possibilities that the project members have to make the project sustainable. However, an opportunity for detailed and meaningful sustainability implementations might lead to a high-quality end-product.

O: Project team's lack of expertise in implementing sustainability

Four management strategies are recommended to deal with this complexity element and generate opportunities. The strategies of control and interaction are less balanced this time, as the focus is on interaction in the first three strategies, while the last one is based on control. As a first step, the framework recommends engaging the relevant stakeholders early upfront. As mentioned for the previous complexity element (fixed project schedule), it is essential to get all the important stakeholders on board from a very early stage, as it can help the project team stay aligned regarding the project goals and enhance the decision-making process. Their roles and responsibilities in the project should be clear as well, and the sustainability consultant should not be absent in the project, as their opinion regarding the sustainability aspects brings high value. The second step is to allow flexibility in the project budget as a higher budget is required for the next step (involving the supply chain). Therefore, as the budget is flexible, the third step is to involve the supply chain in the design process. By involving the contractor, subcontractors, or the suppliers, the quality of the design could be higher, as certain technical aspects that might not be foreseen by the designers and architects could already be implemented early in the design. This might help prevent unpleasant events in the construction stage of the project (for instance, changes in the design). Moreover, since the project team does not have the required expertise to implement sustainability, the supply chain could help, and an opportunity for retaining sustainability-related knowledge can arise. As certain discussions can take place between the project team and supply chain regarding the sustainability goals and design, the last management strategy that could be implemented is the clear understanding of the project sustainability requirements. The project objectives should be clear to all the project members. This can lead to, for instance, reducing the carbon footprint and making the design as sustainable as possible.

O: Difficulties in implementing sustainable project management

To deal with the difficulties in implementing sustainable project management, a combination of two management strategies based on control, and one focused on interaction is recommended. The first strategy involves seeking sustainability knowledge from other internal projects or

stakeholders. This requires looking for similar completed projects or discussing with experts who could offer valuable information regarding how they implemented sustainability practices. The strategy could lead to an enhanced work process by implementing carbon baselining and tracking the progress better, for instance. The next strategy involves engaging the relevant stakeholders early upfront. As mentioned for the previous two complexity elements, it is essential to get all the important stakeholders on board from a very early stage, as it can help the project team stay aligned regarding the project goals and enhance the decision-making process. Their roles and responsibilities in the project should be clear as well, and the sustainability consultant should not be absent in the project, as their opinion regarding the sustainability aspects brings high value. Lastly, it is important to make the project team responsible for making sustainable decisions, as it could lead to opportunities such as giving products as second life and donating old products to other communities (such as schools, football clubs, etc.). Although having difficulties in implementing sustainability might seem to have a negative impact on the project, by engaging all the relevant stakeholders and making the right decisions, the end-product could be of high-quality, which might lead to a good corporate image for the project team and higher profitability.

E: Stakeholders' lack of understanding of sustainability

When dealing with the stakeholders' lack of understanding of sustainability, two management strategies based on interaction and one focused on control are suggested in the framework. The first strategy is to make the stakeholders (client, engineers, designers, architects) part of the core project delivery team, which is followed by aligning the design, project team, and stakeholders on the project sustainability goals. Involving all the stakeholders in the essential team discussions in which important strategies and decisions are made can help both the project team and stakeholders stay aligned regarding the project goals and can enhance the decision-making process. This can lead to gaining sustainability-related knowledge from each other, delivering a high-quality end-product, and creating a good corporate image. The last strategy involves the analysis of different scenarios and methods that could be implemented in the project. The feasibility of the scenarios and methods is recommended to be considered as well. This can generate opportunities such as monitoring and assessing the current energy and resource consumption, creating a better working environment for the end-users, which can also lead to mental and physical benefits, and reduction in absenteeism.

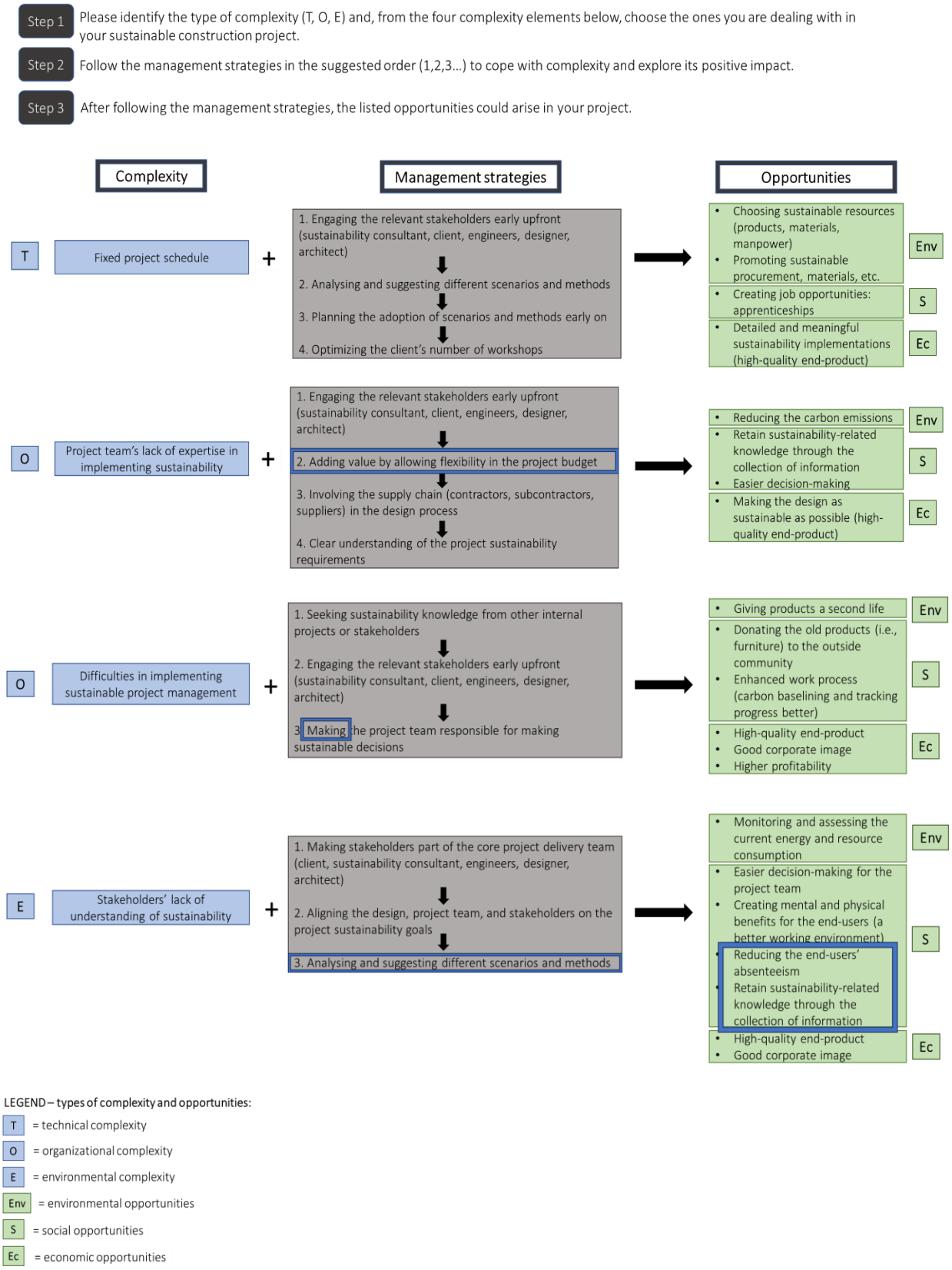

Figure 6.2. CMO opportunity-identifying framework for complex sustainable construction projects

6.4. Conclusion

The framework built in the current study illustrates all the research findings which fill the knowledge gaps. It also represents a guide that could help industry experts in practice. The framework summarizes the research results (complexities, management strategies, and opportunities in sustainable construction projects) and presents them in a way that achieves the research objectives by proving the assumptions made at the beginning of the study. Therefore, the research result is the CMO opportunity-identifying framework that illustrates with specific examples how different complexity elements could lead to several opportunities by using a combination of management strategies based on control and interaction. The framework was developed specifically for sustainable construction projects, which adds value in practice. At a scientific level, the framework shows that complexity can generate opportunities if the suitable management strategies are implemented, accentuating the positive impact that complexity can have.

Although the elements of complexity are often encountered in sustainable construction projects, and several strategies are used to deal with complexity, industry experts still refer to some strategies as lessons that they can learn and apply in future projects. Therefore, the CMO opportunity-identifying framework was developed to help industry experts deal with the most common complexities regarding sustainability and to guide them to use the right strategies from the very beginning of the project. By having a clear image of what could arise and how it can be managed, the project members could explore the positive impact of complexity and generate opportunities from complexities. After presenting the preliminary framework and its improved version based on the expert evaluation, the answer to the fourth research sub-question can be given. The way the framework could help project members generate opportunities from complexities in practice in their sustainable construction projects is by using specific combinations of management strategies. The strategies are based on a balance of control and interaction and should be applied in a recommended order to deal with four common complexity elements that arise in sustainable construction projects at a technical, organizational, and environmental level, and generate environmental, social, and economic opportunities.

7. Discussion

This chapter presents the final thoughts regarding the methods used and findings of the current study. It is divided into two sections which include the interpretation of the results (7.1) and the limitations of the research (7.2).

7.1. Interpretation of the results

Comparison between the academic literature and the case study results

As the key elements of the study were identified by means of two main qualitative methods (literature review and case study), it was observed that the main elements of complexities and opportunities were found in both the academic literature and cases (interviews and documents). Apart from their common elements, the different ones are illustrated in Figure 7.1.

LITERATURE	CASE STUDY	
Organizational complexities: • Project team's interest in implementing sustainability • Conflicts amongst the project team members Economic opportunities: • Competition • Processes	Environmental complexities: • Stakeholders' resource management • Alignment of sustainability methods between the project team and stakeholders • Stakeholders' collaboration • Trust in stakeholders • Stakeholders' geographical location	Social opportunities: • Work process • Social equity Economic opportunities: • New project acquisitions Environmental (outside net zero): • Helping in solving the world's most complex problems • Urban impact Social opportunities (outside net zero): • Charity

Figure 7.1. Differences between the results from the academic literature and case study (complexities and opportunities)

The figure shows that two elements of complexity and two opportunities that were found in the academic literature were not found in the four cases, while the elements found in the cases are additions to the ones presented in the literature that was reviewed and selected for the current study. Regarding the management strategies, all the strategies found in the four cases were analyzed in terms of their level of control and interaction, which are the two approaches found in the literature.

Contribution of the study to academia and practice

At an academic level, the current research explores the complexities and opportunities in sustainable construction projects by means of literature review. In addition, from a variety of complexity elements, the ones that are encountered in general construction projects were eliminated from the study, to strengthen the findings and make them more specific to sustainable construction projects. The study explores the positive impact that complexity can have on projects by developing the CMO opportunity-identifying framework that shows how certain complexities can lead to opportunities by means of management strategies based on control and interaction.

The current study contributes to the academia with the following new elements:

- the sub-categorization of complexities was inspired by the TOE framework and adapted for sustainable construction projects
- the categories of opportunities were also different from the traditional environmental-social-governance categories. The "governance" category was substituted by "economic", as the categories were inspired by the three main levels of sustainability (environment, society, economy)
- the sub-categories of opportunities
- the opportunities found outside the net-zero goal
- the management strategies and their categorization
- the additional key elements found by means of semi-structured interviews and document review (Figure 7.1)
- the conceptual framework that presents the relation between complexity and opportunity through risk as the connector between the two elements and assumes that management strategies could be the way to generate opportunities from complexities. The conceptual framework ultimately led to the development of the CMO opportunity-identifying framework, which presents with specific examples how four common complexity elements encountered in sustainable construction projects can generate opportunities by using recommended management strategies

At a practical level, the research describes to the experts from the construction industry across the world how Ireland, the UK, and the Netherlands manage sustainable construction projects in terms of complexities, opportunities, and management strategies. Lastly, the CMO opportunity-identifying framework could enable project members to see the positive impact that complexity can have on projects and perceive complexity as a mean to identify opportunities.

Observations from the case study

As the study is carried out using qualitative research methods, the key elements of the research can be interpreted in a subjective manner, so they can differ from an author to another: for instance, how the key elements are understood and categorized, how the management strategies are divided based on their dominant strategy – control and interaction, and therefore could have led to a different selection of elements or ways in which complexities could generate opportunities. In line with this, the results could differ from a project member to another as well. For example, Bosch-Rekveldt et al. (2011) stated that the project complexity can be assessed in a different way by individuals participating in the project, depending on their past experiences.

An aspect that was noticed is that several project members who were interviewed mentioned that they might not remember all the aspects and events that happened during the front-end phase of the project, but they expressed their motivation to do so. Most of the interviewees also mentioned that the concept of sustainability is still not understood by all the members of a project, which leads to project complexity.

A first aspect is that in the semi-structured interviews, two of a total of four cases included a senior and a junior project manager who were interviewed. In terms of complexities, the differences between the two generations can be analysed. In project A, most of the complexity elements are mentioned by the senior project manager (a total of six), while the junior only mentioned three. This might show that, due to their experience, the senior recognizes complexity faster than the junior. However, in project D, the junior found two more elements of complexity than the senior, which shows that experience is not necessarily a factor of recognizing complexity but might also show the involvement that the expert has in the project. Another aspect that was noticed is that some elements were perceived as complex by all the project members, while others were only perceived by one or two experts. The common elements were the implementation of sustainable project management, the project sustainable design, or stakeholders' understanding of sustainability, which shows that all the interviewees were impacted by these elements. The other elements might be perceived by only one or two experts as only their involvement was mainly in specific areas (for example, the cost manager noticed complexity in the project budget, while the sustainability consultant noticed how the data is managed by the stakeholders). Lastly, it was noticed that the two sustainability consultants from project B had different opinions regarding the complexity of the project. Except for two elements, the other complexities were different for the two experts. This proves the subjective nature of complexity and that certain aspects are perceived as being complex by an individual, while another expert might perceive it as not bringing complexity to the project. Lastly, another observation was that the director who participated in the expert evaluation works on sustainable construction projects in the public sector. The director confirmed that the key elements found in the cases analysed in this study which are part of the private sector are encountered in the public sector as well.

Regarding opportunities, the project members mentioned similar opportunities in their projects. The different ones might be justified by the number of elements that an expert remembers, or the way the term "positive risk" is interpreted. The majority of the opportunities could benefit either the client or the team from TT. Although the interviewees were asked only about the opportunities for the clients or TT, projects B and C showed that two opportunities arose for the stakeholders as well (enhanced work process and health and safety). Related to the management strategies used to deal with complexity, it was observed that the majority of them are mentioned by only one interviewee, while some were mentioned by two or three. This shows that the strategies to cope with complexity are either perceived differently by each project member, or different strategies are applied by each of them.

Another aspect that was noticed in the study was that, compared to the individual interviews, during the combined interview, the two project managers could better answer the questions as they could confirm the elements mentioned by each other or remember other elements and complement each other's answers. On a different note, the sustainability consultant who was interviewed as part of the project team who was not part of the team from TT provided several valuable insights into the key elements of the project from a sustainability perspective. This shows that the research goals could be achieved with an expert from outside TT as well, because

sustainability is an essential aspect of the study and could not be discussed in detail with project members of different roles. Moreover, two interviews were conducted with the same project manager from TT who is part of the two projects analysed in the Netherlands. The expert's interpretation of the key elements of the study was different in each of the two cases but matched the other project members' opinions, so it did not affect the analysis of the two projects.

7.2. Research limitations

The methodology used for the current study is limited by a few factors:

- the **case study analysis** method is limited to only one case company and four cases that are considered in the study. Other companies might encounter different complexities or opportunities in their projects. This depends on how the concepts of complexity and opportunity are perceived. The applied and suggested management strategies might also differ. Moreover, two cases were analysed in the Netherlands, one in the UK, and one in Ireland, which means that the results cannot be generalized at a country level. Another limitation of the case study analysis is that the cases are sustainable construction fit-out projects in the private sector. Other types of sustainable construction projects, as well as projects in the public sector were not part of the study. Moreover, the research was focused only on the front-end phase of the project, which might encounter specific key elements. Regarding opportunities, only the ones that could benefit the client and organization were the focus of the study. The opportunities that could benefit the stakeholders were not considered
- the **semi-structured interviews** were limited to eleven experts from TT with the roles of project director, project manager, cost manager, and sustainability consultant. One project member was from another company (sustainability consultant). From other stakeholders' perspectives (client, architects, designers, engineers), the complexities, opportunities, and management strategies might differ
- regarding the **evaluation of the framework**, it was limited to a focus group comprising of four experts working within TT. A higher number of participants, other stakeholders (such as client, contractor, designer, etc.), or testing the framework in live projects might have led to different feedback and ways to improve it
- the way **the framework is used in projects** could change the outcomes. Depending on the project members' interpretation of the suggested management strategies, their experience, and the openness of the other project members to manage complexity together as a team (interaction) are factors that could impede the project members from obtaining opportunities

8. Conclusions and recommendations

As initially presented at the beginning of the study, the main research objective is to find the three key elements which are an essential part of sustainable construction projects, as well as to illustrate the relation between complexities and opportunities. By using qualitative research methods, the objectives were achieved. Section 8.1 presents the conclusions of the research, while section 8.2 includes recommendations.

8.1. Conclusions

This section presents the conclusions of the current study, by giving an answer to the four research sub-questions (8.1.1) and the main research question (8.1.2).

8.1.1. Answer to the research sub-questions

The four research sub-questions which helped achieve the research objective are answered:

RSQ1: "What are complexity and opportunity in the context of sustainable construction projects and what management strategies are used to deal with complexity?"

Complexity and opportunity were first defined as general concepts. In the current study, complexity is defined as a phenomenon that can arise at the technical, organizational, or environmental level and can impact the project outcome. Opportunity is considered a positive risk or situation from which one can benefit. In the context of sustainable construction projects, it was noticed that complexity is different compared to general construction projects. This is caused by the different project sustainability goals, requirements, or implemented practices. Therefore, in sustainable construction projects, several elements of complexity from the technical, organizational, and environmental categories (from the TOE framework) were found in papers and grouped in thirteen sub-categories. Regarding opportunities, the ones specific to sustainability are environmental, social, and economic opportunities divided into sixteen sub-categories. The link between complexity and opportunities was presented with risk as the main connector between the two. However, a conceptual framework illustrated that management strategies could be means to generate opportunities from complexities in the context of sustainable construction projects. Therefore, two main categories of management strategies were built to achieve this: control and interaction.

RSQ2: "What complexity elements, opportunities, and management strategies could be found in the front-end phase of sustainable construction projects in practice?"

From analysing the four case-projects from TT EIR, TT UK, and TT NL and conducting twelve semi-structured interviews with the project members working on them, the findings show that the majority of the complexities and opportunities found in the literature are confirmed in practice. However, the cases brought five additional complexity elements from the environmental category. Two social opportunities and one economic opportunity related to the net-zero goal, and two environmental and one social outside the net-zero goal were also found in practice. A few complexities are the project sustainable design, project schedule, project budget, project team's sustainability knowledge and implementation of sustainable project management, stakeholders' understanding of sustainability, compliance with the sustainability codes and standards, and the

influence the market has on the project. The management strategies are related to communication and reporting, project planning, openness to change, team strategies, and external strategies. In terms of opportunities, a few of them are setting standards on the market, sustainability management, use of resources, end-users' lifestyle, training and education, enhanced work process for the project team, costs, image, quality, and resources.

RSQ3: "How can complexity elements, opportunities, and management strategies in the front-end phase of sustainable construction projects be compared in countries working towards achieving net zero?"

The three branch offices (TT EIR, TT UK, and TT NL) were compared considering several aspects: net-zero approach and technical tools, complexities, opportunities, and management strategies. Although the Irish and British project teams are more advanced in terms achieving net-zero and sustainability goals, lessons can be captured from all the three teams and applied by industry experts working on sustainable construction projects. It was noticed that the most common complexity elements are fixed project schedule, project team's lack of expertise in implementing sustainability, difficulties in implementing sustainable project management, and stakeholders' lack of understanding of sustainability. Some of most common management strategies applied or suggested by the project members of the three branch offices are the clear understanding of the project sustainability requirements, planning and prioritizing the project sustainability requirements, analysing and suggesting different scenarios and methods, engaging the relevant stakeholders early upfront, etc. Regarding the unique management strategies that were mentioned in each branch office, some of the ones mentioned by the project members from Ireland were supply chain mapping or escalating problems, while from the UK, a few are building a team of experts with complementary skills and involving the supply chain in the design process. A few unique strategies from the Dutch team are getting the local team or sustainability knowledge and seeking sustainability knowledge. Lastly, the most common opportunities found in practice are setting standards, reducing the carbon footprint, enhancing the end-users' lifestyle, good corporate image, or related to training and education, resources, quality, or work processes.

RSQ4: "How could a framework help project members in identifying opportunities from complexities in the front-end phase of sustainable construction projects by using management strategies?"

As the possibility of generating opportunities from complexities by means of management strategies was presented, the CMO opportunity-identifying framework for complex sustainable construction projects was developed. The framework could guide project members who use it by following its three steps (selecting the current elements of complexity encountered in the project members' project, following the recommended management strategies, and generating the suggested opportunities). The framework was developed by including the four complexity elements that were encountered in all four cases and, therefore, were considered common for sustainable construction projects. Combinations of management strategies are recommended to be used for each complexity element with the purpose of dealing with complexity and generating opportunities. The strategies were selected to balance control and interaction, and to combine the

applied and suggested strategies. The combinations of strategies and their order were selected based on the author's interpretation of their suitability for the four complexity elements. Several opportunities that could arise are illustrated in the framework, the majority of which are common opportunities found in the case-projects.

8.1.2. Answer to the main research question

To express how opportunities could be obtained by using management strategies to deal with complexity in sustainable construction projects, it is essential to first define and identify the three key elements in the literature, followed by their identification in practice. After finding them, the elements can be compared across cases to find the most common and the unique ones. Having compared them, the CMO opportunity-identifying framework can be developed based on them with the purpose of illustrating how complexities can generate opportunities. Therefore, the answers to the four research sub-questions contribute to answering the main research question of the study.

"How could opportunities be generated from complexities by using management strategies in the front-end phase of sustainable construction projects?"

Sustainable construction projects bring different complexity elements compared to general construction projects. As complexity can either influence a project in a positive or negative way, the positive impact could be exploited to identify the potential positive risks than can arise in a project (opportunities). To be able to generate opportunities from complexities, the study found that the management strategies used to deal with complexity can help in generating opportunities. By using a combination of management strategies based on control and interaction, the project members can work toward transforming what seems to negatively impact the project into a positive outcome, which is opportunity. Therefore, the aspects of the project that seem to be challenging and cause issues in the project and maybe even stop its successful delivery could actually be turned into the opposite by properly managing the project complexity. In line with this, the framework that was developed aims to help project members implement the right management strategies to deal with the most common elements of complexity in sustainable construction projects to find opportunities that could benefit the client (project), the organization (all the project members), and/or the environment, society, and economy.

The framework fills the knowledge gaps described at the beginning of the study (the positive impact of complexity and the possibility of generating opportunities from complexities) as it accentuates the positive side of complexity by demonstrating that opportunities can originate from it. The framework aims to help all the project members who work on sustainable construction projects and plan to manage their projects as sustainably as possible. By using the CMO opportunity-identifying framework to deal with complexity in their projects, the opportunities that they might generate could add even more value to their projects and therefore deliver a high-quality sustainable project, from which many more other opportunities could arise.

8.2. Recommendations

This section includes the recommendations of the study for project members from the industry, clients, and case company (TT) (8.2.1). Based on the research findings, the section also makes recommendations for further research (8.2.2).

8.2.1. Recommendations for practice

For a better management of their projects, the following recommendations are made for all the project members who work on sustainable construction projects:

- Involving a sustainability consultant from the beginning of the project – it is important to involve the expert and consider their opinion and expertise from the early stages of the project, for a better understanding of the requirements and clarification of the feasibility of each scenario considered in the project
- Involving all the project members in workshops and making sure they are aligned with the project plan and requirements – no project members should be excluded from the client's workshops; this would ensure that everyone is aligned on the project goals, requirements, and further steps
- Considering other stakeholders' opinions and expertise – as other project members could have more experience in different aspects of the project (for instance, sustainability), their opinions should always be considered for better project outcomes
- Being aware of complexity – as discussed in the current study, complexity arises in any project; is it essential to be aware of what complexity elements are encountered in projects and how they could be tackled
- Being ready to deal with complexity and transform it into something positive – as previously shown, complexity could impact the project in a positive way; the means to exploit its positive impact and generate opportunities are the right combinations of control and interaction management strategies
- Always seek knowledge and reflect on your own work – there will always be room for more knowledge, which is when completed projects or other experienced colleagues could help; reflection on own work is another way of gaining knowledge as it shows what went right and what did not go according to the plan
- Actively looking for opportunities – it is important to be aware of any opportunities that can arise; project members can use the framework in a different way: they can focus on specific opportunities that they would like to obtain in their projects and based on them, several combinations of management strategies can be applied

As they are key-players in achieving sustainability and net-zero goals, the following recommendations are made for clients:

- Understanding what sustainability involves and how it can be translated into project requirements – as sustainability is still a new concept that requires a lot of attention, it is essential that clients are certain about their project goals and requirements regarding

sustainability; this would help in the decision-making process and minimize the potential misunderstandings or conflicts within the project team and stakeholders

- **Being aware of the implications of the certificates –** achieving several sustainability goals might seem an easy task as long as certain certificates are followed; however, complying with these certificates might sometimes require more time, knowledge, and costs
- **Allowing flexibility in the project schedule and budget –** the majority of projects are restricted in terms of schedule and budget; sometimes, for a better cooperation among the team members and stakeholders, better quality of work and end-product, a flexible budget or schedule might make a significant difference
- **Providing the project team with a shared platformed with all the project data –** it is essential that clients offer all the project members (stakeholders) a platform where all the updated documents can be found and utilized; this will ensure that the project members are aligned with the latest documents

For an even greener, more inclusive, and productive world which TT works for, the following recommendations are made for **TT NL**:

- **Sustainability training** – many interviewees from TT mentioned that being trained regarding sustainability would help them better understand the requirements and deliver higher-quality projects; the first step to achieve their clients' sustainability and net-zero goals is to train their experts in regard to sustainability
- **Hiring sustainability consultants** – alongside training their employees related to sustainability, it was noticed that having a sustainability consultant is crucial in a project that is aimed to become more sustainable; their expertise could help the project team in the decision-making process by advising from a more experienced perspective
- **Using the cost-carbon calculator or the NABERS certificate** – as mentioned by the Irish team, the cost-carbon is essential in a sustainable project and the decisions should be made based on it; the British team use the NABERS instead of the cost-carbon calculator, as it helps them assess and improve the energy performance of the office space/building
- **Pushing themselves to comply with the latest versions of the certificates** – a greener world involves pushing ourselves to be more sustainable; the latest versions of the usual certificates could help with this matter as their scoring is different and more challenging

In terms of the comparison made among the three branch offices, unique management strategies were identified from each country. Therefore, at an internal level, the recommendations made for **TT EIR, TT UK, and TT NL** are the unique strategies retrieved from each branch office which are listed in Chapter 5, Table 5.2. The strategies could help them better deal with complexity and identify opportunities. Another recommendation for all the three branch offices is to be aware of the complexities and opportunities and use the management strategies found in the current research in their projects (**Complexities** – Table 3.2 and section 7.1 – Contribution of the study to the literature and practice; **management strategies** – section 5.1.3 – Control and Interaction in the management strategies, **opportunities** – Table 3.4 and section 7.1 – Contribution of the study to the literature and practice).

8.2.2. Recommendations for further research

Considering the research methods used and the findings of the current study, the following recommendations are made for further research:

- Other companies: as the research was carried out within TT, there is room for analysing the key elements of the study in other companies, as they can differ depending on the company's goals, culture, and purpose
- In-depth analysis in other countries: the current research analyses one project in the UK, one in Ireland, and two in the Netherlands; an in-depth analysis of more cases in each of the three countries would help better understand if there are significant differences in the three key elements; for instance, different management strategies could lead to different ways to deal with complexity and identify opportunities
- Public clients: compared to private clients, the public sector might have projects with different goals, requirements, or management strategies; an analysis of cases from the public sector could be further carried out; moreover, a comparison between the two sectors could be made
- Other types of projects: as the research is specific to sustainable construction fit-out projects, other types of projects could be considered for further research (for instance, refurbishment or new-built projects); different key elements might be found
- Other project phases: further research can be carried out for other project phases than the front-end phase, as different complexities might arise, so different management strategies might be required to generate opportunities
- Varied interviewees: the experts' roles in the projects were limited to project director, project manager, cost manager, and sustainability consultant; further research could involve more stakeholders: client, architects, designers, engineers, etc.; as the framework is subjective, other stakeholders might lead to different outcomes
- Opportunities for other stakeholders: the current study focused on the opportunities that could benefit the client and TT; however, opportunities for other stakeholders could also be considered in future research
- Testing the opportunity-identifying framework: further research can be carried out to test the CMO opportunity-identifying framework; the framework can first be tested in sustainable construction fit-out projects, after which other types of sustainable construction projects, clients, or other countries and stakeholders can be considered to evaluate the efficiency of the framework and improve it; other stakeholders' involvement would be beneficial to check whether they would cooperate for a better management of the project using the framework
- Adding elements to the framework: the framework currently includes key elements encountered by project members on their way to net zero; other complexities could later be added from sustainable construction projects with different sustainability goals; new combinations of management strategies could also be made to deal with the new complexities; this might influence the framework and generate new opportunities

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Appendices

Appendix A: Net zero in the Netherlands, the United Kingdom, and Ireland

What is Net Zero?

National Grid (2023) explains the difference between net zero and real zero for a better understanding of the concept. Real zero suggests that all the emissions should be reduced to zero, which is not a realistic plan. Instead, by balancing the emissions, the net value will be zero (Figure A 1).

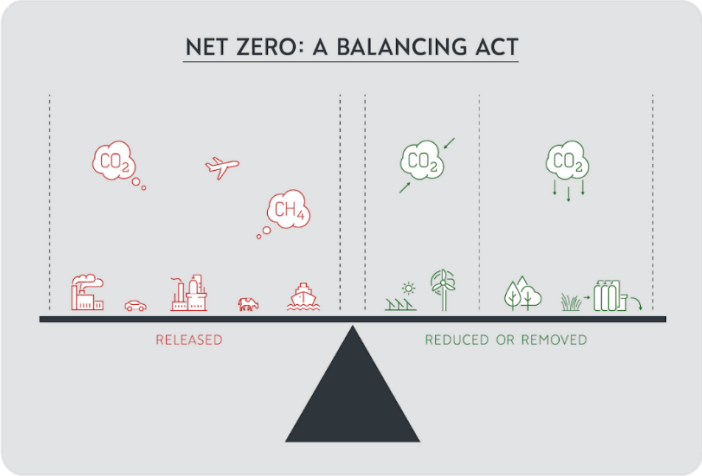

Figure A 1. The balance of emissions (Lang, 2019)

Achieving net zero is crucial to stop the acceleration of global warming. Therefore, the CO_2 emissions must be reduced by around 45 percent by 2030 (compared to 2010) and net zero needs to be achieved by 2050. To do this, plans to achieve net zero must be made worldwide (University of Oxford, 2023). At a national level, several actions must be taken to reduce carbon emissions. According to Hitchings-Hales (2021), such actions would be the complete change of the agricultural processes, the shift to electric cars and to sustainable public transport, and strategies to reduce waste and use renewable resources must be adopted. In the context of achieving net zero, the framework created by the University of Oxford (2023) highlights the importance of reducing the gas emissions. The framework includes the following seven strategies that could help in this matter: front-loaded emission reductions, a clear strategy towards minimizing the emissions, paying attention to the storage of CO_2, effectively regulating the carbon offsets, transitioning to net zero in an equitable way, looking for opportunities in economy, and matching larger social and environmental goals.

Net zero in the Netherlands

According to the Government of the Netherlands (2020), a climate policy was adopted to fight the climate change. The policy is part of the Climate Act 2019 and requires a reduction in the "greenhouse gas emissions by 49% by 2030, compared to 1990 levels, and a 95% reduction by

2050". To achieve these objectives, several sectors will participate and are listed in the National Climate Agreement including the electricity, built environment, traffic, and transport sectors.

The Ministry of Economic Affairs and Climate Policy (2019) made a long-term strategy for all the sectors, namely the built environment, the industry, the mobility, and the agriculture and land use. In the built environment, the residential buildings will be heated in a sustainable way, by using electrical heat pumps, heating networks, and green gas and hydrogen if the latter two will be available. Moreover, the houseowners will be provided subsidies from the government to make sure that they comply with the new requirements. In the industry sector, a CO_2 tax will be implemented, while in the mobility sector, the use of cars will be reduced by advertising other types of transportation. In addition, to save 1Mt of CO_2 per year by 2030, the city councils are planning to implement emission-free traffic by 2050. They also offer grants of 5,900 US dollars to companies and firms to buy or lease electric vehicles, according to Broom (2021). Lastly, in the agricultural sector, changes will be made towards a circular and nature-inclusive agriculture (Ministry of Economic Affairs and Climate Policy, 2019).

Net zero in the UK

The Government of the UK has built its net zero strategy called "Build Back Greener", which includes several policies and suggestions to manage to decarbonize all the sectors in the UK. The strategy was created in accordance with the Climate Change Act 2008 to help reach the net zero target by 2050 (Gov.uk, 2022). The strategy accommodates a ten-point plan which includes major steps which would help the green economy of the UK recover from the impact of COVID-19.

The plan includes the following ten steps that could make the UK "the global leader in green technologies" (Gov.uk, 2020) by recovering, supporting green jobs, and reaching the net-zero objectives:

- advancing offshore wind (essential source of renewable energy)
- driving the growth of low carbon hydrogen (hydrogen could be a source of fuel and heat)
- delivering new and advanced nuclear power (source of low-carbon electricity)
- accelerating the shift to zero-emission vehicles (petrol and diesel cars will be replaced by hybrid cars)
- green public transport, cycling, and walking (zero-emission buses, cycle lanes)
- jet zero and green ships (zero-emission aircraft, developments in the infrastructure of airports and seaports)
- greener buildings (energy efficient, moving away from fossil fuels)
- investing in carbon capture, usage, and storage (capture 10Mt of CO_2 per year by 2030)
- protecting our natural environment (restore the habitats, protect the landscapes)
- green finance and innovation (better products, new business models, impact the consumer behaviour, lower transition costs)

Net zero in Ireland

According to Government of Ireland (2022), Ireland started working on the transition to net zero two years ago. The Climate Action Plan 2021 includes the current and the planned policies that

could help achieve the net-zero goal by setting objectives for several sectors. Some of the current goals that the Government of Ireland has are the following:

- transport sector: 360 million euros are granted to improve the infrastructure for walking and cycling, and 200 public charge points will be placed in public areas for electric vehicles annually
- building sector: center for construction workers to be trained related to the Nearly Zero Energy Building standards
- circular economy: waste action plan
- carbon pricing: improved legislation related to the carbon taxes to 2030
- public sector: regulations to withdraw the fossil fuel vehicles in public fleets
- agriculture: organic farming scheme to adopt sustainable farming practices

Appendix B: Search logs for articles related to complexity

The illustrations (Table B 1 and Table B 2) represent the search logs obtained from the two search strings generated on Scopus. The tables include the articles selected after the identification phase and after eliminating the ones published earlier than 2013. The tables also include the column "Abstract notes", which was added as an extra column to the search logs for a more organized selection process based on the abstract. The lines highlighted in green represent the articles selected after applying all the criteria. For the full version of the search logs, the reader may refer to the excel table.

Table B 1. Search log complexities (sustainable construction & complexit) (Scopus database)*

Authors	Titles	Year	Source t	Volume	Issue	Cited by	Link	Abstract	Abstract not	Author K	Docume	Open Ac	Source
Lindblad F.	Växjö muni	2020	Sustainabil	12	12	1	https://ww	Sweden ha	Developing sus	Governanc	Article	All Open Ac	Scopus
Martinez C	Quantity of	2013	Internation	8	3	1	https://ww	The complexity of climate		CO2 Emiss	Article	All Open Ac	Scopus
Niu X.; Yao	3D numeric	2018	Applied Sci	8	11	3	https://ww	A strong bearing capacity		CFG piles;	Article	All Open Ac	Scopus
Alves J.L.;	Sustainabili	2021	Gestao e P	28	4	0	https://ww	The comple	Sustainability ir	Bibliometri	Article	All Open Ac	Scopus
Mikaelsson	Sustainable	2021	AIMS Envir	8	1	0	https://ww	A large pro	Complexity in ir	Constructic	Article	All Open Ac	Scopus
Cao Y.; Li H	Decision-m	2020	Informatior	11	9	5	https://ww	An appropriate project deli		Project deli	Article	All Open Ac	Scopus
Wu G.; Qia	What are th	2018	Sustainabil	10	8	21	https://ww	Mega susta	Stakeholder-rel	Evaluation	Article	All Open Ac	Scopus
Zhang S.; I	Interface M	2022	Buildings	12	5	1	https://ww	Prefabricat	Complexity and	interface m	Article	All Open Ac	Scopus
Sarker S.;	Spectral Pr	2022	Applied Me	3	3	6	https://ww	The prevention of excessiv		approximat	Article	All Open Ac	Scopus
Hasan U.;	Lifecycle C	2022	CivilEng	3	2	1	https://ww	Growing demand for road		granulated	Article	All Open Ac	Scopus
Rosales-Ca	Exploring t	2015	JASSS	18	1	9	https://ww	This paper	Complexity in n	Agent-Base	Article	All Open Ac	Scopus
Safayeniko	Indirect An	2022	Sustainabil	14	16	0	https://ww	Estimating the mechanical		concrete m	Article	All Open Ac	Scopus
Scherz M.;	A hierarchi	2022	Automatior	139		2	https://ww	In current complex buildin		Building ce	Article	All Open Ac	Scopus
Guo S.; Wa	How indivic	2019	Sustainabil	11	24	4	https://ww	Sustainable	Complexity as a	Project Citi	Article	All Open Ac	Scopus
Kheni N.A.	Determinar	2015	Journal of S	8	3	5	https://ww	Today's world is faced with		Adoption a	Article	All Open Ac	Scopus
Dahooie J.I	A novel app	2018	Symmetry	10	2	77	https://ww	The beginning of the 21st-		Additive ra	Article	All Open Ac	Scopus
Borg R.; G	Building su	2020	Sustainabil	12	23	9	https://ww	Despite am	The project ma	Barriers to	Article	All Open Ac	Scopus
Scherz M.;	How to Ass	2022	Sustainabil	14	5	3	https://ww	Over the pa	A model which	Building ce	Article	All Open Ac	Scopus
Othman I.;	Case study	2014	WIT Transa	181		0	https://ww	Case studie	Design optimiz	Componen	Article	All Open Ac	Scopus
Frost D.; G	Holistic Qua	2022	Sustainabil	14	18	0	https://ww	This paper	A quality model	co-design;	Article	All Open Ac	Scopus
Du G.; Safi	Life cycle a	2014	Internation	19	12	53	https://ww	Purpose: The conventional		Bridge LCA	Article	All Open Ac	Scopus
Chen Y.; Zl	Factors infl	2023	Habitat Int	131		0	https://ww	Developing	Factors influenc	Constructic	Article	All Open Ac	Scopus

Table B 2. Search log complexities (sustainable construction projects & challeng) (Scopus database)*

Authors	Titles	Year	Source t	Volume	Issue	Cited by	Link	Abstract	Abstract not	Author K	Docume	Open Ac	Source
Sarpin N.;	Competenc	2021	Internation	12	5	1	https://ww	The role of Key competen	Competenc	Article	All Open Ac	Scopus	
Cao Y.; Li H	Decision-m	2020	Informatior	11	9	5	https://ww	An appropr	Complexity of p	Project deli	Article	All Open Ac	Scopus
Górecki J.;	Study on C	2022	Applied Sci	12	8	1	https://ww	The constr	The challenges	Circular ec	Article	All Open Ac	Scopus
Ershadi M.;	Barriers to	2021	Cleaner En	3		6	https://ww	Sustainable	Challenges in a	Constructic	Article	All Open Ac	Scopus
Maqbool R.	A systemat	2022	Environme	29	42	7	https://ww	Constructic	Barriers and fa	Barriers; M	Article	All Open Ac	Scopus
El Touny A.	An integrat	2021	Sustainabil	13	15	6	https://ww	A construct	There are man	Constructic	Article	All Open Ac	Scopus
Górecki J.;	Who risks a	2020	Sustainabil	12	8	9	https://ww	More and more constructio		Constructic	Article	All Open Ac	Scopus
Borg R.; G	Building su	2020	Sustainabil	12	23	9	https://ww	Despite ample technologic		Barriers to	Article	All Open Ac	Scopus

Appendix C: Paper selection process for complexity elements

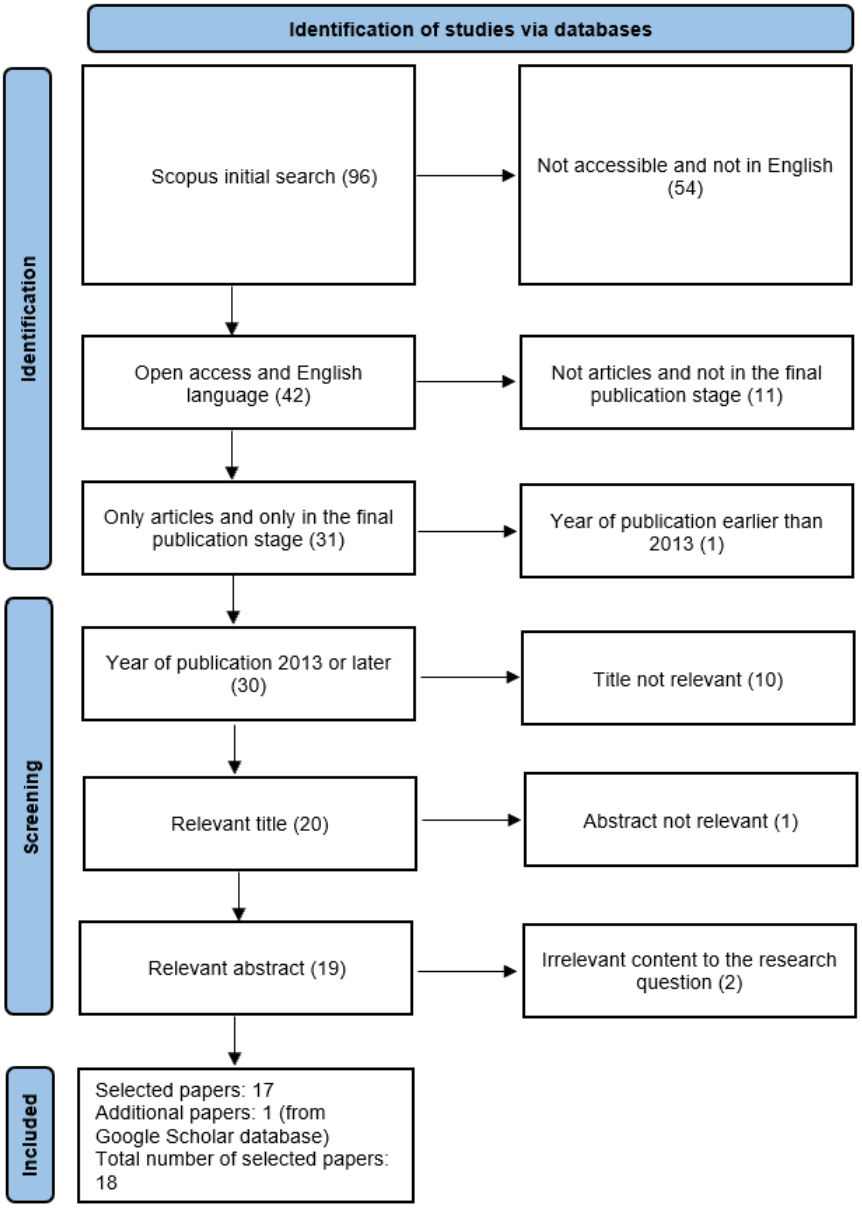

Figure C 1. Papers selection process for complexity elements (University Libraries, 2020)

Appendix D: Search log for articles related to opportunities

Although two search strings were generated on Scopus, the search results obtained from one string were overlapping with some of the results obtained from the other search string. Therefore, only one search log was made. Table D 1 includes the articles selected after the identification phase and after eliminating the ones published earlier than 2013. The table also includes the column "Abstract notes", which was added as an extra column to the search log for a more organized selection process based on the abstract. The lines highlighted in green represent the articles selected after applying all the criteria. For the full version of the search log, the reader may refer to the excel table.

Table D 1. Search log opportunities (sustainable construction & opportunity) (Scopus database)*

Authors	Titles	Year	Source t	Volum	Issue	Cited by	Link	Abstract	Abstract nc	Author K	Documer	Open Ac	Source
Švajlenka J	Mgo-based	2021	Sustainabil	13	21	0	https://ww	Growing global environm		Dry constru	Article	All Open Ac	Scopus
Sonebi M.;	Trends and	2022	RILEM Tech	7		1	https://ww	In recent d	The benefits c	3D Earth Pr	Article	All Open Ac	Scopus
Mofidi A.; A	Novel adva	2020	Sustainabil	12	6	6	https://ww	This paper experimentall		Bio-based c	Article	All Open Ac	Scopus
Yu A.T.W.; J	Integrating	2018	Engineering	25	11	26	https://ww	Purpose: Ir	The ranking o	Constructio	Article	All Open Ac	Scopus
Sharma A.K	Ground gra	2016	Soils and F	56	2	159	https://ww	The potential of using a b		D10; Jel cla	Article	All Open Ac	Scopus
Torgautov	Circular ecc	2021	Buildings	11	11	15	https://ww	The circular	The study per	BIM; Const	Article	All Open Ac	Scopus
Martí J.V.; (	Structural c	2016	Journal of (	120		51	https://ww	An automated procedure		Energy sav	Article	All Open Ac	Scopus
Zu Castell-I	Policies as	2021	Sustainabil	13	16	3	https://ww	A circular e	Many busines	Circular ecc	Article	All Open Ac	Scopus
Lazauskas	Ranking of	2015	E a M: Ekor	18	2	20	https://ww	Crisis of the	Assessment c	Constructio	Article	All Open Ac	Scopus
Gan X.; Zuo	Why sustai	2015	Habitat Int	47		133	https://ww	Rapid urbanization in dev		China; Criti	Article	All Open Ac	Scopus
Araya R.; G	Developme	2022	Sustainabil	14	3	1	https://ww	This article	The identificat	Educationa	Article	All Open Ac	Scopus
Hawkins W	Design, Co	2019	Structures	18		14	https://ww	Rapid global urbanisation		Concrete s	Article	All Open Ac	Scopus
Tavares C.	Machine lea	2022	Cleaner Ma	4		1	https://ww	The emergence of ultra-h		Artificial Int	Article	All Open Ac	Scopus
Tu W.; Zha	Behaviour (	2023	Cement an	138		0	https://ww	Alkali-activated concrete		Damage ev	Article	All Open Ac	Scopus
Murtagh N.	The relatior	2016	Constructio	34	1	50	https://ww	Research o	The aim was t	Architect; n	Article	All Open Ac	Scopus
Tafazzoli M	Opportuniti	2020	Sustainabil	12	11	10	https://ww	Although th	Based on a cc	Integration	Article	All Open Ac	Scopus
Unuigbe M.	Challenges	2023	Built Enviro	13	1	1	https://ww	Purpose: C	Transitioning	Commercia	Article	All Open Ac	Scopus
González-A	Analysis of	2022	Sustainabil	14	8	1	https://ww	This paper looks at the e		building ret	Article	All Open Ac	Scopus
Nitichote K	Recycled Ac	2022	Internation	13	1	0	https://ww	Construction and Demolit		constructio	Article	All Open Ac	Scopus
Cantù C.L.;	The role of	2021	Journal of E	36	13	3	https://ww	Purpose: This paper aims		Circular ecc	Article	All Open Ac	Scopus
Riala M.; Ilc	Multi-storey	2014	Scandinavia	29	4	36	https://ww	Multi-storey	Ways in which	bioeconom	Article	All Open Ac	Scopus
Dlamini L.N	Residents a	2022	Sustainabil	14	8	2	https://ww	The concep	By identifying	awareness	Article	All Open Ac	Scopus
Franco J.A.I	Sustainabil	2022	Infrastructu	7	3	4	https://ww	The civil cor	Identify the cl	constructio	Article	All Open Ac	Scopus
Sokas R.K.;	Building a s	2019	Internation	16	21	23	https://ww	The average U.S. constru		Aging work	Article	All Open Ac	Scopus
Lähtinen K.	Effects of L	2019	BioProducts	4	7	12	https://ww	In the cont	The use of ma	lobbying; p	Article	All Open Ac	Scopus
Karlsson I.;	Reaching n	2020	Renewable	120		41	https://ww	Recent esti	For deep dec	Carbon aba	Article	All Open Ac	Scopus
Heltzel A.;	Metamater	2018	Journal of T	10	5	0	https://ww	A computational study of a metamat			Article	All Open Ac	Scopus
Toderaş M.	Model to as	2017	Sustainabil	9	10	1	https://ww	Geomechanical assessme		Aggregate;	Article	All Open Ac	Scopus
Eze C.E.; U	Green Build	2021	Journal of E	11	2	4	https://ww	The constru	An assessmer	Constructio	Article	All Open Ac	Scopus
Marsh R.J.;	Understanc	2021	Journal of t	63	4	2	https://ww	The constru	This study de	Barriers; Be	Article	All Open Ac	Scopus
Strazzeri V	Qualitative	2023	Cleaner Ma	7		0	https://ww	During the last decades,		Australian c	Article	All Open Ac	Scopus
Booth C.A.;	Insights int	2021	Buildings	11	9	1	https://ww	Sustainable	this study is t	Alternative	Article	All Open Ac	Scopus
Leblanc H.;	Developing	2015	Proceeding	168	MP2	2	https://ww	Effective m	Sustainability	Knowledge	Article	All Open Ac	Scopus
Shan M.; H	A global rev	2017	Sustainabil	9	12	29	https://ww	Despite the	The aim is to c	Financing; I	Article	All Open Ac	Scopus
Piderit M.B.	Net zero bu	2019	Sustainabil	11	5	19	https://ww	The potent	The aim is to c	Energy der	Article	All Open Ac	Scopus

Appendix E: Papers selection process for opportunities

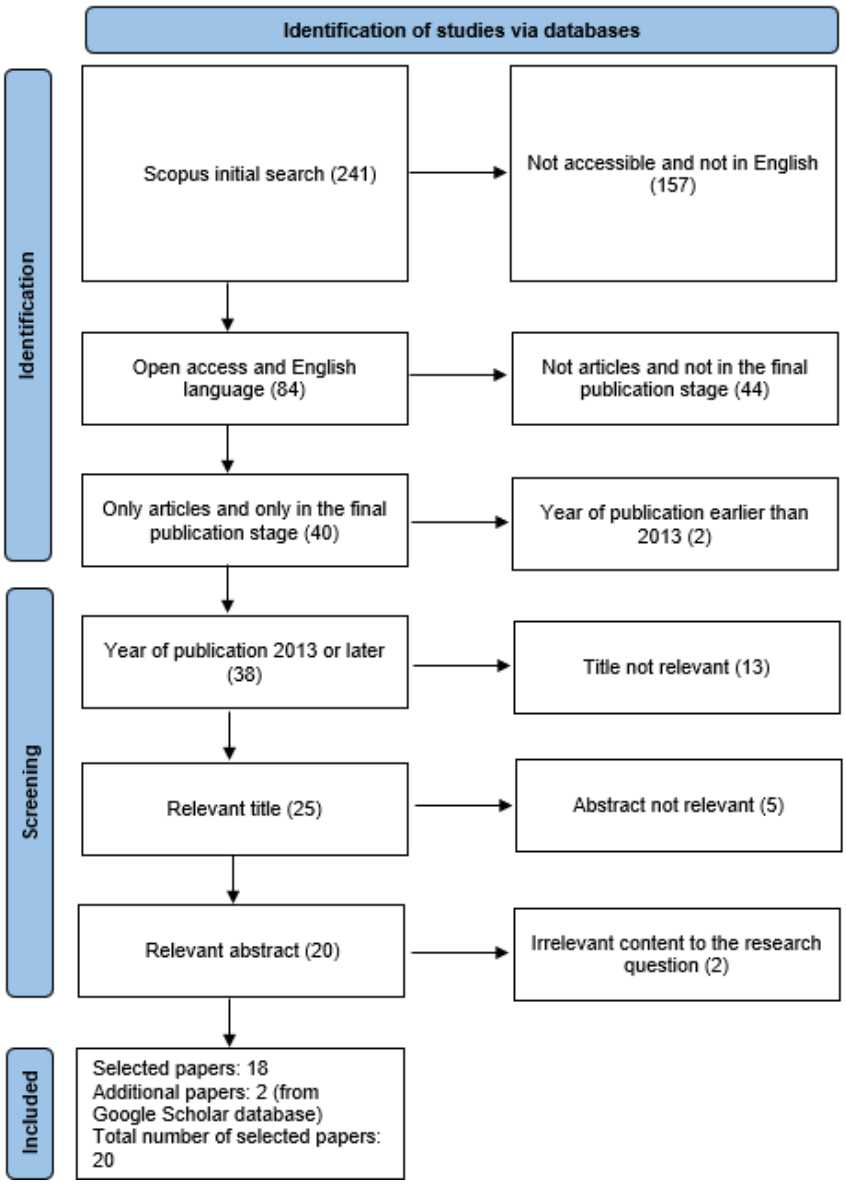

Figure E 1. Papers selection process for opportunities (University Libraries, 2020)

Appendix F: Complexity frameworks

Table F 1. TOE framework (Bosch-Rekveldt et al., 2011)

No	Category	Sub-category	Element of complexity	Question
1	Technical	Goals	Number of goals	How many strategic goals does the project have?
2			Alignment of goals	Are the goals aligned?
3			Unclarity of goals	Are the goals clear?
4		Scope	Largeness of scope	How large is the scope?
5			Uncertainties in scope	Are there uncertainties in the scope?
6			Quality requirements	Are there strict quality requirements?
7		Tasks	Number of tasks	Is there a large number of tasks?
8			Variety of tasks	How various are the tasks of the project?
9			Dependencies	Are there dependencies between tasks?
10			Uncertainty in methods	Are there uncertainties in the methods?
11			Conflicting norms and standards	Are there conflicting norms and standards?
12			Interrelations between technical processes	To what extent do technical processes in this project have interrelations with existing processes?
13		Experience	The usage of new technologies	Are there new technologies used?
14			Experience with technology	Is the project team experienced with these technologies?
15		Risk	Technical risks	Is the project at high technical risk?
16	Organizational	Size	Project duration	What is the estimated project duration?
17			Compatibility of different project management methods and tools	Are there compatibility issues regarding project management methods or tools?
18			CAPEX	What is the estimated budget?
19			Size in Project/Cost Management hours	How many working hours does the project need?
20			Size of the project team	How large is the project team?
21			Size of the site area	How large is the site area?
22			Number of locations	How many site locations are involved in the project?
23		Resources	Availability of resources and skills	What is the availability of resources and skills?
24			Experience with parties involved	Does the team have experience with the parties involved?
25			HSSE awareness	Is the team aware of health, safety, security, and environment?
26			Interfaces between disciplines	Are there interfaces between mechanical, civil, financial, etc. works?
27			Number of financial resources	How many financial resources are involved in the project (own investment, JV, bank investment)?
28			Contract types	How many main contract types are there in the project?
29		Project team	Number of different nationalities	How many nationalities are involved in the project?
30			Number of different languages	How many languages are used in the project?
31			Trust in project team	Is there trust in the project team (client, engineer, architect, PM, CM)?
32			Trust in contractor	Is there trust in the contractor?
33		Risk	Organizational risk	Is the project at high organizational risk?
34	Environmental	Stakeholders	Number of stakeholders	How many stakeholders are involved in the project?
35			Stakeholders' perspectives	Are there different perspectives on the stakeholders' side?
36			Dependencies between stakeholders	Are there dependencies between stakeholders?
37			Political influence	Does the political situation influence the project?
38			Company internal support	Is there internal (management) support for the project?
39			Required local content	What is the required local content?
40		Location	Interference with existing site	Is there any interference with the existing site?
41			Weather conditions	Could the weather conditions affect the project?
42			Remoteness of location	How remote is the location?
43			Experience in the country	Does the project team have experience in the country?
44		Market conditions	Internal strategic pressure	Is there internal strategic pressure from the business?
45			Stability project environment	Is the project environment stable?
46			Level of competition	What is the level of competition?
47		Risk	Risk from environment	Is the project at high environmental risk?

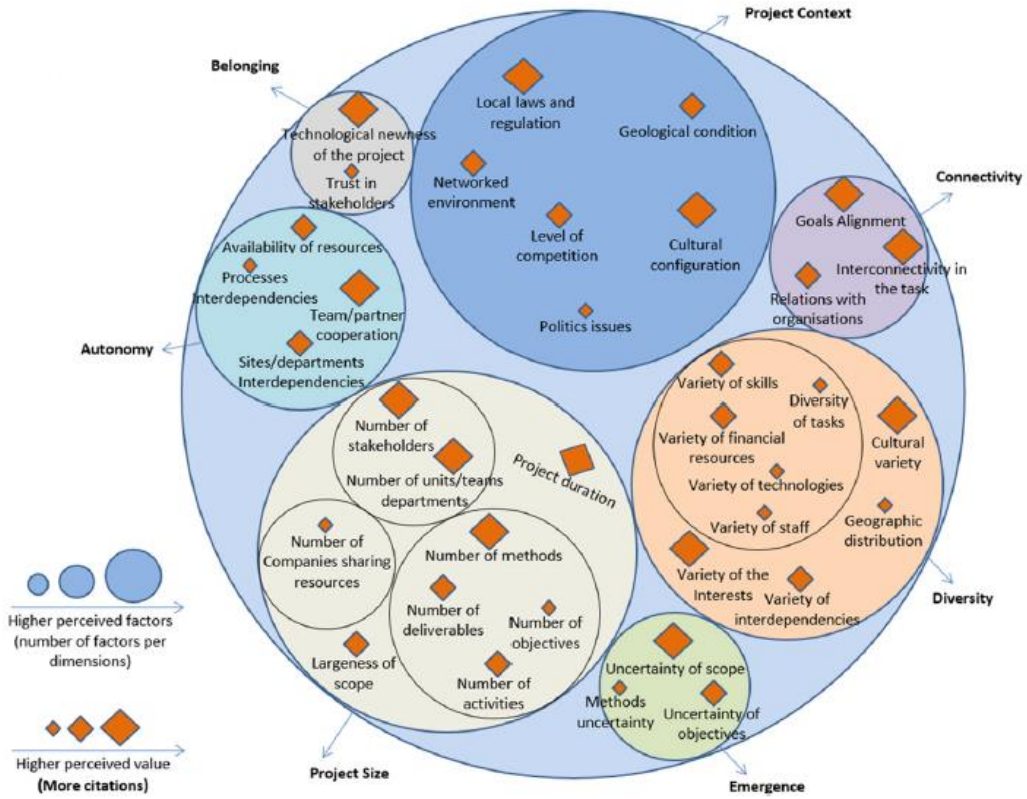

Figure F 1. Project complexity factors (Bakhshi et al., 2016)

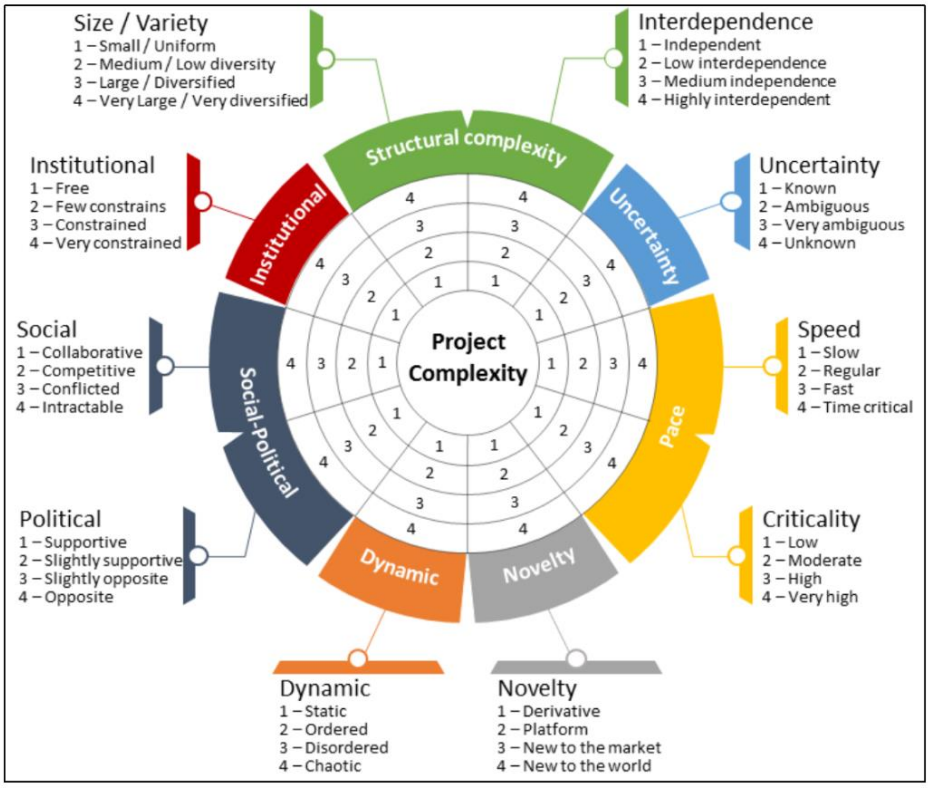

Figure F 2. Project complexity dimensions (de Rezende & Blackwell, 2019)

Appendix G: Complexity elements encountered in sustainable construction projects in the academic literature

Table G 1. Complexity elements encountered in sustainable construction projects in the academic literature

Element no.	Category	Complexity elements in sustainable construction projects	Author(s)	Complexity elements mentioned in general construction projects
1	Technical	Uncertainties in project schedule	Cao et al. (2020); Mikaelsson & Jonasson (2021); Wu et al. (2018); Othman et al. (2014); Chen et al. (2022); Marcelino-Sadaba et al. (2015)	de Rezende & Blackwell (2019)
2		Quality requirements	Cao et al. (2020); Scherz et al. (2022); Othman et al. (2014)	Bosch-Rekveldt et al. (2011)
3		Sustainability requirements	Cao et al. (2020); Alves et al. (2021); Wu et al. (2018); Zhang et al. (2022); Scherz et al. (2022)	
4		Too ambitious sustainability goals	Mikaelsson & Jonasson (2021)	
5		Variety of project tasks	Alves et al. (2021)	Bosch-Rekveldt et al. (2011); de Rezende & Blackwell (2019)
6		Dependencies between project tasks	Mikaelsson & Jonasson (2021)	Bosch-Rekveldt et al. (2011); Bakhshi et al. (2016); de Rezende & Blackwell (2019)
7		Unclear project scope	Othman et al. (2014); Borg et al. (2021)	
8		Uncertainty in project scope	Cao et al. (2020); Zhang et al. (2020); Othman et al. (2014); Borg et al. (2021);	Bosch-Rekveldt et al. (2011); Bakhshi et al. (2016); de Rezende & Blackwell (2019)
9		Lack of supporting processes for the sustainability requirements	Gorecki et al. (2022); Maqbool & Amaechi (2022); Lindblad (2020); Alves et al. (2021); Wu et al. (2018); Borg et al. (2021); Chen et al. (2022)	
10		Uncertainty in technical processes	Chen et al. (2022)	de Rezende & Blackwell (2019)
11		Ambiguity in technical processes	Chen et al. (2022)	
12		Interdependencies between technical processes	Chen et al. (2022); Zhang et al. (2022);	Bosch-Rekveldt et al. (2011); Bakhshi et al. (2016); de Rezende & Blackwell (2019)
13		Uncertainty in methods	Chen et al. (2022)	Bosch-Rekveldt et al. (2011); Bakhshi et al. (2016); de Rezende & Blackwell (2019)
14		Complex and unique (sustainable) design	Cao et al. (2020); Wu et al. (2018); Othman et al. (2014); Frost et al. (2022); Chen et al. (2022); Marcelino-Sadaba et al. (2015)	
15		Adaptability and modularity of design solutions	Gorecki et al. (2022); Alves et al. (2021); Chen et al. (2022)	
16		Variety of technical interconnections (between processes)	Alves et al. (2021); Zhang et al. (2022); Othman et al. (2014); Chen et al. (2022)	Bosch-Rekveldt et al. (2011); Bakhshi et al. (2016);; de Rezende & Blackwell (2019)
17		Uncertainty of data (relevant to the project)	Alves et al. (2021); Othman et al. (2014)	de Rezende & Blackwell (2019)
18		BIM & integrated design	Gorecki et al. (2022); Maqbool & Amaechi (2022); Chen et al. (2022)	
19		High costs	Marcelino-Sadaba et al. (2015)	de Rezende & Blackwell (2019)
20		Safety	Gorecki et al. (2022)	Bosch-Rekveldt et al. (2011)
21	Organizational	Lack of sustainable resources	Maqbool & Amaechi (2022); Marcelino-Sadaba et al. (2015); Othman et al. (2014); Gorecki et al. (2022); Cao et al. (2020); Mikaelsson & Jonasson (2021)	
22		Improper cost management and control	Sarpin et al. (2021); Cao et al. (2020); Gorecki et al. (2022); Ershadi et al. (2021); Alves et al. (2021); Mikaelsson & Jonasson (2021); Borg et al. (2021); Othman et al. (2014)	
23		Under-skilled project manager/project team	Sarpin et al. (2021); Gorecki et al. (2022); Maqbool & Amaechi (2022); Alves et al. (2021); Mazhar & Arain (2015); Othman et al. (2014)	

24	Organizational	Lack of suitable management strategies	Scherz & Vafadarnikjoo (2019); Scherz et al. (2022); Chen et al. (2022); Marcelino-Sadaba et al. (2015); Zhang et al. (2022); Gorecki et al. (2022); Othman et al. (2014)	
25		Lack of sustainability concept knowledge of PM/project team	Sarpin et al. (2021); Gorecki et al. (2022); Alves et al. (2021); Wu et al. (2018); Mazhar & Arain (2015); Borg et al. (2021)	
26		Forms of contracts	Cao et al. (2020); Alves et al. (2021); Mikaelsson & Jonasson (2021); Zhang et al. (2022); Othman et al. (2014); Marcelino-Sadaba et al. (2015)	Bosch-Rekveldt et al. (2011)
27		High number of professionals	Alves et al. (2021); Zhang et al. (2022); Mazhar & Arain (2015); Chen et al. (2022)	Bakhshi et al. (2016); de Rezende & Blackwell (2019)
28		Interfaces between professionals	Othman et al. (2014); Chen et al. (2022); Marcelino-Sadaba et al. (2015)	de Rezende & Blackwell (2019)
29		Lack of teamwork	Ershadi et al. (2021); Maqbool & Amaechi (2022); Zhang et al. (2022); Sarpin et al. (2021); Othman et al. (2014)	Bakhshi et al. (2016)
30		Commitment of the project team (to the project)	Gorecki et al. (2022); Ershadi et al. (2021); Maqbool & Amaechi (2022); Wu et al. (2018); Rosales-Carreon & Garcia-Diaz (2015)	
31		Complex decision-making process	Borg et al. (2021); Sarpin et al. (2021); Othman et al. (2014)	
32		Lack of technical expertise	Sarpin et al. (2021); Gorecki et al. (2022); Chen et al. (2022)	Bosch-Rekveldt et al. (2011)
33		Lack of open communication	Sarpin et al. (2021); Zhang et al. (2022); Othman et al. (2014)	
34		Difficulties in adopting sustainability practices	Sarpin et al. (2021); Ershadi et al. (2021); Maqbool & Amaechi (2022); Alves et al. (2021)	
35		Inadequate sustainable project management collaboration	Ershadi et al. (2021); Maqbool & Amaechi (2022); Mikaelsson & Jonasson (2021); Wu et al. (2018)	
36		Risk management	Cao et al. (2020); Borg et al. (2021); Frost et al. (2022)	
37		Inadequate training/delivering of information of sustainable project management principles	Sarpin et al. (2021); Ershadi et al. (2021); Zhang et al. (2022)	
38		Conflicts between professionals	Othman et al. (2014); Chen et al. (2022)	
39		Experience of the owner staff resources	Cao et al. (2020); Gorecki et al. (2022)	
40		Policy implementation efforts	Maqbool & Amaechi (2022); Wu et al. (2018)	
41		Project size (schedule, budget, resources)	Cao et al. (2020)	Bosch-Rekveldt et al. (2011); Bakhshi et al. (2016); de Rezende & Blackwell (2019)
42		Appropriate project organization structure	Maqbool & Amaechi (2022)	
43		High number of management strategies	Alves et al. (2021)	de Rezende & Blackwell (2019)
44		Lack of economic expertise	Gorecki et al. (2022)	
45		Sensitivity to ecological issues	Gorecki et al. (2022)	
46		Respect for nature	Gorecki et al. (2022)	

Continued…

47	Environmental	Interest/support to adopting principles of sustainable development	Maqbool & Amaechi (2022); Wu et al. (2018); Rosales-Carreon & Garcia-Diaz (2015); Ershadi et al. (2021)	de Rezende & Blackwell (2019)
48		Stakeholers' poor understanding of sustainability (financial, environmental, and social benefits, innovation in sustainability)	Maqbool & Amaechi (2022); Mikaelsson & Jonasson (2021); Borg et al. (2021)	
49		Lack of consensus on sustainability values among stakeholders	Ershadi et al. (2021); Frost et al. (2022); Chen et al. (2022)	de Rezende & Blackwell (2019)
50		Lack of incentives (to implement the sustainability practices)	Ershadi et al. (2021); Mikaelsson & Jonasson (2021); Wu et al. (2018)	de Rezende & Blackwell (2019)
51		Lack of specialized codes and standards (for sustainability requirements)	Chen et al. (2022)	
52		Market supply and demand	Wu et al. (2018); Rosales-Carreon & Garcia-Diaz (2015)	
53		Logistics	Gorecki et al. (2022); Zhang et al. (2022); Borg et al. (2021); Othman et al. (2014); Chen et al. (2022)	
54		Project location	Othman et al. (2014); Chen et al. (2022)	Bosch-Rekveldt et al. (2011)
55		Geographical conditions	Othman et al. (2014); Chen et al. (2022)	Bosch-Rekveldt et al. (2011); Bakhshi et al. (2016)
56		User/owner satisfaction (related to the project)	Wu et al. (2018); Guo et al. (2019)	
57		Number of stakeholders	Zhang et al. (2022)	Bosch-Rekveldt et al. (2011); Bakhshi et al. (2016)
58		Interconnections between stakeholders	Zhang et al. (2022)	Bosch-Rekveldt et al. (2011); Bakhshi et al. (2016); de Rezende & Blackwell (2019)
59		Alignment of interests (of stakeholders)	Chen et al. (2022)	Bosch-Rekveldt et al. (2011); Bakhshi et al. (2016); de Rezende & Blackwell (2019)
60		Site issues	Chen et al. (2022)	Bosch-Rekveldt et al. (2011); Bakhshi et al. (2016)

Appendix H: Interview protocol

Introduction about myself and the research:

First, I would like to take the time to thank you for your participation in my study, it is highly appreciated! I will shortly introduce myself. I am Maria Paraschiv, and I am pursuing my Master's in Construction Management and Engineering at TU Delft. I am currently conducting research for my graduation project at Turner & Townsend.

My research is focused on sustainable construction projects, therefore I am now analysing construction fit-out projects that are driven in a sustainable way as part of TT's net zero strategy in the UK, Ireland, and the Netherlands. The research is related to the challenges and opportunities encountered in this type of projects.

Could you tell me about yourself and your role in the company and the project?

Before we start, I would like to shortly define a term used in the interview. The research concerns only the front-end phase of the project, therefore all the questions are specific to this project phase. The front-end phase includes:

- The RIBA stages 0-2: strategic definition (0), preparation and briefing (1), concept design (2) – for the UK and Ireland
- The following project stages: initiation, concept design, cost estimate, and decision to proceed – for the Netherlands

Interview questions:

1. Could you please briefly describe the project scope and goals?
2. What challenges did you encounter related to sustainability in the front-end phase of the project? Could you give me a few examples of the most impactful challenges for the project?

   Sub-question: What technical, organizational, and external challenges did you encounter? How did the challenges impact the project?
3. Were the sustainability challenges perceived by the project team from TT as impacting the project in a positive or negative way?

   Sub-question: Why do you think the impact was positive/negative?
4. How did you cope with/overcome these challenges? What strategies did you use?

Before we continue, I would like to take a minute to explain another term used in the questions. Projects always come with risks, and risks can have a negative or positive impact on the project. In case of a negative risk, it is called threat, and if it is a positive risk, it is called opportunity. In the following questions, we will discuss positive risks/opportunities that arose in the front-end phase of the project.

5. From the challenges you encountered, was there any situation in which you captured opportunities related to sustainability?

For instance: if it was not clear how to comply with the sustainability requirements, was there an opportunity for training for the team members from TT? Or if the project budget was fixed, was there room for optimization of costs (from choosing sustainable resources)?

6. Could you please give a few examples of other opportunities that arose in the front-end phase of the project?

   These opportunities can be perceived as benefits (and not as project goals) for the client and TT brought by the project.

   Sub-questions: Could you please tell me what were the benefits that arose from the project for the client which added environmental, economic, or social value?

   In the same manner, what were the benefits for the organization (TT)? How are you benefitting from working on the project (on a professional level)? How does it help TT?

7. In case there is any way (strategy) in which the TT project members take the negative impact from challenges and transform them into positive risks (opportunities), could you please give an example?

   Sub-questions: Who initiated the strategy? Did the strategy work? If not, why? If yes, why do you think it worked?

8. In a future sustainable project, what lessons learnt will you apply?
9. Is there anything you would like to add?

At the end: Could you please recommend another project manager/project director and a sustainability consultant from the same project that I can contact for an interview?

<u>Time allocation:</u>

Introduction: 3-5 min

Questions 1-4: 15-20 min

Questions 5-7: 15-20 min

Questions 8-9: 5-10 min

Appendix I: Code schemes for complexities, opportunities, and management strategies identified in interviews and company internal documents

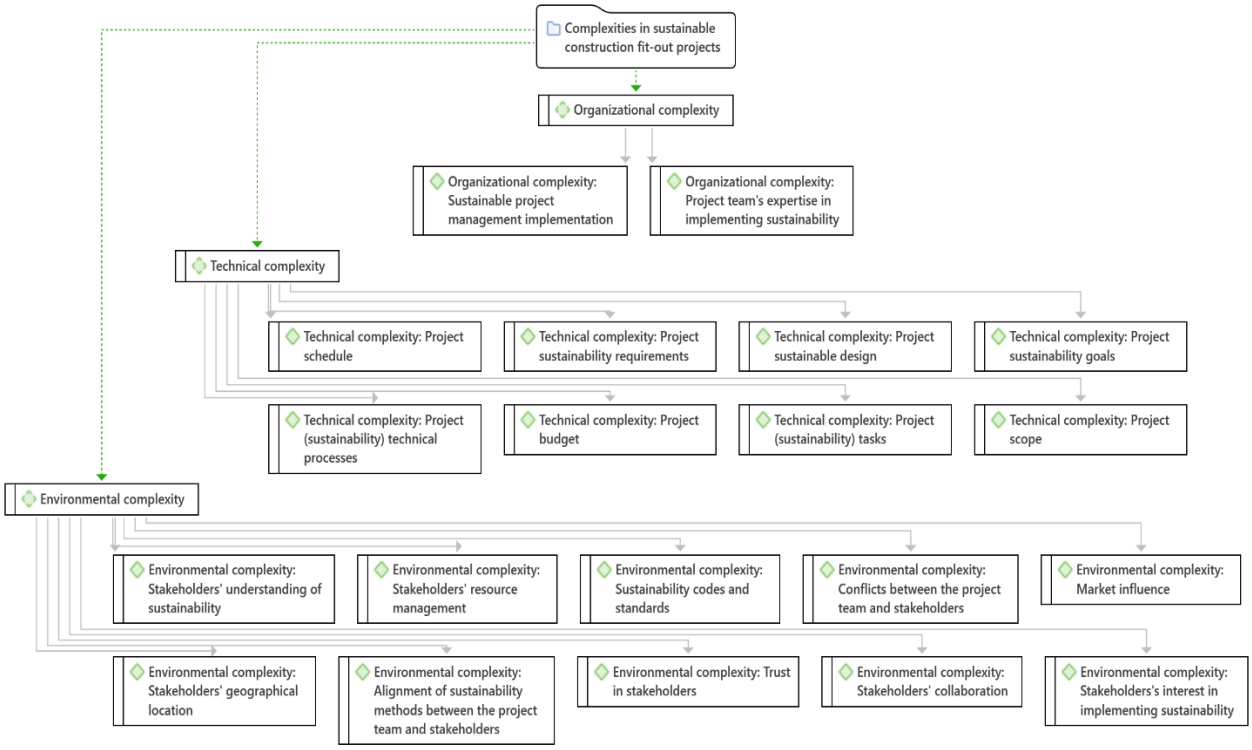

Figure I 1. Code scheme illustrating the categories and sub-categories of complexities from interviews (Atlas.ti)

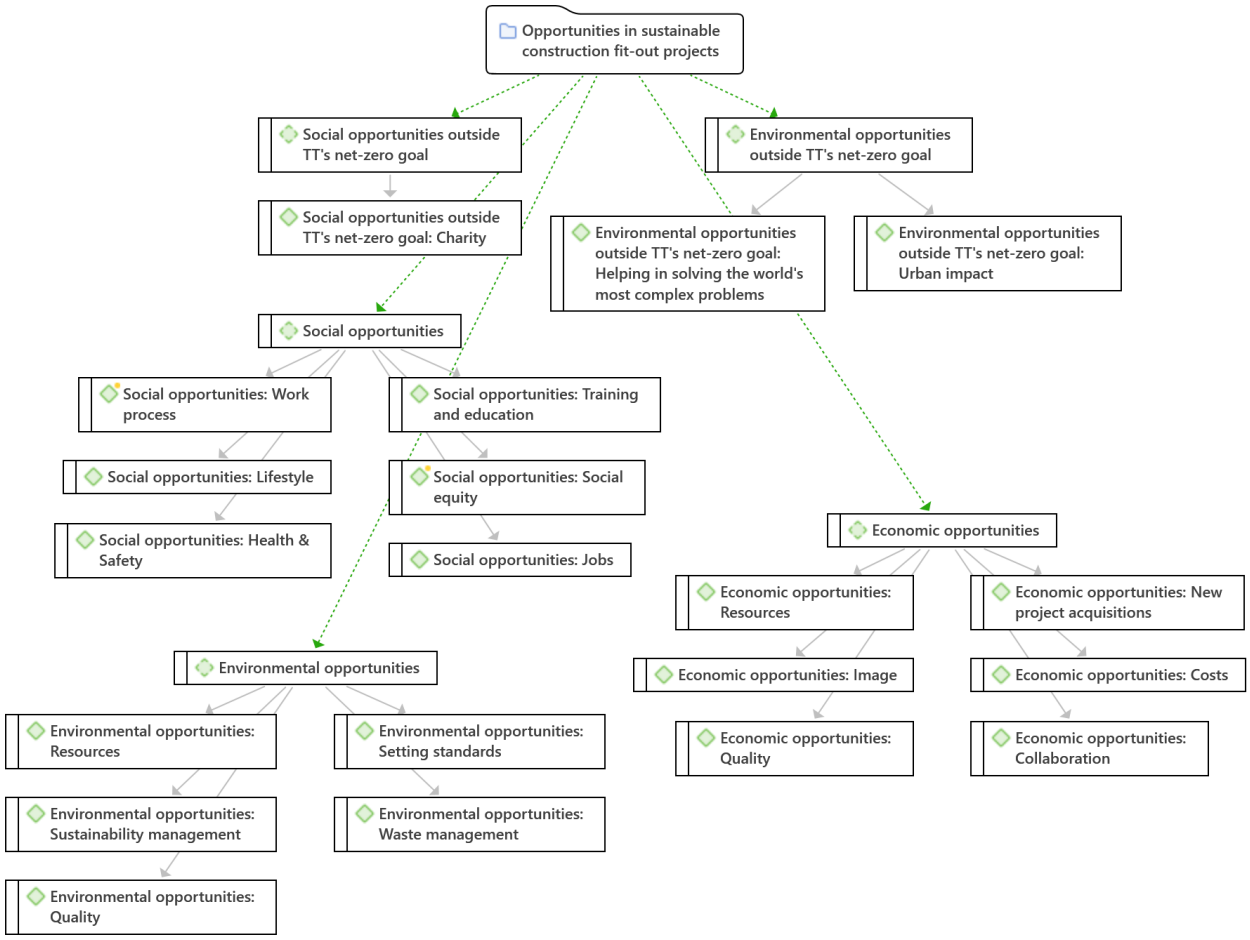

Figure I 2. Code scheme illustrating the categories and sub-categories of opportunities from interviews (Atlas.ti)

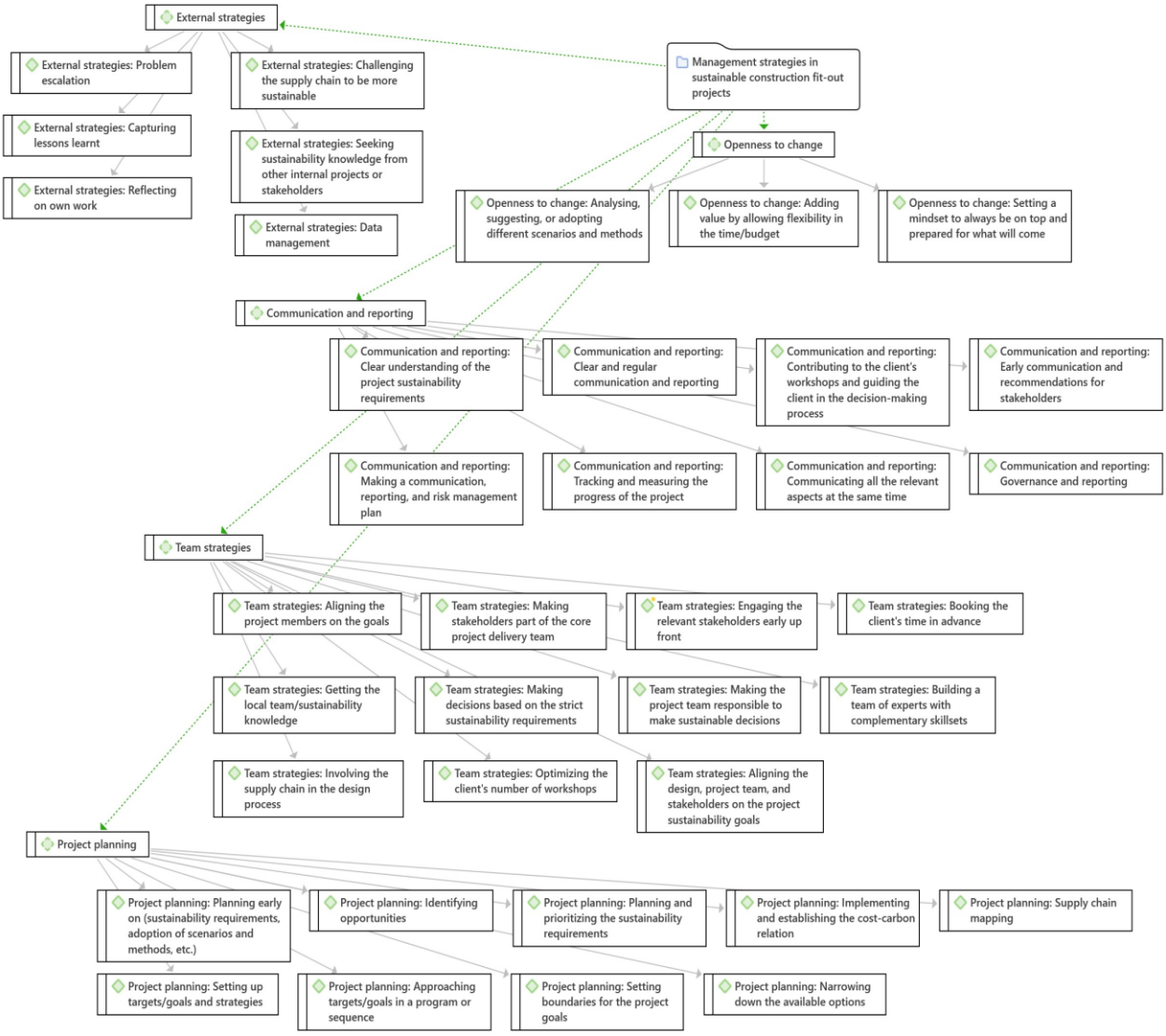

Figure I 3. Code scheme illustrating the categories and management strategies from interviews (Atlas.ti)

Appendix J: Opportunities found in documents (Projects A, B, C, and D)

Table J 1. Opportunities found in documents (Project A)

Opportunities				
Category	Element	Description	Opportunities for	Documents
Environmental	Resources	Water efficiency, material and resource optimization	Client	LEED&WELL client kick-off
	Sustainability management	Reduced carbon footprint (after the project is delivered)	Client	LEED&WELL client kick-off
	Waste management	Construction and demolition waste management	Client	LEED&WELL client kick-off
Social	Health & safety	End-users' enhanced health and well-being	Client	LEED&WELL client kick-off; WELL human resources guidance
	Lifestyle	Comfortable work environment (light, air, transport, movement, etc.)	Client	LEED&WELL client kick-off; WELL human resources guidance
	Training and education	Mental health education	Client	WELL human resources guidance
	Social equity	Ensuring equity for all the project members, community, and supply chain	Client, TT, and stakeholders	LEED&WELL client kick-off; LEED social impact checklist
Economic	Costs	Cost-effective project outcomes	Client	LEED&WELL client kick-off
	Quality	High-performance project outcomes	Client	LEED&WELL client kick-off

Table J 2. Opportunities found in documents (Project B)

Opportunities				
Category	Element	Description	Opportunities for	Documents
Environmental	Resources	Improvements in primary energy consumption, heating, and cooling energy demand; climate change resilience of the building	Client	Sustainability delivery plan
	Sustainability management	Carbon improvements/reduction and offset; compliance with the lifecycle assessment; using recycled aggregates on site	Client	
	Waste management	95% reuse/recycling or recovery of construction and demolition waste; at least 95% of excavation waste diverted for beneficial use	Client	
Social	Jobs	Job creation: 15 new apprenticeships; 20 work experience placements across the supply chain	Client	
	Health & safety	Improved specification for sanitaryware	Client	
	Lifestyle	Improved air quality, ventilation, and lighting for the landlord (end-user); public transport information system;	Client	
	Training and education	15 construction careers information advice and guidance sessions for young people from other priority groups in the community	Client	
	Social equity	Compliance with the client's accessibility best practice guidance (ensuring that the end-users with different disabilities are included)	Client	
Economic	Costs	Reduction in costs due to improvements in primary energy consumption, heating, and cooling energy demand	Client	

Table J 3. Opportunities found in documents (Project C)

Opportunities				
Category	Element	Description	Opportunities for	Documents
Environmental	Resources	Enhanced biodiversity; climate change resilience for the assets; energy and carbon optimization (after the project is delivered); positive urban impact; optimize water use	Client	Project sustainability opportunity guidance
	Sustainability management	Sustainable building materials; energy and carbon optimization; green infrastructure (reducing the use of steel and concrete based facilities; using natural elements with the same functionality); positive urban impact; sustainable procurement (project materials, services, and equipment are purchased based on specific sustainability criteria); enhancement of the assets sustainability in use	Client	
	Waste management	End of life and circular economy (minimization of waste at the end of the project)	Client	
	Quality	Pollution prevention (through assets that do not harm or cause nuisance to the end-users); enhancement of the assets sustainability in use	Client	
Social	Health & safety	Enhanced health and wellbeing of the end-users and stakeholders; pollution prevention; encourage sustainable transport and travel (supporting walking, cycling, and public transport; discouraging use of engine/petrol cars)	Client and stakeholders	
	Lifestyle	Pollution prevention; transport and travel	Client	
	Training and education	Research for the advancement of knowledge and technologies related to sustainability (project level)	Client	
Economic	Costs	Energy and carbon optimization; green infrastructure	Client	
	Resources	Optimized water use	Client	
Environmental outside TT's net-zero goal	Urban impact	Assets making a positive contribution to the wider community (long-term adaptability of the assets, maximization of open green space, reuse of land that was previously occupied)	Environment	

Table J 4. Opportunities found in documents (Project D)

Opportunities				
Category	Element	Description	Opportunities for	Documents
Environmental	Resources	Smarter and more efficient resources (energy, water); minimise water (after the project is delivered)	Client	Carbon case studies
	Sustainability management	Monitor and reduce the carbon emissions	Client	Additional sustainability services proposal; Carbon case studies
	Waste management	Efficiency in waste and space usage	Client	Carbon case studies
Economic	Costs	Reuse of resources is less costly	Client	Carbon case studies
	Resources	Smarter and more efficient resources (energy, water)	Client	Carbon case studies

Appendix K: Unique management strategies in the three branch offices

TT EIR:

- project planning - supply chain mapping: "do a supply chain mapping process and score the supply chain" – CM.A
- team strategies - booking the client's time in advance: "getting their time booked" (to be available outside the client's design workshops as well, when important decisions are made later in the project) – PM1.A;
- team strategies – optimizing the client's number of workshops: "get the client's workshops out of the way as early as possible" – PM1.A
- external strategies - escalating problems: "escalation, so if the project leads are not responding, we go to a different department and escalate this" (within the client's organization) – PM1.A

TT UK:

- communication and reporting – communicating all the relevant aspects at the same time: "having those conversations at the same time in the same workshops helped change the agenda" – SC1.B
- project planning – narrowing down the available options: "rather than going out to ten potential manufacturers or ten products, we can focus on that down just to look at two or three because there are people with data available" – SC1.B
- project planning – setting boundaries for the project goals: "we had defined boundaries. We had to work towards WELL and we helped establish around energy, carbon, and water consumption, so they were the main themes of focus for the project" – SC1.B
- openness to change - setting a mindset to always be on top and prepared for what will come: "it is just framing. It is a mindset thing of framing it for teams that this is the direction we all need to be going in"; "we are proactively working with it, so seeing what is coming up and making sure that we do not come across those potential issues. Just proactively managing is the key to it" – PM.B
- team strategies – building a team of experts with complementary skills: "we have to build a team of two or three people who can complement each other with those skillsets" – SC1.B
- team strategies – involving the supply chain in the design process (contractors, subcontractors): "to look at the design and what we think works, where is gets real value is when you start introducing the supply chain, the manufacturers, the contractor, the installers, you can say that it might save a little bit of money and carbon, but actually it is going to take an awful lot more time to install and we keep getting called out because it keeps failing" – SC1.B
- team strategies – making decisions based on the strict sustainability requirements: "we are not just getting everything from local suppliers if it means that carbon goes up" (the decision to collaborate with suppliers from outside the local area is made based on the strict sustainability requirement to reduce the carbon emissions of the building) – SC1.B

TT NL:

- team strategies - getting the local team or sustainability knowledge: "you need to have the local knowledge about this kind of initiatives"- PD.C
- external strategies - seeking sustainability knowledge from other projects or experts: "follow up on what was possible within the budget at the end, so we made the cost estimate at the beginning, and it comes out to the amount of money per square meter. And he (the cost manager) used another project" – PM2.D; "to have internal training so that we have the basic knowledge about what to look out for, what you need to do. So, if something will come up, you could tackle it straight away" – PM.C; "it is almost non-negotiable anymore, new starters need access to good practice examples of tendering, sustainability assurance in this sense" – SC.C
- external strategies - reflecting on own work: "I really need to work on myself, but it really helps that we have these assignments and theses about sustainability, it challenged me as well to really think about it and my decisions" – PM.C
- external strategies - data management: "that would be good as well, a data management of a SharePoint" – SC.C

Appendix L: Expert evaluation: focus group session

The focus group session started with a presentation of the main topics of the current study, after which the experts were asked a few questions with the purpose of validating the results of the research and hearing their thoughts to improve the framework. The questions asked and the experts' responses were the following:

1. Do you recognize the pattern? Do you consider the complexity elements common in your sustainable construction projects?

   The experts confirmed the pattern and stated that the four complexity elements illustrated in the framework are common in their sustainable construction projects. They also described how they dealt with the complexity elements encountered in their projects by mentioning several management strategies. The strategies were either already part of the framework or listed in the results of the case study.

2. Do you consider the suggested management strategies suitable to deal with the complexity elements chosen?

   The experts confirmed the suitability of the recommended management strategies for the selected elements of complexity. They made a few suggestions regarding the clarity of the strategies, potential additions, and explanations for how the management strategies help deal with the complexity elements.

3. Do you think you could generate the suggested opportunities in your projects?

   The experts confirmed the recommended opportunities and suggested a few more that were related to the opportunities that were already part of the framework. They also asked if the opportunities were considered for the stakeholders or only at the project level (client) and organizational level (TT).

4. How can the framework be improved?

   The experts did not suggest any improvements in addition to the ones previously mentioned in questions 2 and 3. They appreciated the way the framework is illustrated, the colors, and the small boxes with categories of opportunities and complexity elements (the legend). The experts expressed their appreciation for the categorization of opportunities according to the three pillars of sustainability, instead of the usual "environmental-social-governance" categorization.

5. Do you think you can use the framework in your sustainable projects?

   The experts confirmed that they would use the framework in their projects and considered potential options of how to implement it as part of their daily work. A year after having used the framework, the experts would like to add or change elements depending on the outcomes and dynamics of their projects after using it. They also considered transforming the framework into a tool in the future and were interested to see the complete tables of complexities, management strategies, and opportunities.